Building Stock and Policy Assessment Report

Development of Green Building Standards for Zimbabwe

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Presented to:

The government of Zimbabwe

Presented by:

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List of abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
COMESA	Common Market for Eastern and Southern Africa
ECI	Energy Cost Index
EUI	energy use intensity
EEM	Energy efficiency measure
EIA	Environmental Impact Assessment
EMA	Environmental Management Agency
GHG	Greenhouse gas emissions
IEC	International Electrotechnical Commission
IEQ	Indoor environmental quality
KW	Kilowatts
NCCRS	National Climate Change Response Strategy
NDC	Nationally Determined Contribution
NDS	National Development Strategy
NREP	National Renewable Energy Policy
IPPU	Industrial Processes and Product Use
REEESAP	Renewable Energy and Energy Efficiency Strategy and Action Plan
RTCP	Regional Town and Country Planning
RTCP	Regional Town and Country Planning Act
SADC	Southern Africa Development Community
SI	Statutory Instrument
SDGs	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change
ZETDC	Zimbabwe Electricity Transmission and Distribution Company
ZERA	Zimbabwe Energy Regulatory Authority
ZINWA	Zimbabwe National Water Authority

1 Executive summary

1.1 General Background

Zimbabwe has compelling incentives to reduce emissions in the building sector, particularly in light of the ongoing energy crisis and the imperatives of climate change and international commitments like the Paris Agreement. The energy crisis, as exemplified by the precarious situation with the Kariba South Bank Power Station and the substantial reliance on coal for electricity generation, has highlighted the vulnerability and inefficiency of the current energy infrastructure. This crisis underscores the urgent need for a transition to more sustainable and resilient energy systems (supply and demand), a shift that is essential not only for energy security but also for reducing greenhouse gas emissions. Similarly, climate change is already causing significant impacts in Zimbabwe, including altered rainfall patterns affecting hydroelectric power generation. By focusing on green building practices and reducing emissions in the building sector Zimbabwe can make strides towards meeting its Paris Agreement obligations. Therefore, reducing emissions in the building sector aligns with both national interests in addressing the energy crisis and global commitments to mitigate climate change, representing a strategic move towards sustainable development and environmental stewardship.

The Building Sector (residential, commercial, and public sectors) accounts for an estimated 51% of all electricity generated in the country[1], and a much larger proportion of the total final energy consumption (65%) given the reliance on biomass by the over 60% of households that are not connected to the electricity grid[2]. As the country develops, the 2.3 million households in Zimbabwe will aim to gain access to electricity services in coming decades adding pressure into the electricity system[3]. Furthermore, the overreliance on biomass by 60% of households causes environmental and land degradation through deforestation and its related negative impacts. Finally, this is added to demand for petroleum fuels and coal from households and businesses.

The transition to green buildings presents a unique opportunity that simultaneously provides economic, social, environmental, and climate benefits to individuals and the country at large, supporting the attainment of national policy objectives, international commitments, and global development goals:

- Green buildings offer significant cost savings through lower operational energy needs, allowing for greater access to energy services at a lower cost.
- and the possibility that the limited access to high quality energy (electricity) reaches to further sectors of the economy, which is essential in a region with fluctuating and often costly energy supplies. This shift also opens avenues for job creation in sustainable building practices and renewable energy sectors, increasing property values and attracting foreign investments focused on sustainability.
- Socially, these buildings enhance occupant health and wellbeing through improved air quality and natural lighting, while also contributing to energy security with decentralized renewable energy systems, lessening reliance on an unstable grid.
- Environmentally, green buildings reduce the demand for unsustainable traditional biomass and its related negative impacts by incorporating modern and sustainable renewable energy and efficient technologies to meet the growing demands of a country that is growing.
- From a climate perspective, these buildings are vital in mitigating climate change through reduced energy consumption and emissions, and they offer adaptive capacities against climate-induced adversities. This integrated approach not only aligns with Zimbabwe's national development objectives but also resonates with global environmental commitments, positioning green buildings as a strategic and multi-benefit solution for the country's future.

[1] https://au-afrec.org/zimbabwe

[2] https://www.linkedin.com/pulse/green-buildings-key-addressing-energy-crisis-zimbabwe/

[3] Statistics Zimbabwe

- The passive design elements of Green Building design can also be beneficial for the poor and marginalized societies as there it can provide low cost energy services.

Therefore, the implementation of a Green Building Standard focused on energy performance has been identified as a key action to support greenhouse GHG emissions reductions objectives in the country. The implementation of such standards can provide an approximate reduction of 30% of average HH electricity demand by 2030 (Figure 1), even as the cumulative total increases due to population and economic growth.

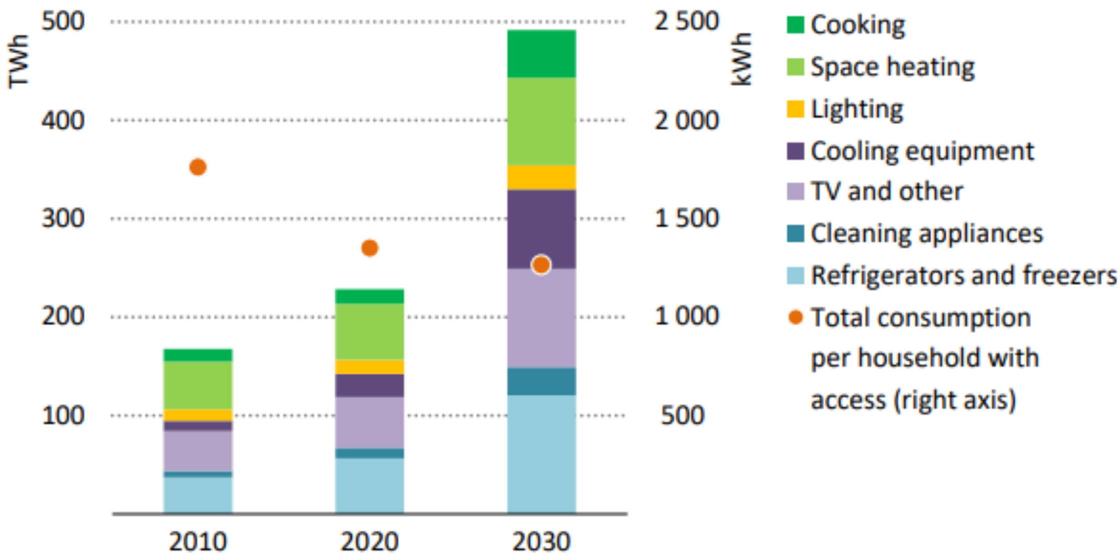

Figure 1: Projected residential electricity demand in Africa in the Sustainable Africa Scenario (Source: African Energy Outlook. IEA, 2022).

Enforcement and implementation of building standards promote reduction of emissions through the improvement of buildings energy performance and the application of low carbon building materials and techniques and work particularly well when paired with Minimum Energy Performance Standards (MEPS) for energy using appliances that are used in buildings. Some of the key options in which building standards support emissions reductions include:

- Improved building insulation to minimize the need for active cooling and heating.
- Optimized building design to minimize and/or maximize thermal and gains and losses from building according the climatic and seasonal needs.
- Optimized building design to maximize benefits from natural lighting.
- Optimized building design for its purpose to improve users experience minimizing needs for elevators and other conveyance needs.
- Install renewable energy generation (electricity and heat) on site where possible to supply the building.
- Use of construction materials that while optimum for the building purpose and longevity, reduce the emissions from their production, for example wood as construction material reduces emissions compared to concrete or steel.
- Improve occupant productivity through improved comfort and operational efficiency.

Further, when considering Green Building Standards, the benefits go beyond energy demand and emissions reduction, but look at other aspects of users' wellbeing, and minimization of all negative impacts from the construction and operation of buildings, whether commercial or residential. This can include pollution reduction, minimize use of toxic substances, water consumption minimizations, and more.

However, Zimbabwe is constrained in its ability to fully implement sustainable building practices, adopt environmentally friendly technologies, and put appropriate measures in place to respond to climate change requirements due to limited institutional and financial resources. Accordingly, there is an urgent need to look at domestic systems and improving them through the establishment of new building systems and practices based on green thinking and energy efficient measures and design. For this, it is important to develop effective green building standards, build capacity and experience, develop policy guidelines and MV&E frameworks, and ensure clear and strong mandates for each of the implementing agencies along with powers to enforce the programmes.

The objective of this project is to develop a green building standard in three building types (**residential buildings, office buildings, and commercial complexes**) and introduce effective mechanisms for their operationalization. This will include:

a) a comprehensive assessment of building groups and regulations in Zimbabwe, and analysis of technological needs,
b) the development of draft green building standards and policy guidelines, and
c) the development of effective mechanisms and tools for the implementation of building standards, including an MV&E framework, user manuals, and the delivery of a training the trainers' programme.

In this report, the baseline situation in Zimbabwe is explored including the existing policies relevant to construction and the energy performance of buildings, an assessment of building performance in the target buildings, and a gap assessment indicating the best technological and policy options for possible adoption as part of the adoption of a Green Building Standards.

2 Introduction

This report provides a detailed description and results of the activities 2.1 and 2.2 of the project that look to provide a thorough background and baseline analysis for the development of the Green Building Standards for Zimbabwe. The key elements included are:

- **Policy and regulatory analysis** – this analysis assesses the progress in the country to promote or mandate the performance of buildings in the country with specific focus on energy performance. This include looking at building codes, policy plans, building industry strategies, and city level by-laws among others to understand what is currently required and enable an assessment of possible future steps.
- **Baseline building performance analysis** – this will look at the current performance of buildings in terms of energy demand and the presence/absence of different design features and energy-using appliances to determine the average energy demand of the sector and provide the basis to recommend changes to improve performance. This analysis will also include projections of the building sector illustrating increases in demand and the resulting energy and emissions increases over time. This will form the baseline to assess the possible savings that can be achieved through the implementation of a Green Buildings Standard.
- **Identification of international best practices** –the most effective energy demand reduction options will be identified in the different stages of the buildings sector. This will include a general description as well as example of specific applications and how do they compare to the status quo. With this information, it is possible to start guiding a selection of options that can be included in the Zimbabwe Green Building Code and estimate the potential savings that can be delivered through their implementation.

These elements together provide the basis for Green Building Standards providing a starting point for progress in terms of the technologies that are present in operating buildings, the building design practices, and the policy practices to support and incentivise the implementation of green buildings.

3 Green buildings concepts

3.1 Definition of Green Buildings

While the conceptions and definitions of green buildings vary between jurisdictions, it is often described as a comprehensive method for creating affordable, energy saving, and environmentally friendly living and working spaces. In this concepts, green buildings are not limited to building design but include the entire building life cycle, that is, site selection, design, construction, operation, maintenance, demolition, and renovation. Bungau et al. (2022) provided a comprehensive definition of green buildings, which describes them as a practice that involves creating structures and using processes that are environmentally responsible and resource-efficient throughout the life cycle of the building, from siting to design, construction, operation and maintenance, renovation, and disposal.

In many definitions, Green Buildings are designed, constructed, and operated, not only to minimize environmental impacts, but also to enhance the health and well-being of its occupants. Key features and principles of green buildings include energy efficiency, water conservation, sustainable materials, favourable Indoor air quality (IAQ), appropriate site selection, sustainable operational practices and re-usable materials at demolition.

However, the focus of this project is to support the minimization of GHG emissions from the construction and operation of buildings. As such, the key deliverables will focus on the energy consumption aspects of buildings which generate the larges emissions while only briefly touching on the construction materials, and other aspects of green buildings

3.2 Key Features of Green Buildings

Based on the definition above, the key features of sustainable buildings are energy efficiency, water efficiency, sustainable site selection and land use, material selection and resource efficiency, indoor environmental quality, waste management, and green infrastructure. These concepts are explored in this project for completeness, but the focus will be on energy efficiency with some discussion relating to building materials and design feature that are relevant to the minimization of energy demand such as minimization of transport, elevator use, etc. The key concepts are summarised below.

Energy Efficiency

Globally, buildings account for more GHG emissions than in other sectors. They use a large amount of energy to cool or warm their interiors, cooking, lighting, appliances and equipment, water heating, and plug loads. Much of this energy is produced using fossil fuels. Green buildings aim to minimise energy use in buildings through the incorporation of design strategies that optimise natural lighting, ventilation and insulation thereby reducing the need for artificial lighting, heating, and cooling and hence, reducing energy consumption. The implications for policy and regulatory framework for this are that policies and regulations should provide necessary guidelines, standards and incentives that encourage the adoption of sustainable building practices.

Material Selection and Resource Efficiency

Green buildings emphasise the use of sustainable (low emissions) and recycled materials that are responsibly sourced and produced to minimise environmental impacts and promote long-term sustainability such as timber, recycled materials, natural materials, green insulation materials, recycled plastic, and high-performance concrete alternatives. Many of these materials represent significant emissions reductions compared to standards concrete and steel, which require large amounts of energy to mine and process into final products. Resource efficiency involves the effective and sustainable use of resources throughout the life cycle of a building, from construction, operation, and demolition. It involves minimising resource consumption, reducing waste generation/ and optimising resource utilisation. The implications for this to policy and legal frameworks are that necessary guidelines, regulations, incentives, and standards should be put in place to encourage the construction and operation of sustainable and energy-efficient buildings.

Sustainable Site Selection and Land Use

Green buildings consider the environmental impact of site selection and land use. They are designed to minimise disturbances to natural habitats and to protect biodiversity. Thus, when choosing a location for a building, factors such as the presence of sensitive ecosystems or endangered species should be considered to avoid causing harm to these areas. Additionally, green buildings aim to reduce reliance on vehicles by locating the building near key services. Green buildings integrate amenities such as parks, recreational areas, and commercial facilities within walking distance to reduce the need for long-distance travel and encourage physical activity. The policy and legal framework implications are that policies should consider instruments and tools that discourage building development at inappropriate sites and encourage the reduction of the environmental impact from the location of a building on the site.

Green Infrastructure

Green buildings refer to the integration of natural elements and systems within and around buildings to enhance sustainability, environmental performance, and human well-being. This includes the incorporation of elements of nature such as vegetation and water features. Green infrastructure can include components such as roofs, living walls, rain gardens, and permeable pavements. The integration of green infrastructure in green buildings is greatly aided by policy and legal frameworks, which offer the standards, rules, incentives, and guidelines required to promote the adoption and use of green infrastructure practises.

Indoor environmental quality (IEQ)

This refers to building characteristics and factors that can have an impact on the health, comfort, and well-being of its occupants. Interior air quality, thermal comfort, lighting, acoustics, and variables that contribute to a high-quality interior environment of green buildings. The provision of policy and legal frameworks play a crucial role in promoting and ensuring high indoor environmental quality in green buildings because they establish guidelines, regulations and standards that encourage the adoption and maintenance of IEQ measures.

Waste Management

Waste management is a key feature of green buildings. It focuses on minimising the generation of waste, promoting recycling and reuse, and sustainable waste disposal practises. This includes waste reduction and prevention, recycling and reuse, waste segregation and collection and waste management infrastructure. The integration of efficient waste management strategies in green buildings contributes to the creation of more sustainable built environments. This includes, looking at the possibility the implementing biodigesters to manage all the organic waste and produce clean energy.

A green building standard will require that building projects include and waste management plan to minimize waste from the building.

4 Review of international recommended practices

4.1 International setting

Energy demand in the building sector, which includes energy used for constructing and energy services during building operations such as heating, cooling, and lighting in homes and businesses, as well as the appliances and equipment installed in them, accounts for over one third of global energy consumption and 26%[4] of global energy-related emissions - 8% being direct emissions in buildings and 18% indirect emissions from the production of electricity and heat used in buildings. For Zimbabwe, this represents 51% of the electricity supply and 18% of emissions.

Global floor area is growing rapidly, especially in developing countries, and growing wealth means more and more consumers are buying air conditioners and other appliances that consume energy which in turn are likely to lead to increasing CO2 emissions. Because of the long lifetime of structures, heating and

[4] This is a global figure and is sourced from the International Energy Agency, but latest figure from the EU indicates that within EU 36% of total emissions in EU comes from the building sector. Link

cooling systems, and other appliances, design and purchasing decisions made today will shape energy use for many years to come.

Existing technologies can deliver significant energy and cost savings and other benefits, but stronger policy support such as minimum performance standards and building energy efficiency codes will be required to put the buildings sector on track with the Net Zero Emissions by 2050 Scenario. Minimum performance standards and building energy efficiency codes are increasing in scope and stringency across countries, and the use of efficient and renewable buildings technologies is accelerating. Yet the sector needs more rapid changes to get on track with the Net Zero Emissions by 2050 Scenario. This decade is crucial for implementing the measures required to achieve the targets of all new buildings and 20% of the existing building stock being zero-carbon-ready[5] by 2030.

4.2 Green building international certification schemes

Building Certifications can vary from one country to another, but there are several internationally recognized certifications and practices that are widely considered to be among the best for promoting sustainability and environmental responsibility in the construction and operation of buildings. These schemes are voluntary in most countries and the certification process can involve such as submission of plans to the certification body ahead of construction for vetting, thorough inspection to ensure standards are being following, and official recognition from the issuing body.

The key advantage of these schemes is that they provide an incentive to developers in form of a marketable certification that increases the value of the property (accounting for increased cost of construction) while the operating costs of building operators are lower as well as enjoying other benefits such as improved wellbeing for building occupants.

Some of the most notable ones are included in Table 1.

Table 1: Selection of internationally recognized Green Building Certification Schemes.

	LEED from the US Green Building Council provides a framework for healthy, highly efficient, and cost-saving green buildings. It offers various certification levels based on points earned across several categories, including sustainable site development, water efficiency, energy performance, materials selection, and indoor environmental quality.
	BREEAM (Building Research Establishment Environmental Assessment Method): This standard is widely used in the United Kingdom and several other countries. BREEAM assesses the environmental performance of buildings, including their design, construction, and operation.
	Green Star: This is an Australian-based rating system for sustainable building design and construction. It evaluates a building's environmental performance across various categories and has gained recognition in several countries.

[5] Zero-carbon-ready buildings are highly energy-efficient and resilient buildings that either use renewable energy directly or rely on a source of energy supply that can be fully decarbonised, such as electricity or district energy. The zero-carbon-ready concept include both operational and embodied emissions.

	Living Building Challenge: The Living Building Challenge, administered by the International Living Future Institute, goes beyond just energy and water efficiency. It aims to create buildings that are "regenerative" and produce more energy and resources than they consume.
	Passivhaus (Passive House): Originating in Germany, Passivhaus focuses on extreme energy efficiency and is designed to reduce a building's energy consumption significantly. It's applicable in many countries and regions.
	Estidama: This is the sustainability rating system used in the United Arab Emirates, with a particular focus on the environmental performance of buildings in the desert environment.
	GRIHA (Green Rating for Integrated Habitat Assessment): Developed in India, GRIHA assesses the environmental performance of buildings and infrastructure projects in the Indian context.
	Green Mark: Singapore's green building rating system, Green Mark, evaluates and rates the environmental performance of buildings in the city-state.
	Excellence in Design for Greater Efficiencies (EDGE): Used in over 100 countries, EDGE is a free software and an international green building certification system. A green building solution created by the International Finance Corporation (IFC), a member of the World Bank Group, EDGE empowers you to optimize your designs to use less energy, water, and embodied energy in materials.

4.3 Building Energy Efficiency Codes (BEEC)

Building energy efficiency codes are regulatory standards set by governments or local authorities to establish minimum requirements for the energy performance of new and renovated buildings. These codes aim to improve energy efficiency, reduce greenhouse gas emissions, and enhance the sustainability of the built environment.

In the following some key aspects and benefits as well as operational conditions of building energy efficiency codes are briefly elaborated on as well as. These shape the impact of the codes, the level of compliance, and the ability of the market and government to adhere and/or enforce the regulatory conditions.

4.3.1 Ambition

One of the key characteristics of effective building energy codes is their ambition, which refers to the level of energy performance required for compliance. Ambitious codes set higher standards for insulation, HVAC systems, lighting, and other building components, leading to greater energy savings. In the context of Zimbabwe, it should be noted that compared with several other developing countries the operational consumption of energy per m^2 in buildings appears to be relatively low because of a general poor access to stable electricity supply, but in some regions of the country the prevailing climate increases the need for certain energy services such as air conditioning or heating and therefore impacting on energy demand. At the same time, the means to satisfy these energy needs remain unaffordable for a significant proportion of the population. Therefore, the implementation of ambitious and ambiguous standards is unlikely to have a real effect.

For this, a stepwise implementation of standards is important to account for different components of building energy demand. This project will focus on the development of standards that will render benefits for different regions and economic levels.

4.3.2 Scope

Energy efficiency codes typically address various aspects of building design and construction include but are not limited to:

- **Building envelope quality** – the physical barrier between the conditioned interior of a building and the outside environment. This includes the walls, roof, windows, doors, and foundation of the building. The main purpose of the building envelope is to protect the indoor environment and to help regulate the indoor climate.
- **Insulation** – which aims to maintain desirable indoor conditions by keeping desired heat inside buildings during the winter and outside during the summer, which minimizes the need for heating and air conditioning.
- **Heating, ventilation, and air conditioning equipment efficiency** – which aims to provide suitable heating and cooling services for buildings in an energy efficient manner.
- **Lighting systems** – to provide suitable lighting for the activities that happen within the buildings. For example, technical and desk-based activities may require different lighting level for optimum performance.
- **Renewable energy requirements** – some jurisdiction may require buildings of certain types to generate some of the energy consumed onsite through renewable technologies such as solar PV.

The coverage of green building codes can vary depending on the priorities of the enacting jurisdiction. This includes the comprehensive codes enacted in several countries cover both residential and commercial buildings, ensuring that all sectors contribute to energy savings. However, in some countries, building codes focus primarily on "larger consumers" limiting the coverage of the BEEC to buildings above certain floor area (m^2) and therefore may excludes single-family residences.

In other occasions, the BEEC may focus on areas where the greatest gains can be obtained from the least level of effort (especially costs). For example, with the development of LED technologies for lighting, some building codes will require the use of them whenever possible regardless of the type of buildings, activities, etc.

4.3.3 Compliance and Enforcement

The biggest challenge with building energy efficiency codes faced by countries, especially developing countries, is ensuring compliance during construction and retrofitting activities. Robust enforcement mechanisms usually include:

- **Inspections** – by qualified staff that ensures that the development of buildings adheres to the requirements set forth in the BEEC.
- **Permits** – provided by relevant authorities for qualified companies/individuals to carry out building activities that comply with the BEED.

- **Penalties for non-compliance** – this usually involves monetary fines for buildings that do not comply with the BEEC requirements, although in some jurisdictions, egregious violations of the BEEC can result in imprisonment, building sites closed, licences revoked, and more.
- **Incentives** – Often, to support or reward compliance with BEEC requirement above the minimum, some countries provide monetary incentives. These usually involve a set amount of money per square meter. In occasions, the incentives can take the form of special concessions that can be monetized by building developments. For example, allowing an extra floor to be built on a building where hight limits apply.

These elements are essential to achieving the intended energy savings and maintaining the integrity of the codes. Efforts, in developing countries, on preparing and formulating energy efficiency codes are supported by development organisations. However, it is essential to ensure that these efforts include strong components of capacity building as qualified and experienced staff are the single greatest requirements for the success of a BEEC implementation.

4.3.4 Flexibility and adaptability

BEECs need to be flexible to effectively accommodate the diverse range of building types, differing climates, and various construction methods encountered globally. This flexibility ensures that residential, commercial, and industrial buildings can all achieve optimal energy efficiency without compromising on their unique functional requirements. Moreover, because building technology, energy prices, and environmental priorities are always evolving, it's important that these codes are regularly updated. These updates allow the integration of the latest building materials and technologies, adapt to economic shifts that affect cost-effectiveness, and align with emerging environmental concerns, ensuring that the codes stay relevant and practical.

To effectively evolve with the changing conditions of the building industry, robust monitoring and evaluation schemes are crucial. These systems not only ensure compliance with current codes but also gather critical data on how buildings perform under various conditions. By analysing trends and outcomes, experts can refine and adjust the codes, ensuring they remain up to date with the latest industry developments and environmental demands. Additionally, nurturing national competencies in building science through ongoing education helps professionals stay ahead of technological advances and implement the most effective building strategies. This dynamic approach to maintaining and evolving energy efficiency codes helps create a continuously improving framework that adapts to new challenges and opportunities in the building sector.

The review requirement, process, and periodicity of the BEEC review and update should be included in the regulations that enforces them. The key methodologies, priorities, and stakeholders should be specified, and responsibilities allocated to a specific agency to ensure that this takes place.

4.3.5 Cost effectiveness

While initial construction costs may increase due to compliance with energy efficiency codes, the long-term benefits typically outweigh the upfront investment. This is because energy-efficient and green buildings consume less energy and are made with higher quality materials compared with standards buildings, leading to lower utility and maintenance costs of operation resulting in reduced lifecycle costs.

The accrual of costs and benefits is one of the main barriers related to the higher costs of developing green buildings as developers look for lower costs while the benefits of green buildings are large accrued by those operating/living in the buildings. This is called split-incentives. As such, some of the incentive programmes for the construction of green building allow developers to monetize the improved quality of the building through direct subsidies, concessions for extra floor space build where limitations may apply, and certification programmes that allow for increased market value.

The cost-effectiveness of green buildings can also be achieved (observed) through improved health and comfort building inhabitants which will result in a positive productivity boost for workers in an office building or reduce health costs for household residents. Energy-efficient buildings often provide improved indoor air quality, thermal comfort, and daylighting, which contribute to occupants' health, productivity, and well-being. Enhanced insulation and airtight construction also help to reduce drafts, noise infiltration, and moisture problems which leads to reduced health issues.

4.3.6 Climate impact

It is widely acknowledged that building energy efficiency codes play a crucial role in mitigating climate change by reducing the carbon emissions of the built environment. By promoting energy efficiency and encouraging the use of renewable energy sources, codes contribute to lower emissions of greenhouse gases and other pollutants.

4.3.7 Market transformation, public awareness, and education

Energy efficiency and green building codes can play a pivotal role in the transformation of the construction industry and markets by pushing for the widespread adoption of energy-efficient technologies, materials, and design practices. By setting ambitious standards for energy efficiency, these codes do not merely ensure that new buildings consume less energy; they also spur demand for innovative building solutions that can meet or exceed these standards. This creates a vibrant market for advanced materials like high-performance insulation and windows, energy-efficient HVAC systems, and smarter building management systems. In turn, this demand encourages manufacturers and industry stakeholders to invest in research and development, leading to technological innovations that continue to push the boundaries of what is possible in energy-efficient design.

However, the success of energy codes in driving market transformation and enhancing building practices significantly depends on effective implementation, which requires comprehensive public awareness and educational initiatives. Stakeholders such as builders, architects, homeowners, and tenants need to be well-informed about the benefits of energy efficiency and the specific requirements of these codes. Outreach programs that can include community workshops, informative webinars, and distribution of educational materials play a crucial role in this process. These resources help demystify the technical aspects of energy codes and illustrate the tangible benefits of compliance, such as reduced energy costs and improved building comfort. Training workshops specifically designed for industry professionals can equip them with the necessary skills and knowledge to implement these codes effectively, ensuring that energy-efficient buildings become the norm rather than the exception. Through sustained educational efforts, energy codes can lead to a more informed public that values sustainability and is committed to upholding high standards in building construction and renovation.

4.3.8 Global harmonization

Harmonizing energy efficiency codes across different levels—regional, national, and international—is a strategic approach that promotes uniformity in building standards and facilitates a more cohesive effort towards sustainability across national boundaries and a global level. This kind of harmonization not only encourages collaboration and knowledge sharing among countries but also ensures that good practices in one region can be adapted and implemented in another, thus accelerating the transition to a more sustainable and energy-efficient built environment globally.

When energy efficiency codes are aligned across borders, it allows for a streamlined process in which innovations and advancements in one country can easily be transferred to another. This is particularly beneficial for multinational companies and architects who work across different countries, as they can apply the same building principles and practices without having to navigate a complex web of local codes. Harmonized codes can also lead to economies of scale in the production of building materials and technologies allowing manufacturers to produce high-efficiency materials that meet a wide range of international standards, potentially reducing development costs and increasing the adoption rate of sustainable technologies.

By implementing rigorous and universally accepted energy efficiency metrics, countries can collectively make significant impacts in reducing global greenhouse gas emissions. Policymakers can leverage international forums and agreements to share successful strategies and technologies, fostering a spirit of cooperation and collective action. This global network of shared standards and knowledge not only enhances each country's capabilities in sustainable building practices but also builds a unified front in the fight against environmental degradation, promoting a healthier planet for future generations. Through such collaborative efforts, the world can move more swiftly towards energy-efficient infrastructures, setting a strong foundation for a sustainable economic and environmental future.

Green building certification programmes generally look to improve harmonization through following its requirements. For example, the global Green Building Council programme.

4.4 Current global status

Mandatory requirements are typically understood as minimum design requirements which either are "prescriptive" and relates to specific requirements for technologies or end-uses (such as lighting or cooling) or "performance" based where the overall energy efficiency performance of a building is assessed (such as requirements of total kWh per square meter per year), and which often requires a simulation tool to assess. Such whole performance-based requirements are now becoming standard in most developed economies. It requires a certain minimum level of data and specifications for the various measures as well as construction materials to be able to make such assessments.

Figure 2 below shoes the global status of the development and enforcement of either voluntary or compulsory building energy efficiency minimum requirements.

The performance standards are typically voluntary rating schemes where building and house owners can choose to have a performance assessment made, and the building will then be rated according to the prescribed scale of the standard (often leading to a performance label being issued for the building). Such scales or labels are often locally or nationally defined and can be different from scheme to scheme. There are also international rating schemes for building performance which are using a general scale/label rating.

The case of Nigeria

In 2016, GIZ launched the support for the development of Nigeria's first version of Building Energy Efficiency Codes. Prior to this development a comprehensive awareness programme had been implemented which included development of general design guidelines that was based on a review and assessment of the design and construction practices. The first version of the BEEC was based on a Technical Study (Technical Study - Nigeria). It was decided to include measures for the 1st BEEC that were expected to contribute with highest saving potentials. Hence the Nigeria BEEC includes minimum efficiency requirements on:

- Roof insulation
- Max. Window-to-wall ratio
- Max. Lighting power density for (residential and office buildings)
- Min. Performance for AC split units, and a requirement for only inverter types to be installed.

The 1st version allowed for both a compliance method to the above prescriptive requirements as well as a performance-based method. The performance method required building modelling, and a list of recommended tools was included in the BEEC. The 1st BEEC initially was adopted for the Abuja Region/State and later on later on three other States had BEECs developed for adoption.

(Building Guidelines - Nigeria)

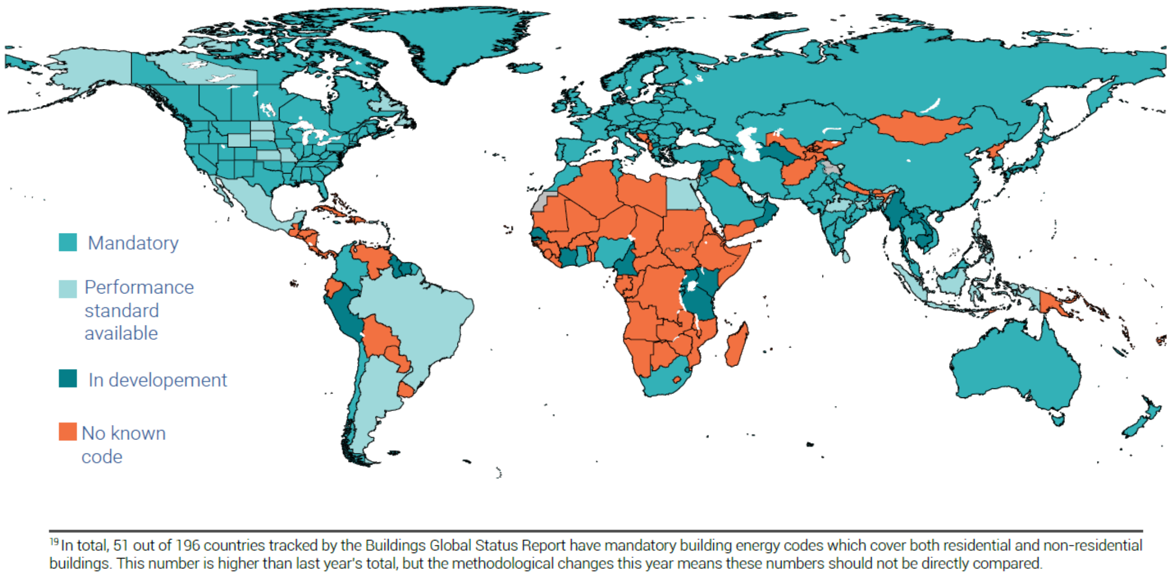

Figure 2: Status of Building Energy Efficiency Codes.

"Prescriptive requirements" provide a specific technical performance threshold (or scale with several levels) for example, lighting measures must comply with a certain minimum requirement related to the W/m2 which can provide an acceptable level of lux/m2 in the room/building that are addressed. There are internationally accepted standards for how many lux are required for different function areas, such as hotels, hospitals, offices, private living room, schools etc. For other appliances, such as air conditioners, the sector also has developed ratings that are referring to terms such as Coefficient of Performance (COP) or Energy Efficiency Ratio (EER). Both ratings relate to how much energy/power is used for the appliances to remove the same amount of energy/heat from the area that is serves. Such information is normally displayed on the labels on the equipment.

4.5 Scope of building energy efficiency codes

4.5.1 Building envelope

The building envelope plays a critical role in the energy efficiency of a building as it dictates the thermodynamic exchanges with the environment. It consists of all the elements that separate the interior environment from the exterior, including walls, windows, doors, roofs, and floors. Enhancing the building envelope's efficiency can significantly reduce energy consumption, lower utility costs, and decrease the environmental impact of a building. Like for the measures mentioned above existing standards related to the envelope elements are either prescriptive minimum requirements for each element or a whole performance requirement can be adopted.

Depending on the climate/location of the building, the orientation of it can also have a determined factor on the energy performance of the specific building. For a building located low (compared with the sea level) and in a tropical zone, air conditioning is likely needed throughout the year and therefore it would reduce the cooling demand if the building were oriented and designed so that direct sunlight through windows is avoided (as it increases the heat gain). In this case a north-south orientation is recommended.

4.5.1.1 Insulation

The heart of the insulation concept is the prevention of unwanted heat losses or heat gains from the environment depending on the needed indoor conditions for comfort. Different international standards are recommending different techniques and measures to minimize these unwanted heat exchanges. Generally, proper insulation in walls, roofs, and floors helps to minimize heat transfer between the interior and exterior environments or reverse.

The concept of R-value is central for insulation. R-value is a measure of a material's thermal resistance and quantifies how well an insulation material can resist heat transfer with higher R-values meaning better insulation properties and greater resistance to heat passage. This means that insulation materials can both help in reducing heat loss from a building located in a temperate climate where one wants to maintain/keep the heat and also prevent heat gain for a building that is located in a tropical climate where one would require/need to protect from the sun's heat gain.

The Case of South Africa

The National Building Regulation of South Africa (SA) includes supporting documents / sections: Part X: Environmental sustainability and Part XA: Energy usage in buildings. In addition to that the regulations also refer to a series of normative references on specific Standards that covers general requirements for different elements of a building or installations in it.

A central point of Part XA: Energy usage in buildings, is the "Energy Zones" that SA has been divided into. The Zones have been identified in terms of the need for "heating and/or cooling" in buildings. The specific zones are identified by a combined rating (low, medium, high) for the heating/cooling demands. This qualitative assessment results in 7 energy zones in SA, each of them with individual minimum requirements for design elements and appliances installed in buildings.

The Regulations cover all classes of buildings that occupies people. Part XA includes a table with all types of building classes that must comply with the minimum requirements and depending on the location within the 7 energy zones. The requirement is specified by a maximum annual energy consumption per building (kWh/m2/year). This nominal requirement is determined based on details of the building design and is hence a theoretical value that is developed by the use of a building simulation tool (must be a tool certified by the national authority).

Part XA has two main sections:

1. Building envelope requirements:
    - a. Orientation
    - b. Shading
    - c. Fenestration
    - d. Floors
    - e. External walls
    - f. Roof assembly
    - g. Building sealing
2. Services (for indoor comfort) that specifies requirements for:
    - a. Hot water supply
    - b. Lighting
    - c. Air conditioning

In regions with temperate climates, such as parts of the U.S. or Europe, the primary insulation concerns are during the cold winter months to retain heat. Buildings here benefit significantly from high R-value insulation in the walls and roofs, which traps heat inside, reducing the need for excessive heating and thereby lowering energy costs. An example of good practice is the use of spray foam insulation or double-layer fiberglass batts in residential homes, which can adapt to the thermal needs throughout varied seasons.

Conversely, in tropical climates, like those in Southeast Asia or the Caribbean, the challenge is to keep out the intense heat and humidity. Here, reflective, or radiant barriers are often used in conjunction with shading, building orientation, and traditional insulation materials to minimize heat gains from the sun. These barriers, often installed in roofs, possess high R-values and act effectively to reduce heat gain, ensuring cooler indoor environments without over-reliance on air conditioning systems.

When considering suitable insulation options for a country like Zimbabwe, which generally has a subtropical climate with variations ranging from semi-arid to temperate in different regions, it's important to choose insulation that adapts well to both warm and cool seasons. The objective here would be to reduce heat gain during the hot months and minimize heat loss during the cooler periods, especially in the Eastern Highlands where temperatures can be significantly lower.

4.5.1.2 Air sealing

Preventing air leakage through the building envelope is important for maintaining a comfortable indoor environment and reducing heating and cooling loads. Sealing gaps, cracks, and joints with weatherstripping, caulking, and sealants helps to minimize air infiltration. These are normal practices in the implementation of high efficiency buildings, but depending on local climate conditions there might be special conditions that promote a design of buildings that are more “open” to support ventilation or natural cooling that may be supported due to optimum local conditions.

4.5.1.3 High-performance windows

In many modern buildings, windows can comprise a significant portion of the building envelope, often ranging from 15% to 60% depending on the design and architectural style. This large surface area means that the type of windows installed can profoundly influence the building's overall energy efficiency.

As such, the use of energy-efficient windows with low-emissivity (low-E) coatings, multiple glazing layers, and gas fills (such as argon or krypton) provide better insulation and reduce heat transfer precenting heat losses of between 10 and 30%. Additionally, choosing windows with appropriate solar heat gain coefficients (SHGC) can control the amount of solar heat entering the building. In some cases/locations, because of particular climate conditions, it may be an opportunity to take advantage of the heat gain from the sun light and therefore building orientation is always important to maximise the potentials of energy efficiency.

Regulating the window size/area in relation to the total wall area of a building can also be warranted in certain climates to minimize solar gains, this can be the case in tropical climates. Window to wall ratio or WWR is a common concept included in BEECs in such locations. As an example, in South Africa and in Nigeria a WWR of 20% (meaning that 20% of the overall wall area is made up of windows) is the requirement in the respective BEEC. In cases where various shading devises and measures are incorporated in the design of a building, a higher WWR can be allowed - to gain the benefit of natural ventilation or natural daylight - as long as such measures results in reduced demand on active cooling or heating demands.

4.5.1.4 Thermal mass

Incorporating materials with high thermal mass into the design of a building can significantly enhance its energy efficiency by stabilizing indoor temperatures. Thermal mass refers to the ability of a material to absorb and store heat energy. High thermal mass materials, such as concrete or masonry, can absorb heat during the day and release it slowly over time as temperatures cool, which reduces the need for mechanical heating and cooling systems to constantly run, thus saving energy and maintaining more consistent indoor temperature levels.

For example, during the hot daytime hours, a concrete wall can absorb a large amount of heat, preventing it from penetrating indoors which keeps the interior cooler. Conversely, at night, as temperatures drop, the same wall can gradually release stored heat, keeping the interior warm. This attribute of thermal mass effectively reduces the temperature swings within a building, leading to more comfortable living conditions and lower reliance on HVAC systems, which in turn reduces energy consumption and utility costs.

However, it's important to consider the environmental implications of using materials like concrete and masonry. While these materials are excellent for thermal mass, they do not bind CO_2 in the way that bio-based materials such as wood or timber do. In fact, the production of cement (a key component of concrete) is highly energy-intensive and significantly contributes to CO_2 emissions. Similarly, masonry production can also be quite energy-intensive and environmentally demanding.

Despite these drawbacks, the use of high thermal mass materials can be a part of a balanced approach to green building design if sustainably sourced by reducing operational energy use over the life of the building. Moreover, innovative practices such as using recycled materials in concrete or masonry, improving the efficiency of production processes, or combining these materials with other, more sustainable options (like using timber framing along with masonry elements) can help reduce the overall carbon footprint and enhance the building's environmental profile.

4.5.1.5 Reflective roofing

Installing cool or reflective roofing materials is an effective strategy to enhance the energy efficiency of buildings, particularly in areas that experience high temperatures and intense sunlight. These specialized roofing materials are designed to reflect more sunlight and absorb less heat compared to traditional roofing products. By doing this, they significantly reduce the amount of heat transferred into a building, which can drastically lower cooling loads and decrease overall energy consumption during hot weather.

When implementing cool or reflective roofing, it's important for builders and homeowners to consider their specific local climate and building regulations. For instance, in hot and sunny climates, a white or very light-coloured roof may be most effective at reflecting heat. In cooler regions, the benefits must be weighed against the potential need for more heating in winter months, though the net energy savings are generally positive.

In Zimbabwe, where the climate ranges from tropical to temperate, installing cool or reflective roofing materials can be particularly advantageous. Due to the general high temperatures and abundant sunlight throughout most of the year, especially in lowland regions and valleys, buildings can benefit significantly from the solar reflectance provided by these materials. The implementation of such roofing would not only reduce the energy demand in buildings but also is a practical measure to counter the heat island effect in increasingly urbanized areas like Harare and Bulawayo, where built-up areas tend to accumulate heat.

4.5.1.6 Shading and overhangs

Exterior shading devices such as awnings, louvers, and overhangs enhance a building's energy efficiency by controlling the amount of sunlight that enters through the windows. By blocking direct sunlight, especially during peak solar hours, these devices can significantly reduce the internal temperatures of a building and, consequently, lower the demand for air conditioning. This not only helps in saving energy but also improves the comfort levels within the building by maintaining a more consistent indoor temperature. Additionally, these shading devices are effective in reducing solar glare, which can be a major disturbance in both residential and office spaces, thus enhancing visual comfort for occupants.

The strategic use of these shading solutions varies based on the building's orientation, window size, and local climate. In the case of Zimbabwe, installing deep overhangs over windows facing the north and west can block the intense afternoon sun that these directions commonly receive can significantly reduce cooling loads. Similarly, adjustable louvers offer the versatility needed to adapt to the seasonal variations in sun angle, particularly useful in Zimbabwe's mixed subtropical climate. By integrating these passive design elements, buildings can achieve significant reductions in peak cooling loads and improve their overall energy performance.

4.5.1.7 Passive solar design

Designing the building envelope strategically to harness natural light and manage heat gain is another technique for optimizing energy performance. This involves careful planning of the building's orientation, window placement, and the use of shading devices to create an environment that stays warm during the cool winter months and cool during the hot summer months without excessive reliance on heating and cooling systems.

In Zimbabwe, the winter months can be quite cool, especially in the highland areas, it's important to maximize heat gain from the sun. By orienting a building to have its main windows face north (in the Southern Hemisphere), it can take advantage of the sun's rays during winter when the sun is lower in the sky. The use of thermal mass materials (Section 4.5.1.4) can be used in combination with passive solar design as they have strong synergies.

Conversely, during the hot summer months, the focus is on minimizing overheating to keep cooling costs low. This can be achieved by incorporating features such as wide eaves, awnings, or pergolas that shade windows, using reflective roofing materials or light-coloured external paints to reflect heat away, and maximizing natural ventilation also plays a role in cooling.

These strategies are especially beneficial in hotter regions like the Zambezi Valley and the southern lowveld of Zimbabwe, where temperatures can soar during the summer.

4.5.1.8 Ventilation

Implementing natural ventilation strategies is a highly effective way to reduce reliance on mechanical cooling systems and improve indoor air quality. By designing buildings with operable windows, vents, and considering the orientation, builders can harness the natural breezes and airflow patterns to cool interiors and freshen indoor spaces naturally. For example, positioning windows on opposite walls in a room can facilitate cross-ventilation, allowing cooler air to enter from one side and push warmer air out the other. This not only cools the space naturally but also improves air quality by reducing the buildup of pollutants, which is particularly important in urban areas like Harare and Bulawayo where air quality can be compromised by traffic and industrial emissions.

The strategic orientation of a building may enhance the effectiveness of natural ventilation. In the hotter lowveld regions, buildings can be oriented to maximize exposure to prevailing winds while minimizing direct sunlight exposure during the hottest times of the day. Incorporating architectural features such as wide corridors, atriums, and raised ceilings can also promote better airflow, creating a stack effect that draws cooler air into lower levels and expels hot air from the top. These natural ventilation strategies are not only cost-effective but also environmentally friendly.

4.5.1.9 Advanced building materials

The use of innovative building materials with advanced thermal properties can significantly improve the energy efficiency of building envelopes. Materials such as aerogel insulation and phase change materials (PCMs) offer superior insulation and thermal regulation compared to traditional building materials. Aerogel, for instance, has an extremely low thermal conductivity and is known for being one of the best insulating materials available. This property makes it particularly useful in Zimbabwe's mixed climatic regions, from the cold, damp conditions in the Eastern Highlands to the intense heat in areas like the Lowveld, where traditional materials may not suffice in minimizing energy costs for heating and cooling.

Phase change materials (PCMs) are another innovative option that can be integrated into building fabrics to enhance thermal efficiency. PCMs work by absorbing and releasing heat at specific temperatures, thus helping to stabilize indoor temperatures throughout the day. During peak heat hours in hot climates such as Zimbabwe's Zambezi Valley, PCMs can absorb excess heat, preventing it from raising indoor temperatures. Conversely, at cooler times, such as during the night or in winter months, these materials can release stored heat to maintain a comfortable indoor environment.

4.5.2 Energy Modelling and Analysis

Conducting energy modelling and simulations during the design phase is a strong tool for architects and engineers aiming to optimize building envelopes for superior energy performance. This process involves using advanced software tools to simulate how a building will perform under various conditions, analysing factors such as insulation, window placement, and potential thermal bridging. By modelling energy flows and temperature patterns throughout the building beforehand, designers can identify and rectify potential inefficiencies in the initial design. This pre-emptive approach allows for adjustments to be made before construction begins, ensuring that the building will operate optimally in terms of energy usage. It also helps in avoiding costly post-construction modifications that might be required to address unforeseen energy leaks or inefficiencies in the building's thermal envelope.

Energy modelling can also serve as a decision-making tool about which technologies and design strategies will be most effective for a specific building project. For example, simulations might reveal that increasing the insulation in certain areas could significantly reduce heating demands, or that orienting the building in a particular direction maximizes natural lighting and reduces reliance on artificial lighting. In regions with diverse climate conditions like Zimbabwe, such detailed analyses are invaluable, enabling architects to tailor buildings to the local environment and type of used while enhancing comfort and minimizing energy costs.

4.5.3 Climate conditions and zones

Building Energy Efficiency Requirements should be developed with careful considerations to the prevailing climate conditions in the country/region in which they are to be adopted.

One of the key concepts in this context is to determine the degree days which is a measure used to estimate the cooling or heating demand particular to a region and supports energy management and climate analysis. Degree days are calculated by comparing the actual average outdoor air temperatures in a location to a standard temperature deemed to be 'comfortable', usually 18^{o} or 20 C^{o}. Degree days provide a way to quantify the demand for heating or cooling over a specific period, typically a day, month, or heating/cooling season. They are widely used in energy modelling, building design, and HVAC system sizing.

There are two types of degree days:

- Heating degree days (HDD) – A measure of heating needs in a location.
- Cooling degree days (CDD) – A measure of cooling needs in a location.

While not sufficient on its own, used in conjunction with other climate information such as usual temperature maximums and minimums and the length of the seasons that inflict extreme cold or heat, HDD/CDD provides a strong tool for building design.

For countries that are located in and cover an area that is diversified in terms of climate, meaning that different regions or zones of the country are impacted by varying climate conditions (temperature, humidity, precipitation, etc.) it may be necessary to analyses how these climate conditions are impacting buildings in different ways and therefore also necessitate defining different requirements applying to each region/zones, and this may lead to defining different climate zones within a country. For example, South Africa's BEEC defines 6 climate zones, each with its own specific requirements developed according to meet the needs of the climate conditions.

4.5.4 Advancing the establishment of a GBS in Zimbabwe

The approach for development of National Building Energy Efficiency Codes, where no earlier codes exist, is often either a process of adapting existing codes from a country/region with comparable climate and building construction practices (alternatively adaptation of International Codes, such as ASHRAE or IECC) or through an analytical process starting from defining the baseline of current national design and construction practices and from this developing targets for saving opportunities or potentials using energy efficient technologies available in the local marked. Both approaches require a detailed insight into the common national design and construction practices as well as validated information on the energy performance level of various existing building types. If such information is not sufficiently available, it can take several years to generate the needed market awareness on the topic and an additional number of years to develop and introduce a mechanism (and developing the technical capacity) for enforcing the energy efficiency regulations.

In the case of Zimbabwe, the data collection and reviews performed during the inception stage of this project revealed that only few organisations had collected energy performance data for various building types, if any. It was also disclosed that the common design and construction practices was governed by regulations that do not take energy efficiency into account. It was however found that some design practices do relate to efficient building design, such as the passive design requirements for natural ventilation of buildings. Such passive design measures are relevant to include in BEEC for Zimbabwe.

Overall, it is found that the data that have been collected for review are still considered insufficient to perform detailed analysis that eventually can justify the development of minimum efficiency requirements for the building types that have the focus of this project in Zimbabwe.

Alternatives to the analytical approach has therefore been suggested. This alternative involves seeking inspiration from neighbouring countries such as South Africa, where a BEEC has been developed and which is defining specific energy efficiency requirements for 6 different climate zones.

Post-project activities:

- Awareness/capacity building activities
- Energy Audit training
- Monitoring and evaluation

5 Zimbabwe policy and regulatory review

5.1 General overview

As a party to several international agreement including the United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement to the UNFCCC (2015), Zimbabwe takes its commitments to climate change seriously and has sought to take actions to reduce emissions to mitigate climate change, and adaptation measures to support a better tolerance to climate related impacts on health, the economy, society and more.

Zimbabwe is also party to several multilateral environmental agreements that aim to reduce humanity's impact on the environment and improve the options for future development and living. Some of these include:

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
- Stockholm Convention on Persistent Organic Pollutants (POPs)
- Vienna Convention for the Protection of the Ozone Layer
- Montreal Protocol on Substances that Deplete the Ozone Layer

As part of this commitment, and the general development direction, the country has adopted several policies documents to guide development and set objectives such as the NDC. The country has also developed regulations and other interventions to stimulate desired outcome.

The latest NDC for Zimbabwe states a per capita GHG emissions reduction target of 40% across all sectors of the economy below the projected business as usual scenario by 2030 (relative to the 2017 emission baseline). As one of the key emitting sectors, however, buildings do not figure prominently in the NDC with only general mentions, and mitigation and adaptation measures including the sector in an implicit manner rather than explicitly developing targets and measures for buildings. Some of the measures the address building in passing in the revised NDC include:

- Promoting **energy efficiency** in the commercial and residential sectors. There are emissions reductions targets for the sector, although the only specific mention of specific measures refers to the use of improved insulation.
- Promoting the use of **renewable energy**, especially solar, has a direct impact on buildings.
- Strengthening **infrastructure resilience (including buildings)** to climate change impacts, such as extreme weather events. This has a direct connotation to buildings codes and standards, although they are not mentioned.

At a national level, the country is guided by the Vision 2030 and the National Development Strategy 2021 – 2025 (NDS 1) "Towards a Prosperous and Empowered Upper Middle-Income Society by 2030" which seek to transform Zimbabwe into an upper-middle-income economy and reduce poverty levels while attaining the Sustainable Development Goals (SDGs) and the Africa Agenda 2063 objectives.

The constitution of Zimbabwe[6] has domesticated the principles of sustainable development. It guarantees environmental rights that include the right to an environment that is not harmful to health or well-being. The promotion of sustainable housing, and buildings that are informed by environmental planning laws, regulations, and by-laws that are underpinned by environmental impact assessments are implied in this environment. In addition, the Constitution as the supreme law of Zimbabwe requires that all laws should be aligned with the Constitution and MEAs[7].

Zimbabwe has adopted legal, regulatory and policy frameworks that promote a sound basis for the development of sustainable housing. The **Legal** Framework includes:

- The Environmental Management Act (Chapter 20:27)
- The Zimbabwe Energy Regulatory Authority Act (ZERA) (Chapter 13:23)
- The Regional Town and Country Planning (RTCP) Act (Chapter 29:12)
- The Urban Councils Act (Chapter 29:15)
- The Rural District Councils Act (Chapter 29:13)
- The Housing and Building Act (Chapter 22:07)
- The Housing Standards Control Act (Chapter 29:08)
- The Model Building By-laws of 1977
- The Town Planning Standards, and
- The Town Planning Circular 70 of 2004.

The Regulatory Framework includes:

- Statutory Instrument (SI) 2018 - 86 Electricity (Net Metering) Regulations, 2018;
- SI 38 of 2022, Electricity (Net Metering) (Amendment Regulations, 2022 (No. 1);
- The SI 2019-235 Electricity (Solar Water Heating) Regulations, 2019; and
- SI 103 of 2008 Electricity (Licensing) Regulations, 2008.

[6] Amendment No 20 of 2013/

[7] See section 34 of the Constitution. It states: "The State must ensure that all international conventions, treaties and agreements to which Zimbabwe is a party are incorporated into domestic law."

The Policy Framework include:

- Vision 2023
- The National Development Strategy 1 (2021–2025): Towards an Upper Middle-Income Economy by 2030
- The Decentralisation and Devolution Policy
- The National Human Settlements Policy (2020)
- The National Environmental Policy and Strategies (2009)
- The National Climate Policy (2017)
- The National Energy Policy (2012)
- The National Renewable Energy Policy (2019)
- The Water Act (2013)
- The Zimbabwe Crisis Response Plan (2020-2021)
- The Zimbabwe Long-term Low Greenhouse Gases Emission Development Strategy (2020–2050)
- The National Climate Change Response Strategy, and
- The National Gender Policy (2013 – 2017).

There is also an ongoing review and revision of the National Environmental Policy and Strategies; The National Gender Policy; and National Energy Policy. These will be aligned with emerging trends and issues such as green building codes and standards, and climate change actions.

However, to date, there are no policies or regulations providing guidance on absolute levels of performance relating to energy or water consumption during their operation or building stages to minimize emissions. Similarly, the institutional arrangements for the implementation and enforcement lack clarity and have several areas of overall between agencies allowing for confusion, lack of a cohesive approach, and poor coordination, resulting in an overall low level of oversight of the sector.

This report provides a review of the current policies and regulatory framework for green buildings in Zimbabwe. This is against the background that, despite acknowledging that green buildings contribute to global efforts to mitigate climate change, reduce energy consumption and waste generation, promote resources, and circular economy (Howe, 2011; Mafuku, 2019; Sinha et al., 2013; Tanyanyiwa & Juba, 2018), the policy and legal framework does not comprehensively respond to the need to support green buildings in Zimbabwe. In addition, the adoption of green building practices still faces various barriers and challenges, including a lack of awareness, standards, and regulations. Therefore, it is important to review the policy and legal framework for green buildings in Zimbabwe to identify gaps, best practices, and opportunities for improvement. The report provides a review focusing on the following aspects: the definition and scope of green buildings to put context to the report, the policy context, and the existing legal and regulatory frameworks that have a bearing on green buildings.

The gaps and limitations identified in the current frameworks governing the construction and operations of buildings to minimize GHG emissions include:

- Lack of comprehensive policies and laws/regulations.
- Limited Institutional Capacity and Technical Expertise.
- Insufficient coordination and collaboration of various stakeholders.
- Limited Financial Incentives and Access to Finance.
- Limited integration of renewable energy and energy efficient buildings.

Additionally, there are overlapping mandates among different regulators such as ZERA, Zimbabwe National Water Authority (ZINWA), Environmental Management Agency (EMA) and local authorities such as municipalities and town boards. This has resulted in policy changes/shifts, inconsistency, incoherency, unpredictability, and uncertainty.

5.1.1 Policy and Legal Framework Implications for Green Buildings

The development of green buildings can have important policy and regulatory ramifications as there are various policy tools, rules, incentives, and standards that assist or shape the construction, operation, and maintenance of green buildings. Building codes and regulations, green building certification programs, energy efficiency standards, renewable energy policies, research and development funding, and monitoring and evaluation should all be implemented to create a conducive environment for sustainable development, energy efficiency, and environmental stewardship in building construction and operation. The rules and regulatory requirements provide a framework for designing, constructing, and managing buildings that minimise environmental consequences, save resources, and promote building users' health and well-being. The section that follows provides a review of the existing international, regional, and national policies related to buildings and sustainability as a basis for establishing any gaps, limitations, or opportunities for the establishment of green building standards in Zimbabwe.

5.2 Policy context

The policy context refers to the set of principles, guidelines strategies and objectives that inform decision-making and guide the development and implementation of policies. In this context, they shape and govern building development, construction, operation, and management at a high level. They are often developed by governments to define their policy priorities, approaches, and desired results. This report acknowledges that policies vary across different jurisdictions and regions. Therefore, the report reviews these policies based on the level, that is, the global, regional, and local levels.

In Zimbabwe, the framework for construction contracts and the development of green building standards is shaped by both traditional legal practices and emerging environmental concerns. The legal landscape includes provisions for contract termination under specified circumstances, recognition of force majeure, and it allows claims by third parties under certain conditions. Construction contracts often allow for the employer to terminate the contract based on just cause, such as failure to perform obligations or significant delays when time is crucial. The concept of force majeure is recognized, providing a mechanism for parties to be relieved from their obligations due to unforeseen and uncontrollable events, although economic challenges do not typically qualify as force majeure.

The development of this Green Building Standards in Zimbabwe is a response to the country's increased vulnerability and commitment to climate change, such as altered rainfall patterns and more frequent extreme weather events. These Standards aim to foster an environmentally responsible construction sector by minimizing the climate impacts of buildings through energy efficiency and renewable energy systems to minimize climate emissions. The standards also look at ensuring the economic performance of both new and existing buildings across commercial, institutional, and residential sectors.

5.2.1 Global policies on green buildings

Zimbabwe is a signatory to several international and regional legal instruments that include the United Nations Framework Convention on Climate Change (UNFCCC); Paris Agreement to the UNFCCC (2015); Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; Stockholm Convention on Persistent Organic Pollutants (POPs); Vienna Convention for the Protection of the Ozone Layer; and Montreal Protocol on Substances that Deplete the Ozone Layer.

Table 2: Global policies that promote green building actions.

Policy	Provisions	Comment/Analysis
United Nations Framework Convention on Climate Change (UNFCCC) (1992)	Article 2	• Green buildings, particularly those designed to be energy-efficient and use renewable energy sources, can help to reduce greenhouse gas emissions, and mitigate climate change.
	Article 4	• Green buildings can play a significant role in achieving the commitments outlined in Article 4 by reducing energy consumption, promoting energy efficiency, and integrating renewable energy technologies.
Paris Agreement to the UNFCCC (2016)	Articles 2; 4; 7; and 10.	• The provisions of article 2[8] increase funding opportunities for green building projects and enhance access to financing and hence, reduce the financial barriers associated with green building funding. • Article 4 calls upon each Party to prepare, communicate, and maintain nationally determined contributions, while also pursuing domestic mitigation measures to achieve these objectives. The implications are that, to meet the national targets, the country can, among other measures: o Increase the stock of green buildings to reduce energy consumption and emissions from buildings; and o Establish or enhance regulatory frameworks that encourage the implementation of green buildings. • The provisions of article 7 justify the need for green buildings, which are adaptive and resilient to climate change. • The implications of the provisions of article 10 are that the adoption of innovative and sustainable building practices, including energy efficient systems, renewable energy integration and advanced construction materials can be facilitated. The provision also implies capacity building initiatives in terms of training, knowledge transfer and technical capabilities of the construction industry are increased. This overrides the barriers related to limited awareness, skills and capacity that hinder the adoption of green building practices.

[8] Paris Agreement, Article 2 Subsection 1c: pp 2

Sustainable Development Goals (SDGs)	Goal 3: Good health and well-being	• The goal implies that green buildings should be adopted to meet this goal as they prioritise the well-being of occupants by promoting healthy indoor environments. They also contribute by providing healthier and more supportive living and working environments.
	Goal 6: Clean water and sanitation	The implications of the goal with respect to green buildings are that: • Green buildings advance sustainable development addressing environmental concerns including water conservation, water quality, energy efficiency and resource management.
	Goal 7: Affordable and clean energy	The goal justifies the need for the adoption and implementation of green buildings since they: • Can reduce energy demand while increasing the building sector's energy efficiency; and • Use renewable energy sources like solar, wind, and biomass, as well as smart technologies like sensors, to improve energy performance and lower energy costs.
	Goal 11: Sustainable cities and communities	• Green buildings can improve the resilience and sustainability of the urban environment. • They also help to reduce the urban heat island effect, improve air quality, reduce flood risk, conserve water resources, and support urban biodiversity and ecosystem services.
	Goal 12: Responsible consumption and production	• Green buildings can adopt the principles of circular economy and reduce waste generation and resource consumption of the building sector. • They can use materials that are long-lasting, recyclable, renewable, and low impact, as well as strategies such as reuse, refurbishment, recycling, and recovery, to reduce their environmental footprint and maximise resource efficiency.
	Goal 13: Climate action	• Green buildings reduce the greenhouse gas emissions of the building sector, which is projected to rise by 50% by 2050 under the current scenario[9]. • They can also adapt to changing climate conditions and increase the built environment's resilience to the effects of extreme weather events such as heat waves, droughts, floods, and storms.
New Urban Agenda	Paragraph 53	• Green buildings can reduce carbon emissions and lower costs, making them more energy efficient and environmentally friendly.

[9] https://wbdg.org/design-objectives/sustainable

		• They help to clean the air, reduce pollutants in neighbourhoods and make cities more liveable. • They can promote the health and well-being of building inhabitants, representative of a healthy ecosystem
	Paragraph 63	• Green buildings integrate water-efficient technologies and practices in their design, construction and operation. This helps help to conserve water, protect the environment and support the goals of the New Urban Agenda (NUA)
	Paragraph 64	• Green buildings can contribute to the reduction of cities' carbon footprints, improve air quality and reduce vulnerability of urban centres and their inhabitants to the adverse impacts of climate change and other human made disasters as stated in paragraph 64.
	Paragraphs 71; 79 and 88.	• Green buildings make significant contributions to achieving the objectives outlined in paragraph 71 of the New Urban Agenda by prioritising sustainable resource management, waste minimisation, reduction of hazardous chemicals and air pollutants, noise reduction, ecosystem conservation and restoration, and the principles of the circular economy. • They play a crucial role in creating environmentally responsible and sustainable urban environments and supporting the transition to a more resilient and sustainable future.
Global Policy Principles for a Sustainable Built Environment	Carbon Principle	• Green buildings seek to reduce carbon emissions associated with the entire building life cycle, from material extraction to construction, operation, and decommissioning. • They also encourage the use of renewable energy sources and energy-efficiency technologies to achieve net zero or even net positive carbon performance.
	Resilience Principle	• Green buildings are resilient to the impacts of climate change, such as extreme weather events, flooding, heat waves and water scarcity. • Green buildings also enhance the adaptive capacity of the occupants and the community by providing safe, comfortable and healthy spaces that can cope with disruptions and shocks.
	Circularity Principle	• Green buildings use a circular economy approach that reduces resource consumption and waste generation.

		• They also maximise the reuse, recycling, and recovery of materials and components, as well as the life span and functionality of buildings.
	Water Principle	• Green buildings save water and improve water quality by incorporating water-saving technologies, rainwater harvesting, greywater recycling, and wastewater treatment systems. • They protect and restore the natural water cycle and ecosystems, and prevent water pollution and flooding
	Biodiversity Principle	• Green buildings protect and enhance the biodiversity and ecosystem services of the surrounding environment by avoiding or mitigating the negative effects of building activities such as habitat loss.
Green Building Principles: The Action Plan for Net Zero Carbon	Principles 1–10	• Green buildings can contribute to the achievement of the goals of the Green Building Principles: The Action Plan for Net Zero Carbon by adhering to the 10 principles and implementing efforts to minimise their carbon footprint, enhance their renewable energy supply, and offset their remaining emissions. By increasing indoor air quality, thermal comfort, natural lighting, and acoustic performance, green buildings can help to improve human health and well-being as well as environmental quality. • Green buildings can also provide social and economic benefits such as job creation, reduced energy costs, and increased property value. • Green buildings can demonstrate their leadership and commitment to global climate action and the United Nations Sustainable Development Goals by adopting the Green Building Principles.

5.2.2 Regional Context: African Policies

At the regional level, the relevant policies that are pertinent to Green Buildings include Agenda 2063; Common Market for East and Southern Africa (COMESA) Regional Strategy on Renewable Energy and Energy Efficiency (2019–2030); and Southern Africa Development Community (SADC) Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP) (2016–2030)

Table 3: Regional policies: African Perspectives.

Policy	Provisions	Comment/Analysis
COMESA Regional Strategy on Renewable Energy and Energy Efficiency (2019–2030)	The policy aims to promote the development and deployment of renewable energy and energy efficiency technologies and practices in the COMESA region, which comprises 21 countries in East Africa, Southern Africa and the Indian Ocean[10]	• Green buildings utilise renewable energy sources like solar panels, wind turbines, and biomass to generate electricity or heat, reducing their reliance on fossil fuels and lowering greenhouse gas emissions. • Green buildings can enhance energy performance by implementing high-efficiency appliances, improved insulation, smart meters, and demand response programs, thereby reducing energy consumption and costs. • Green buildings utilise sustainable materials, water conservation practises, and waste management to minimise environmental impact and minimise water use and waste generation.
The SADC Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP) (2016–2030)	The Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP) 2016–2030 aims to provide reliable energy data to help governments and the SADC Secretariat make informed decisions on the upscale of renewable energy, energy efficiency, and access to energy. • Strategy and Action Plan proposes performance indicators to assess the status of renewable energy, energy efficiency, and access to energy in the region. • The Strategy and Action Plan also establishes a monitoring and evaluation system to track progress towards the achievement of SADC's goals and objectives.	• The Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP) 2016–2030 suggests the establishment of green building councils to promote renewable energy and energy efficiency in the built environment. • The Strategy and Action Plan also recommends the development of mandatory and voluntary building codes to regulate the market and set minimum requirements for energy usage in new buildings. Therefore, the provisions of the plan aim to facilitate the adoption of green building practices and technologies. • The provisions of the plan aim to facilitate the adoption of green building practices and technologies. By promoting the use of renewable energy and energy-efficient technologies in buildings, the plan aims to increase energy access and security, reduce energy costs, and mitigate the negative environmental impacts of energy consumption. • Green buildings can contribute to the success of the plan by reducing energy consumption, promoting the use of renewable energy, and improving energy efficiency in the built environment.

[10] Armenia 2022 – Analysis – IEA

Agenda 2063	Sets out the aspiration of African countries to focus on sustainable development.[11]	• The implementation of green building practices aligns with these goals by promoting resource efficiency, reducing the impact on the environment, and improving the quality of life for the people living and working in these buildings.

5.3 Legal and regulatory analysis: Zimbabwe

Table 4: Local policies and legal/regulatory frameworks.

Policy/Regulation	Provisions	Comment/Analysis
The Constitution of Zimbabwe (Amendment No. 20 of 2013)	Section 73: the provision gives every person (natural and juristic person) the right to: a) an environment that is not harmful to their health or well-being; and b) (b) to have the environment protected for the benefit of present and future generations, through reasonable and legislative and other measures that. (i) prevent pollution and ecological degradation. (ii) promote conservation. (iii) secure ecologically sustainable development and use of natural resources while promoting economic and social development.	• The section provides a strong legal foundation for environmental protection and the promotion of green buildings. • This includes measures to prevent pollution and ecological degradation, promote conservation, and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. • The provision also suggests a dedication to environmentally friendly building and infrastructure development methods. It implies that environmentally harmful building practices should be avoided in favour of better health and well-being. This implies that the construction industry should use integrated waste management, efficient water systems, and energy-saving technologies. • It also entails clean cooking in residential and non-residential places.

[11] https://au.int/en/agenda2063

Policy/Regulation	Provisions	Comment/Analysis
		• Although the Constitution does not promote the right to shelter, this right is impliedly promoted in terms of section 73 of the Constitution. • The term 'environment' includes a place where people live and work from. Section 28 calls upon the 'State and all institutions of government at every level must take reasonable legislative and other measures, within the resources available to them, to enable every person to have access to adequate shelter.' • Even though this provision is not legally enforceable, shelter was adopted as part of a national objective that influences the formulation of national policies, laws, by-laws and standards to promote the right to shelter in a progressive manner. • This provision has influenced the adoption of the National Human Settlements Policy (2020). • Both this provision and the National Human Settlements Policy (2020) will give guidance in the development of Green Building Standards and revised Model Building By-laws for provincial, metropolitan and local councils.
	Chapter 14 of the Constitution provides for Provincial and Local Government.	• Devolution of power from central level to provincial and district levels is provided for in terms of section 264. • One of the principles that bind these provincial, metropolitan and local councils is the principle to secure the public welfare. Green Building Standards are inferred in this principle. • Similarly, these standards are implied in the planning functions of these councils. Section 267 gives the local authorities a mandate to 'make by-laws, regulations or rules for the effective administration of the areas for which they have been established' in terms of the Urban Councils Act, and Rural District Councils Act. • Section 270 outlines the functions of provincial and metropolitan councils to include 'planning and implementing measures for the conservation, improvement and management of natural resources in its province; (…) and exercising any other functions, including legislative functions, that may be conferred or imposed on it by or under an Act of Parliament.'[12]

[12] Constitution of Zimbabwe, Section 270 (1)(c) and (f).

Policy/Regulation	Provisions	Comment/Analysis
Vision 2030	The vision has four pillars. Key to green buildings is the infrastructure pillar.	• The infrastructure pillar in Zimbabwe aims to enhance the quality and efficiency of physical and digital infrastructure, including roads, bridges, railways, airports, dams, power plants, telecommunications, and internet. In this respect, green buildings can contribute by reducing energy consumption, water use, greenhouse gas emissions, waste generation, and operating costs, while improving indoor air quality, comfort, productivity, and resilience.
National Development Strategy 1 (2021–2025): Towards an Upper Middle-Income Economy by 2030.	The NDS1 has 14 national priorities, one of which is environmental protection, climate resilience and natural resource management.[13] This includes strategies to restore and conserve natural resources, such as forests, wildlife, wetlands and soils, and combat land degradation, deforestation, and biodiversity loss. It also includes strategies to strengthen the environmental governance and regulatory framework and ensure compliance with the Environmental Management Act and other relevant laws and standards.	• Green buildings contribute to the goals of the NDS by promoting the use of renewable energy sources, such as solar, wind, hydro and biogas, and increasing the share of renewable energy in the national energy mix. • Green buildings also support the NDS' objective of restoring the country's natural resources like forests, wetlands, combating land degradation by using sustainable building materials, such as recycled, reused, or renewable materials, and minimising waste generation and pollution.[14] • Green buildings are guided by the principle of designing for durability, flexibility and recyclability and ensuring proper disposal or reuse of building materials at the end of their life span. This enhances the management of solid and liquid waste as enshrined in the NDS 1.
The Climate Policy	The Policy guides Zimbabwe to meet its NDCs to the UNFCCC and Paris Agreement and creates resilient communities. It acknowledges that urban and rural areas are both vulnerable to climate variability and change.	Climate change mostly affects rural areas because of their overdependence on natural resources, which are also highly climate-sensitive, whilst increased migration to urban areas puts pressure on the available resources and infrastructure in the urban areas. The Policy seeks to build a climate-resilient and low-carbon Zimbabwe. It recognizes the need to address loss and damage associated with climate change. It calls for the development of measures to address this issue.

[13] National Development Strategy 1

[14] https://sustainablyforward.com/advantages-of-green-buildings/

Policy/Regulation	Provisions	Comment/Analysis
National Climate Change Response Strategy	Some of the key provisions of these documents are to: • Promote a climate-resilient and low-carbon development pathway for Zimbabwe, in line with the national development agenda and the SDGs. • Outline the institutional arrangements, monitoring and evaluation mechanisms, and resource mobilisation strategies for national climate change response; and • Outline the country's commitment to reduce its greenhouse gas emissions through the Intended Nationally Determined Contribution (INDC) and NDCs.	The provisions of the National Climate Policy and the National Climate Change Response Strategy provide a good basis for the development of green building standards and regulations for the following reasons: • Green buildings, as a low-carbon development strategy, contribute to climate change mitigation and the achievement of INDC targets by reducing energy consumption and greenhouse gas emissions. • Green buildings improve climate resilience by incorporating features like thermal insulation, shading, rainwater harvesting, and renewable energy sources. These improvements enhance comfort, health, and safety, reducing occupants' dependence on external resources.
The National Water Policy (2013)	The Policy promotes water conservation and efficiency.	The Policy recognizes climate change as a cross-cutting issue in water resources management. It also recognizes the potential impact of climate change on planning for future investments and ensuring the resilience of existing investments.
National Renewable Energy Policy (NREP) (2019).	The NREP aims to promote the development and sustainable exploitation of renewable energy sources such as solar, hydro, biomass, wind and geothermal. It sets out the vision, goals, objectives, targets and strategies for the renewable energy sector in Zimbabwe.	• The aims of the policy present opportunities to consider the adoption of frameworks, regulations and strategies for green buildings adoption. It is important to note that this Policy is due for revision. • It is envisaged that the revised policy will address emerging issues such as clean energy for cooking, decarbonisation of the economy, low emissions development, circular economy, e-waste, waste-to-energy, and energy-water-food nexus that are pertinent for gender groups such as women in energy transition.

Policy/Regulation	Provisions	Comment/Analysis
		• The Policy aspires to 'install more than two hundred and fifty thousand (250,000) solar geysers in old (as retrofits) and new buildings by the year 2030'.[15]
The National Energy Policy (2012)		It states that the 'Government will emphasise the adoption of energy-demand management and the implementation of energy-conservation measures in institutional buildings and in Government departments.'[16]
The Zimbabwe Long-term Low Greenhouse Gases Emission Development Strategy (2020–2050)	The Strategy provides for a clear, economy-wide low-emission development pathway for Zimbabwe.	The Government of Zimbabwe developed the long-term Low Greenhouse Gas Emission Development Strategy (LEDS). A positive aspect noted is that the LEDS was developed through a consultative process that involved the participation of government departments and state-owned enterprises, development agencies, research and academic, private sector, CSOs and women and youth organisations. However, the strategy is silent on gender and social inclusion issues.
National Environmental Policy (2009)	The Policy provides for the sustainable management of natural resources and protection of the environment; the prevention of pollution and environmental degradation; and the integration of environmental considerations into economic and social development.	The National Environmental Policy of Zimbabwe provides a basis for the adoption of green buildings in several ways. • The policy outlines the government's commitment to promoting the development and implementation of environmental standards and codes of practice for building construction and maintenance. • The policy outlines the government's commitment to promoting sustainable building materials, waste management, and water conservation through the development and dissemination of appropriate technologies.
Human Settlements Policy	Section 2.8: Legal and Regulatory Framework.	The sections make policy proposals that present opportunities for the adoption and implementation of green buildings.

[15] The National Renewable Energy Policy (2019), p 7.

[16] The National Renewable Energy Policy (2019), p 7.

Policy/Regulation	Provisions	Comment/Analysis
	• Subsection 85 • Subsection 86	• Subsection 85 recommends that there is need, among others, to review relevant Acts that govern the development and management of human settlements. This can lead to the introduction of new regulations and guidelines specifically aimed at promoting green buildings. • The provisions of subsection 86 create an opportunity for the development of standard Model Building By-Laws, along with the continual review and updates, can provide a framework for local authorities to adopt and implement green building practices consistently.
	2.9: Urban regeneration and renewal	This policy proposal provides opportunities to introduce green buildings through regeneration and renewal projects.
	2.11: Institutional arrangement for the policy	• This policy provision recommends the creation of relevant portfolio to the planning, development, and management of sustainable human settlements. • It also recommends for coordination with national and international institutions to ensure consistency of legislation. • This provision creates opportunities to address the institutional gaps that are likely to exist in the adoption, implementation, and enforcement of green buildings.
	Section 2.14: Environment, climate change and new building technology	This provision acknowledges the importance of observing protocols relating to the environment and climate change, for the promotion of green energy buildings[17] and for investment in climate proofing building technology[18].
	Covers Environment, Climate Change and New Building Technology	The Policy recognises that: • Absence of robust regulatory instruments such as By-laws resulting in climate-induced disasters; • Poor planning and governance of settlements have increased the people's vulnerability to extreme weather conditions such as floods. • There are no 'early warning systems, disaster response capabilities and established recovery-development pathways' for settlements.[19]

[17] Zimbabwe Human Settlement Policy (section 2.14 subsection 112)

[18] Zimbabwe Human Settlement Policy (Section 2.14 subsection 113)

[19] Ibid, p 51.

Policy/Regulation	Provisions	Comment/Analysis
		The National Housing Settlements Policy calls for the planning, development, and management of settlements to be aligned with national and international disaster risk reduction frameworks such as the Sendai Framework for Disaster Risk Reduction (2015–2030) as well as environmental and climate change policies, laws and standards.[20] The Policy promotes green energy buildings. In addition, 'Investment in climate proofing building technology will help to build resilience and sustainability without overlooking affordability. Thus, research and development become imperative in building technologies and methods.'[21] The Policy calls upon a close working relationship between 'state institutions that lead on environmental and climate change policies, laws and standards.'[22]
Revised NDC (2021)	In 2021, Zimbabwe revised the NDC, representing an ambitious 7% increase in emissions reduction from 33% in the first NDC to 40% in this revised NDC.	The NDCs outline the country's commitments to addressing climate change and its strategies for reducing greenhouse gas emissions and adapting to the impacts of climate change. Zimbabwe's NDC include both mitigation and adaptation measures. Unlike the first NDC covering only the Energy Sector, it progressed towards an economy-wide NDC, including the Waste, Industrial Processes and Product Use (IPPU) and the Agriculture, Forestry and Other Land-Use (AFOLU) Sectors. Zimbabwe's updated NDC considers its low GHG emissions per capita and substantial vulnerability to the impacts of climate change. The Revised NDC presents adaptation action in response to the country's high vulnerability to climate change impacts. The 2021 Revised NDC recognises that one of the impacts of climate change is reduced hydroelectric power output from the energy sector. The NDC report identifies the co-benefits of mitigation measures, including: Increased uptake of biogas will lead to improved air quality, health and gender outcomes; Increased composting and waste-to-energy processing will result in employment creation and reduced pollution to soil and water bodies; and Increased energy efficiency, reduced transmission and distribution losses and increased electricity supply from solar and waste-to-energy projects will reduce supply constraints and reliance on climate-sensitive hydropower. This underscores the fact that Zimbabwe is committed to a just transition to a climate-resilient and low-carbon economy.

[20] Ibid.

[21] Ibid, p 52.

[22] Ibid.

Policy/Regulation	Provisions	Comment/Analysis
Environmental Management Act (Chapter 20:24)	Section 4: Environmental rights and principles of environmental management	Key principles are sustainable development and environmental rights (rights of present and future generations) precautionary approach, preventive principle, polluter pays principle, community participation and good neighbourliness. The provision provides a basis for adopting green buildings and the need to develop standards and legal frameworks to protect them because of green buildings: • Promotes environmental rights such as the right to health, right to access to information, right to environmental justice and right to legal remedies. • Helps to mitigate the effects of climate change and improve air quality. • Helps to prevent water scarcity and contamination and protect aquatic ecosystems. • Preserves natural resources and reduce landfill and toxic emissions. • Helps to prevent respiratory diseases, allergies, and other health problems, and to enhance productivity and well-being. • Mitigates potential environmental risks.
		Section 4 of the Act is pertinent in the development and implementation of the ZERA Code, Green Building Standards and Building By-laws. The functions of the Minister of Environment, Climate and Wildlife are outlined in section 5. Some of the functions that are relevant to this ZERA Code, Green Building Standards and Building By-laws are: *'(a) to regulate the management of the environment and to promote, co-ordinate and monitor the protection of the environment and the control of pollution; and* *(b) to regulate the activities of all government agencies and other agencies to the extent that their activities impact on the environment; (…).'*[23]
	The Act overrides all other statutes in relation to environmental issues in terms of section 3.	This means it has overriding effect on other laws that including the Zimbabwe Energy Regulatory Authority (ZERA) Code and Building By-laws. Section 4 provides for environmental rights that include *'Every person has the right to an environment that is not harmful to their health or well-being'* as well as protection from pollution and environmental degradation.

[23] Environmental Management Act, Section 5(a) and (b).

Policy/Regulation	Provisions	Comment/Analysis
		It is aligned with section 73 of the Constitution of Zimbabwe which promotes improved air quality and clean environment. It impliedly promotes the right to shelter.
	Sections 5, 10, and 65.	These set out the institutional frameworks for the protection, management and enforcement of environmental laws and regulations. For example: • The Environmental Management Agency EMA has the mandate and authority to promote and enforce green building standards and practices through the environmental impact assessment process, quality standards and the licensing system. • The institutional provisions of the Act provide a mechanism for the EMA to monitor and regulate the implementation of the project, and to ensure that it adheres to the green building standards and practices. • The EMA's roles include enforcing and sanctioning developers who violate green building standards and practices, as well as protecting the environment and the public.
	Sections 4, 97–100.[24] Schedule 2 of the Act.	• These provisions provide for mandatory EIAs for housing developments; Tourist, resorts, and recreational developments– (a) resort facilities and hotels. • (b) marinas; (c) safari operations; Tourist, resorts, and recreational developments – (a) resort facilities and hotels; Waste treatment and disposal; and water supply. • Sections 4, and 97–100 provide a legal basis for evaluating the environmental and economic performance of a project, ensuring it incorporates green building principles and technologies like energy efficiency, water conservation, waste management, and indoor air quality.
	Section 140 empowers the Minister in consultations with other Ministries, Departments and Agencies to make regulations.	This provides for enactment of regulations on: 'aa. regulating or restricting the installation or provision of heating or cooking facilities in buildings and prohibiting the installation in any building of any appliances other than types of appliances specified in the regulations or any appliances which do not comply with such requirements as may be prescribed in the regulations.'

[24]Statutory Instrument 7 of 2007, Environment Management Act (Environmental Impact Assessment & Ecosystems Protection) Regulations, 2007.

Policy/Regulation	Provisions	Comment/Analysis
The Energy Regulatory Authority Act (ZERA) (Chapter 13:23)	ZERA Act provides for the establishment of the ZERA	The mandate of ZERA is to regulate the procurement, production, transportation, transmission, distribution, importation, and exportation of energy derived from any energy source. It sets energy prices and tariffs and licences on-grid and off-grid IPPs.
Regional Town and Country Planning (RTCP) Act (Chapter 29:12)	Section 10	Section 10 (1) empowers the municipal councils, town councils and rural district councils or local boards as the 'local planning authorities' for the areas under their respective jurisdictions and clearly defines their roles and responsibilities. Section 10 empowers 'every municipal council or town council for the area under its jurisdiction' as a local planning authority'.
	Section 6; 14, and 17 provides for the preparation of Regional, Master and Local Plans respectively.	Regional, Master and Local Plans can specify standards and guidelines for the design and construction of buildings, including green buildings in the planning area. Therefore, the sections provide a legal basis for the adoption, implementation, and enforcement of green buildings.
	Section 14	It provides for a Master Plan whose measures include 'the regulation of the use of land and the construction and use of buildings.'[25] During the development of the Master Plan, the local planning authority 'shall consult with neighbouring local planning authorities and local authorities and any other statutory or other body whose activities or plans may affect the master plan, with the object of ensuring coordination of policies; (…). This means statutory bodies such as the Environmental Management Agency and ZERA are supposed to be consulted.
	Section 25; 26; 30; 32 and 34. These sections empower the Minister to make development orders, grant permits for the development or use of land or buildings, make building preservation orders for the preservation of any building, make enforcement orders for	• Development orders may prescribe standards and requirements for the design and construction of buildings. This can include green buildings. • The Minister or planning authority may impose conditions on the grant of a permit, including conditions relating to the design and construction of buildings, such as green buildings, in accordance with the relevant regional plan, master plan, local plan or development order.

[25] Section 14(2)(a)(i)

Policy/Regulation	Provisions	Comment/Analysis
	the prevention of any development in contravention of the RTCPA or any Regional Plan, Master Plan, Local Plan, development order or permit and make prohibition orders for the prevention of any development that is likely to be detrimental to the physical environment.	• A building preservation order may also prescribe standards and requirements for the maintenance and repair of the building, including the use of environmentally friendly materials and techniques. • Enforcement orders may require the owner or occupier of the land or building to stop the development or use, or to restore the land or building to its previous condition, or to carry out any works or take any steps necessary to comply with the RTCPA or any regional plan, master plan, local plan, development order, permit, building preservation order or tree preservation order, within a specified period. • A prohibition order may also prescribe standards and requirements for the design and construction of buildings, including green buildings, in the area.
Urban Councils Act (Chapter 29:15) and Rural District Councils Act (Chapter 29:13)	Section 232 of the Urban Councils Act and section 93 of the Rural District Councils Act empower the councils to make model building by-laws for the regulation and control of buildings, including the standards and specifications of materials, design, construction, alteration, demolition, and maintenance of buildings.	• The by-laws are required to provide for the promotion of energy efficiency, water conservation, waste management and environmental protection in buildings.
	Section 141 of the Urban Councils Act and section 66 of the Rural District Councils Act authorise the councils to appoint building inspectors who are responsible for inspecting and certifying the compliance of buildings with the by-laws and any other applicable laws and regulations.	• The building inspectors are supposed to issue notices, orders and directions to remedy any defects or violations in buildings and may take legal action against associated violations.
	The Urban Councils Act and the Rural District Councils Act empower councils to establish and maintain	• The councils are required to charge fees and levies for the services provided by the building inspectors and the building control funds.

Policy/Regulation	Provisions	Comment/Analysis
	building control funds, which are used for the administration and enforcement of the building by-laws and regulations.	
Model Building By-laws in terms of the Urban Councils Act (Chapter 214) section 183 and section 83A of the Rural Councils Act.	Parts 3, 4, 5, and 6.	The following parts of the Model building By-laws are important in the adoption, implementation and enforcement of green buildings in that they: • Provide an outline for the general requirements for building design and construction, which include complying with the relevant standards and codes of practice, incorporating passive design strategies, using appropriate materials and technologies, optimising the use of natural resources, reducing waste generation and emissions, and ensuring accessibility and safety for all users. • Outline technical requirements for building services, ensuring energy, water, ventilation, lighting, heating, cooling, fire protection, security, and communication systems, integrating renewable energy sources and smart technologies. • Outline building operation and maintenance requirements, including ensuring building functionality, conducting regular inspections, implementing preventive measures, and adopting best practices for management and occupant behaviour. • Outline building operation and maintenance requirements, including ensuring building functionality, conducting regular inspections, implementing preventive measures, and adopting best practices for management and occupant behaviour.
Housing and Building Act (Chapter 22:07)	Part 2, Sections 4, and 5	• These provisions discuss the establishment of Housing and Guarantee Funds, and the powers of the Minister to guarantee certain loans, advance money to purchase and let dwellings. • This addresses the funding challenges that are often associated with green buildings' construction as shown through the review of literature on green buildings (Chigwenya & Zhakata, 2020; Mafuku, 2019).
	Part 4, Sections 14, and 15	• The Act empowers the Minister to construct buildings. It establishes housing and guarantee funds.

Policy/Regulation	Provisions	Comment/Analysis
		• These provisions provide for the establishment of Building Funds and the powers of the Minister to construct dwellings and other buildings, provide essential services and conduct experimental projects related to the construction of dwellings and other buildings. • This aids in addressing the research and development aspect that assist in identifying the most suitable designs, materials and structures for green buildings for different localities.
Housing Standards Control Act (Chapter 29:08)	The Act provides for, inter alia, "the repair, demolition or closure of buildings of an unsatisfactory standard; to provide for the abatement of overcrowding of dwellings; to control the harmful use or occupation of premises and the undue interference with the rights of the residents of a neighbourhood; (…)."	• The Act does not provide for green buildings.
Town Planning Standards	Layout Design Manual	• The Town Planning Standards are relevant to the building industry. • They cover areas such as: subdivision, height restriction, land use, zoning, and minimum dimensions of the land where construction will take place. In addition, 'The plot should ideally contain adequate space for constructing a basic structure, future expansion and gardening and or recreation.'[26] • The manual provides guidelines and standards for the planning and design of urban and rural settlements in Zimbabwe. One of the key provisions that have a bearing on the implementation of green buildings is the guideline on the orientation of blocks of stands. • It encourages orientation of blocks of stands in a way that allows buildings to be oriented to capitalise on natural lighting and ventilation, which is a key aspect of green buildings.

[26]Mohammad Sharif Zami & Angela Lee. THE INFLUENCE OF HOUSING STANDARDS IN THE DEVELOPMENT OF LOW-COST SUSTAINABLE HOUSING IN ZIMBABWE, p 339. Research Institute for the Built and Human Environment, University of Salford.

Policy/Regulation	Provisions	Comment/Analysis
Town Planning Circular 70 of 2004	Introduced new planning and construction standards for infrastructure and houses in all urban areas. 'Walls can be constructed of burnt clay brick or block, cement bricks or blocks and stabilised soil bricks or blocks. Burnt farm bricks, as approved by the Department of Public Works, can be used for the construction of single-storey buildings. Recommended roofing materials include asbestos sheets, clay tiles, and zinc.'[27]	• One of the key aspects of the Circular that speaks to green buildings is the section on construction materials[28]. The materials listed include burnt farm bricks. These are good for green buildings since: • They are durable and can last for a long time without requiring much maintenance. • They have good thermal mass, which means they can store heat and release it slowly, reducing the need for artificial heating and cooling. • They are recyclable and biodegradable, which means they can be reused or disposed of without harming the environment. • They are locally available and can be produced using low-cost and low-energy methods, reducing the carbon footprint of transportation and manufacturing.
The National Gender Policy (2013 – 2017).	Has a pillar on Gender, Environment and Climate Change.	The policy is silent of green buildings and housing. Some of the policy strategies that cover aspects of green buildings include: • Educate and popularise the constitutional provisions on environmental rights and implement initiatives to actualise them. • Review the current environment and natural resources management, sustainable energy, climate change water and sanitation policies and strategies and audit for gender considerations, identify gaps, and incorporate gender perspectives. • Build the capacity of state and non-state development agencies in gender mainstreaming in environment, climate change and sustainable energy policies, programmes and national action plans and budgets. • Institute mechanisms to increase the participation of men and women, boys and girls, in the sustainable utilisation of natural resources for economic benefits including opportunities for carbon trading.

[27] Specifics on Circular Number 70 of 2004.

[28] Section 3.1.4 (a) Circular No. 70 of 2004

Policy/Regulation	Provisions	Comment/Analysis
		• Popularise the green economy and carbon trading initiatives and other alternative forms of energy and related technologies. • Ensure national level strategies for climate induced disaster management and risk reduction and coping mechanisms are gender responsive.

5.3.1 Gender considerations

In Zimbabwe, gender mainstreaming and integration in buildings has been limited and due to lack of awareness and low representation of women as players and beneficiaries in the built environment sector. Subsequently, there has been too few policies that recognise women as key stakeholders in building projects and energy use. Women and girls are overwhelmingly more likely to be affected by poor thermal comfort and indoor air quality since most of the household chores are performed by women in Zimbabwe.

The country aims to promote gender equality and women's empowerment hinged on national gender policies, climate change policies, Vision 2030 (NDS1 & 2), The revised National Gender Policy (2017) provides a national guiding framework for mainstreaming gender across all sectors. Under the Thematic area Gender, Environment and Climate Change, the policy objective is to increase gender responsiveness of national policies and strategies on environment and natural resources management, sustainable energy and climate change adaptation and mitigation as gender considerations in these and other sectors are limited. The Zimbabwe Human Settlements Policy (2020) seeks to frame the attainment of all Sustainable Development Goals (SDGs) based on its focus goal of well-planned and governed settlements. The Policy highlights that settlement planning and design will be based on a criterion which includes environmental stewardship/sustainability and resilience amongst its criteria. The two policies do not, however, speak to consideration of gender in buildings.

The international policy framework for improving gender considerations in buildings is anchored on Sustainable Development Goal 5 and Africa's Agenda 2063. From the Climate conference of parties in 2023(COP26) targets, energy efficiency of buildings is to improve by 30% by 2030 and gender needs will need to be accounted for to reach this target. Green architecture can help protect women's health and wellbeing by creating energy efficient and climate resilient and sustainable buildings. Improved health and safety – green buildings prioritize indoor air quality, natural lighting, and the use of non-toxic materials. Zimbabwe's green building code should, therefore, aim to raise the level of gender awareness, change attitudes, and inculcate an engendered work culture among stakeholders in the built environment value chain.

5.3.2 The energy efficiency regulatory framework

The use of energy and maximizing the efficiency of energy use is a key element of green building policies and programmes from the construction techniques and materials to the operation and appliances used in buildings. Some of the more notable ways in which buildings can reduce energy demand include:

- Implementation of effective design to passively optimize thermal energy (cooling and heating) flows between the building and the surrounding environment. This focuses on minimizing or maximizing cooling or heating gains and losses.
- Improved design buildings to optimize energy demand of the operation of buildings, including lighting, internal movement, and appliance demand.
- Use of effective building insulation.
- Installation and use of energy efficient equipment such as air conditioning.
- Installation of use of renewable energy to offset demand from the building.

In Zimbabwe, there are no regulatory frameworks that directly guide/require the implementation of Green Buildings, although there are some regulations and laws that support the implementation of energy efficiency and renewable energy in buildings including:

1. **Statutory Instrument (SI) 2018 - 86 Electricity (Net Metering) Regulations (2018) -** The Regulations came into effect in 2020. This instrument allows for commercial, agricultural, and domestic customers that have PV installations sell excess solar power to the Zimbabwe Electricity Transmissions and Distribution Company (ZETDC) to feed into the grid.

2. **SI 38 of 2022, Electricity (Net Metering) (Amendment Regulations, 2022 (No. 1) -** The Regulations allow individuals and corporations to feed back up to 5 MW of their excess electricity into the grid.
3. **The SI 2019-235 Electricity (Solar Water Heating) Regulations (2019) -** The Electricity (Solar Water Heating) Regulations, 2019, regulate the installation, licensing, operation, repair, maintenance, retrofit and upgrade of solar water heating systems for the production of sanitary hot water to save electricity. It mandates all new and old houses to have a solar water heater connected [unless technically not possible] as a precondition to the house being connected to the national grid. This can attract private companies to invest in solar systems.
4. **SI 103 of 2008 Electricity (Licensing) Regulations (2008) -** The SI provides for licences for generation, transmission, distribution, and application electricity more than 100 kilowatts (KW). These licences are for IPPs who generate, transmit and bulk supply and distribute electricity either on-grid or off-grid.
5. **Energy Efficiency Policy and Regulations** – The government of Zimbabwe is currently developing an Energy Efficiency Policy and Regulation. These will aim to promote efficient utilisation of electricity generated by off-grid systems.

5.4 Regulation of the Building Sector in Zimbabwe's Urban Areas

The management and enforcement of the building sector is done at a local level by the relevant government ministries, departments and agencies, and local authorities. The local authorities have power to designate the standards that guide construction which are informed local by-laws. Currently, building regulation focus on the development of safe and durable buildings with little consideration for the ease of operation, the social and environmental footprints, or the climate performance.

The various tools and approaches that are used to regulate the building sector in Zimbabwe are discussed below.

Table 5: Regulation of the building sector in Zimbabwe's urban areas

Regulatory means	Key aspects in relation to building sector regulation
Stipulating building standards	This involves the designation of building standards through the Model Building By-Laws by the local authorities. Circular No. 70 of 2004 plays a crucial part in this process by setting the minimum standards that have a bearing on human settlements including building design and construction material. Key among these is allowing farm bricks to be used for building construction in urban centres.
Approvals and Consents	The approval process is one way of regulating the building sector. It comes before any construction work commences. The building is approved for its satisfaction of requirements on the floor plan design, plumbing and structural aspects. Materials are not a major consideration during the approval phase of the construction.
Monitoring Housing Development	This process involves setting out the rules and guidelines that must be followed during the construction of buildings. In Zimbabwe, the building inspectorate department of the local authorities monitors the various stages of the building construction process. The building is monitored for safety, structural integrity, and urban planning principles. Health and sanitation are also crucial aspects that are monitored during the construction process of a building. These include provisions related to waste management, drainage systems and ventilation.

The local authorities are responsible for the inspection, approval, enforcement, and penalisation for non-compliance with the building regulations. The penalties vary depending on the specific violation and the severity of the non-compliancy and the discretion of the local authority responsible for enforcement.

The regulatory means summarised in the table 4 represents an ideal scenario, while in reality there are varying approaches to the regulation of the building sector depending on the local authority, their resources and expertise. It is generally believed that the existing building regulations are weakly enforced due to low availability of experience personnel, weak administrative infrastructure, strong incidence of informal settlements, low political will, and corruption.

Similarly, the policies that allow parallel development practices in buildings, especially in the housing sector, have usually negative implications on the regulation of the building sector (see Mutsindikwa et al., 2021). As such, some buildings can be constructed without being monitored and inspected by the local authorities, or with limited oversight as complex project can be carried out in parallel.

5.5 Buildings policy and regulatory enforcement in Zimbabwe

5.5.1 Enforcement of Existing Regulations in the Building Sector: An Assessment

The enforcement of existing building sector regulations has been fragmented and faces significant challenges around the need for resources, expertise, and experience that make enforcement of the building sector regulations difficult, although there are some success stories[29]. All local authorities have dedicated departments that are responsible for approval of building plans and subsequent inspection and monitoring of the building construction processes, although they often seem to be understaffed.

In terms of the law, the owner of the building is mandated to submit design drawings to the local authorities for approval before construction work begins. The local authorities building inspect and, if the plans meet the requirements, issues a building permit. For quality control purposes, most local authorities have a database of approved architects, engineers, masons and tradesmen for the design and erection of buildings within its jurisdiction. The permit serves as a referral document during construction, and the building must be inspected at set stages of construction. At the end of the works and before the building is ready for use, the owner must apply for a certificate of occupation to satisfy that the design and the output are in sync and safe for habitation. The local authority building inspectors are required to conduct random inspections on construction projects. This is evidenced by the low cases of accidents emanating from structural failure of buildings in most formal settlements within urban areas. It is also important to note that the enforcement of the regulations varies across towns and cities. Some areas have stronger enforcement mechanisms (plans review for permitting and inspections) and therefore, higher compliance rates while others have more significant challenges due to various factors.

Similarly, the building sector natural overlaps with several other sectors as much of human activity takes place in buildings, and the impact of buildings often goes beyond the construction sites. This includes aspects of economy, environment, human health, history, and more. As such, the regulation of the sector often involves multiple institutions and agencies such as:

- Ministries responsible for National Housing, Health, Climate, Environment and Wildlife that usually look at national level developments such as ensuring the existence of national policies, high level targets, etc.
- Entities such as the Environmental Management Authority (EMA), Zimbabwe Energy Regulatory Authority (ZERA), Zimbabwe National Water Authority (ZINWA), and local authorities – manage the impacts of buildings under the Environmental Management Act which require environmental impact assessment for a variety of building developments, or the regulation of appliances used in buildings.

[29] Chirisa, 2014. Building and Urban Planning in Zimbabwe with Special Reference to Harare: Putting Needs, Costs and Sustainability in Focus. Consilience: The Journal of Sustainable Development Vol. 11, Iss. 1 (2014), Pp. 1–26.

To effectively regulate building activities requires the effective coordination and cooperation of all these actors to ensure policy consistency and coherency as well as comprehensive enforcement. However, cooperation and coordination among the enforcing entities is weak resulting in gaps in enforcement and inconsistent application of regulations.

An assessment of the factors contributing to the fragmented nature of regulatory enforcement in Zimbabwe includes:

- **Outdated Standards**: Zimbabwe's construction industry still heavily relies on building standards developed under the British system, which have become outdated given the changes in culture, and the socio-economic and physical environments. This adherence to old standards has made the building process cumbersome and raised transaction costs, thereby affecting the efficiency and sustainability of construction projects.
- **Challenges in Enforcement and Compliance**: Zimbabwe has also faced significant challenges in the enforcement of building codes and standards. Factors such as economic hardships, bureaucratic hurdles, and corruption have impeded effective enforcement and widespread compliance.
- **Challenges with capacity and expertise**: Additionally, the lack of resources and technical capacity within enforcement agencies has contributed to these challenges, making it difficult to police construction activities across the city.
- **Low political will**: While there are prospects for sustainable construction practices including the adoption of new technologies, such as the use of polystyrene panels and hydraform blocks, which can contribute to cost efficiency and environmental sustainability. However, these initiatives remain largely experimental and have not been applied on a mass scale due to scepticism from local authorities and a lack of political will.
- **Limited collaboration among stakeholders**: The paper highlights the importance of collaboration among various stakeholders, including government agencies, the private sector, and local communities, to foster sustainable construction practices. Building the capacity of enforcement agencies, particularly the building inspectorate departments, is essential to ensure the sustainability of structures and adherence to building codes.

These barriers are commonly faced in many developing countries leading to dire consequences for construction quality, safety, and performance. These issues manifest in heightened risks to structural integrity and increased vulnerability to natural disasters, resulting in both human and economic losses. Furthermore, legal ramifications for non-compliance, alongside the socioeconomic impact of making compliant housing unaffordable for lower-income groups, exacerbate social disparities. The overall development and adoption of innovative construction technologies are also hindered, affecting countries' competitive edge and development pace. Addressing these multifaceted challenges necessitates streamlining codes, improving enforcement, curbing corruption, and adapting standards to new technologies and local needs.

5.5.2 Impact of the regulations and policies on building performance

The development and enforcement of policies and regulations play a crucial role in enhancing both the environmental and energy aspects of buildings. These guidelines set benchmarks for energy efficiency, covering new buildings and updates to existing ones. They detail requirements for things like efficient lighting, insulation, building materials, and the use of renewable energy sources. By insisting on energy-efficient building methods, such regulations lead to lower energy use, cost savings on construction and operation, and fewer greenhouse gas emissions.

The impact of regulations on building performance has not been researched or documented as no national studies on the matter have been conducted. The only indicative information was obtained from the results of the National Energy Efficiency Audit (NEEA) that was carried out in 2015 on behalf of ZERA which indicated that there are potential savings from electricity consuming sectors of nearly 380 MW or 1,393

GWh[30] (18% of national consumption)[31]. The NEEA is intended to look at the impact of legislation on this achieving energy efficiency results, but the report has not been made available. Similarly, the results of the NEEA would be largely obsolete by now as the data used would be 10 years old, or older.

In the 2022 ZERA annual report, 0.63MW worth of demand was saved on the seizure of banned products resulting from inspections carried out as part of the energy efficiency programme, 208 lighting products were verified for compliance and 127 were registered. This information indicates a reasonable level of existing experience and capacity to enforce regulatory actions on the buildings sector in the future. However, considering that the existing building regulations (Section 5.3) do address energy or carbon emissions performance directly, it is not possible to assess direct impacts.

In terms of renewable energy implementation, the government is promoting the adoption of solar water heaters and photovoltaic energy systems. But there has not been a coordinated reporting to present results. The envisaged installation of 250,000 solar water heaters on old and new buildings by 2030 has also not been well coordinated and baseline reports are not available while progress has not been tracked.

Aside from the lack of codes that directly address energy and/or carbon emissions performance from the construction or operation of buildings, the implementation and enforcement of these standards can pose challenges for economies like Zimbabwe. This is because the cost, logistics, and expertise requirements pose a challenge not only for the implementation perspective, but for the compliance, and the general market as it they raise construction costs, making housing and commercial space more expensive.

As a result of the harsh economic situation in Zimbabwe, the hyperinflationary environment experienced in recent memory, and poor credit environment, there are very few banks and building societies that have loan and mortgage lending facilities. Furthermore, the economy is becoming increasingly informal, exacerbating the difficulty for traditional finance products such as mortgages and home loans to be established in this market. When this is added to a poor compliance record with the complex building codes and laws/regulations such as EIAs requires additional time and resources, posing challenges for smaller construction firms.

Research has established that 'Urban planning standards, espoused in Zimbabwean statutes, have inhibited the majority of homebuilders and low-income families from building houses that meet the requirements of public authorities.'[32] Furthermore, the effectiveness of regulations and policies in improving building performance may vary depending on factors such as enforcement, monitoring, and public awareness. These challenges and limitations should be considered when evaluating the overall impact of laws/regulations and policies on building performance.

5.6 Existing Studies on Green Buildings in Zimbabwe

Green construction is an under-researched area in Zimbabwe. The literature review shows that two studies on green construction have been done. Mafuku (2019) carried out a study that focuses on greening the construction industry in Zimbabwe. The study evaluated the construction industry in Zimbabwe and its contribution to sustainability. The other one was carried out by Chigwenya and Zhakata (2020). The focus was on the possibility of adopting green construction technology in Zimbabwe.

Both studies revealed that the adoption of green construction is slow in Zimbabwe although there are signs of green construction as shown by the existence of buildings that are classified as green buildings such as Eastgate, Batanai Gardens, Kurima House and Chinhoyi Hospital. The studies acknowledge that the absence of a clear government policy (Chigwenya and Zhakata, 2020) on green buildings and the unavailability of tools and methods to evaluate the sustainability of buildings being constructed (Mafuku, 2019) are some of the factors contributing to the slow uptake of green construction in the country.

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[30] ZERA Annual Report 2015

[31] ZERA Annual Report 2022

[32] Innocent Chirisa (2014). Building and Urban Planning in Zimbabwe with Special Reference to Harare: Putting Needs, Costs and Sustainability in Focus, p 8. Consilience: The Journal of Sustainable Development Vol. 11, Iss. 1 (2014), Pp. 1–26.

5.7 Gaps and limitations in the current frameworks for building construction

5.7.1 Lack of comprehensive policies and laws/regulations

This review of the policy and legal frameworks in Zimbabwe that address the buildings sector demonstrates an absence of a well-defined and comprehensive policy and legal framework specifically tailored to promoting green buildings. None of the acts, regulations and policies comprehensively and intentionally address green buildings. Where aspects of green buildings are catered for, it is incidental. The lack of comprehensive policies and regulations can have several impacts such as inconsistency and uncertainty among developers, architects, and other stakeholders. This makes it difficult to understand the specific requirements and expectations for constructing and certifying green buildings. This uncertainty can lead to inconsistent practices and subsequently hinder the widespread adoption of green construction methods.

The review also revealed that the current building policies and regulations (Table 4: Local policies and legal/regulatory frameworks.) do not adequately address green buildings principles. They are not regularly updated to incorporate the advancements in sustainable technologies and practices and yet the Building Codes and Standards are crucial in ensuring that construction practices meet relevant sustainability criteria. The Model Building By-Law in Zimbabwe of 1977, has been overtaken by changes such as sustainability and climate change proofing issues that are taking place in the construction world.

In addition, the absence of comprehensive policies and regulations leads to fragmented implementation and non-enforcement of environmental planning laws. Different stakeholders may interpret and apply green building principles differently due to an absence of a unified approach. This might result in differences in the performance and quality of construction of buildings. This disarray has the potential to reduce the overall efficacy of sustainability initiatives.

One of the aspects to the success of green buildings implementation is enforcement. It was deduced that there are no enforcement mechanisms arising from the absence of a comprehensive legal and policy framework for adoption, implementation and enforcement of Green Buildings. This is further worsened by the absence of Green Buildings Standards and Regulations. As a result, there may be a lack of compliance, greenwashing (false claims of green features) and substandard practices that do not align with sustainability goals. In addition, the following specific issues were observed:

1. The Regional, Town and Country Planning Act No. 22 of 1976 is outdated and does not address emerging issues such as greenhouse gas emissions; effects of climate change through climate proofing of housing developments and buildings as required by the National Human Settlements Policy, National Climate Change Policy and NCCRS; principles of environmental management that includes the precautionary principles and EIAs; and decentralised renewable energy systems.

2. The Model Building By-laws have been criticised as:
    a. Being very rigid and outdated thereby hampering the 'smooth implementation of infrastructure development works in local authority areas.' [33]
    b. Being 'very high, rigid and not amenable to physical and climatic conditions, and not responsive to the needs and requirements of the end users.'[34]
    c. Not able to accommodate poor people from urban areas.

3. Absence of Municipal Courts.[35] The Administrative Court does not adequately deal with issues arising from municipal authorities, towns and boards regarding housing developments and buildings.

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[33] Ibid.

[34] Ibid.

[35] Kudzai Chatiza (2020). The State of By-laws and their Contributions to Urban Resilience in Zimbabwe, p 15. UNDP, Government of Zimbabwe (Ministry of Local Government and Public Works) and UNICEF.

4. The Model Building By-laws are not aligned with the Constitution of Zimbabwe and Environmental Management Act that promote environmental rights especially an environment that is not harmful to health and well-being, improved air quality and housing/buildings that are sustainable to present and future generations.
5. No periodic reviews and updates of Model Building By-laws to accommodate emerging issues such as climate change mitigation, reduction of emissions and improved air quality, waste disposal and energy efficiency.
6. The Housing and Building Act (Chapter 22:07) does not provide for Model Building By-laws and Standards.
7. Town Planning Circular 70 of 2004: Some disadvantages associated with farm bricks include environmental and wetland degradation, deforestation, sand poaching and gullies that are not rehabilitated and pose as death traps to humans and animals as well as the buildings that cannot withstand climate-induced disasters. For example, 'Some of the houses collapsed during the rainy season due to the poor quality of materials used and lack of proper planning and supervision.'[36]

Absence of improved cookstoves in District Plans and Building by-laws for local authorities: Improved cookstoves which are central to clean cooking are not part of plans and Building By-laws for local authorities. For example, the Rural District Councils (RDCs) are important strategic partners for the MoEPD because the RDCs are closer to the communities. The Ministry of Energy and Power Development is not fully decentralized hence working with the RDCs would ensure that an improved cookstoves focal person at district level is part of National Improved Cookstoves Task Force. Additionally, the Local Authorities have potential of biogas waste to be used for institutional clean cooking but is not fully explored.

To address these challenges, a comprehensive approach is needed. This should start with simplifying building codes to make them more understandable and accessible to construction professionals, thereby facilitating compliance. Strengthening institutional frameworks and increasing the capacity of enforcement agencies can ensure more effective monitoring and enforcement. Implementing transparent systems and leveraging technology for monitoring construction projects can reduce corruption and increase accountability. Additionally, promoting stakeholder involvement in the development and periodic review of building codes can ensure they remain relevant and incorporate advancements in construction technology. Education and training programs for builders, architects, and engineers on the importance and application of building codes are crucial for building a culture of compliance.

5.7.2 Limited Institutional Capacity and Technical Expertise

The building and construction sector institutions, such as local authorities, regulatory bodies, and professional associations, have limited capacity and expertise to effectively promote, implement, and enforce green building practices. This includes a shortage of trained professionals, inadequate knowledge about green building technologies and techniques as well as renewables and energy efficiency, inadequate planning for clean cooking, and limited resources for capacity building initiatives.

5.7.3 Insufficient Coordination and Collaboration of Various Stakeholders

Inadequate coordination and collaboration among different Government Ministries, Departments and Agencies, industry stakeholders, local authorities and relevant organizations could impede the wider adoption of green buildings. Effective coordination is crucial for the development of coherent and cohesive policies, streamlined approval processes, and the dissemination of information, training, and technical support.

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[36] Republic of Zimbabwe, National Report for Habitat III 2015, p 20.

5.7.4 Limited Financial Incentives and Access to Finance

The review shows that none of the policies and laws provide for targeted financial incentives such as blended finance, guarantees, tax credits, grants, and concessional/low interest loans for the adoption of green buildings. This may discourage project developers and property owners from investing in green building technologies as a result of very high upfront costs. In addition, the continued informal nature of the economy makes it difficult for prospective property developers to access loans for building construction. In addition, there are very few banks and building societies offering mortgages and loans with favourable repayment plans due to the economic hardships and uncertainty around the continued use of multicurrency regime.

Further, due to the low experience with green buildings and green construction, there are no financial tools that specifically cater to the needs of the activity.

5.7.5 Limited Integration of Renewable Energy and Energy Efficient Buildings

There is lack of specific Regulations or incentives that encourage the use of renewable energy technologies such as solar panels or geothermal systems and energy efficient buildings. However, there is an improvement in the ZERA Act that makes it mandatory for households and other users to use electrical geysers. In addition, the following observations were found:

- The building-related regulations do not promote clean cooking planning in the buildings as well as addressing indoor pollution and fires caused by cooking appliances.
- The Energy Efficiency IEC Standards that were adopted are not supported by primary energy legislation for them to be legally enforceable. For example, there is no Energy Act supporting mandatory implementation of Quality Standards.
- In relation to mitigation, the Revised NDC (2021) do not address emissions from buildings. While the NDC does aim to achieve emissions reductions from the residential and commercial sector the actual potential from buildings is not addressed. Specific measure for buildings should be included in future iterations of the NDC to support integration of the sector into climate policy.

5.7.6 Limited Integration of Renewable Energy and Energy Efficient Buildings

There are overlapping mandates among different regulators such as ZERA, ZINWA and Environmental Management Agency (EMA). This has resulted in a number of negative impacts to the progress of green buildings in Zimbabwe:

- Policy changes/shifts that impact the sector differently the sector confusing industry players.
- Inconsistency in the application of rules and the requirements for planning, designing, and developing buildings.
- Uncertainty in the market about what rules are in effect and how to comply with disparate regulations.

5.8 Conclusions and recommendations

The international, regional and national legal, regulatory and policy frameworks provide some policy and regulatory guidance for the adoption of Green Buildings Codes and Standards. However, there is no comprehensive policy and legal/regulatory framework that promotes or mandates the development of Green Buildings in Zimbabwe. The legal, regulatory and policy framework is characterised by gaps, lack of financial incentives, institutional capacity limitations, fragmentation in implementation and overlaps as indicated in section 5.7 of this report. Based on these gaps, the following recommendations should be implemented to better promote and support the Green Building Outcomes in Zimbabwe:

- **Review and draft new Model Buildings By-Laws, align with Building Codes and incorporate green building standards**. The Green Buildings Codes and Standards should be used as a basis for enforcement of green buildings.
- **Develop a national comprehensive policy and legal framework for green buildings in Zimbabwe**. This should clearly indicate the main players in assessing and enforcing the implementation of green buildings. The green building standards being generated as part of this project should be technical basis for the legal framework proposed.
- Identify and set up a robust institutional framework which adopts a "whole government approach." This includes:
  - **Identifying clear roles and responsibilities of each institution.**
  - **Strengthening institutional capacity to ensure that the local authorities**, regulatory bodies, and professional associations have the necessary capacity and expertise to effectively promote, implement, and enforce green building practices. This should include training and capacity building workshops.
  - **Strengthening coordination and collaboration among different Government Ministries**, Departments and Agencies, industry stakeholders, local authorities and relevant organizations should be improved to ensure wide adoption of Green Buildings.
- **The Government should consider providing targeted financial incentives** such as tax credits, grants, or low interest loans for the adoption of Green Buildings. This may encourage developers and property owners to invest in green building and renewable energy technologies.
- **Develop a Costed National Green Building Strategy and Action Plan with goals, objectives, strategies and timeframes.**
- Develop a robust Monitoring and Evaluation Framework.

In summary, to tackle challenges associated with adoption of Building Code and Standards, there is a need for a legal, regulatory and policy framework as well as Model Building By-laws that are aligned with the MEAs, SDGs, Constitution of Zimbabwe and Vision 2030. Strategic measures such as resources mobilisation; adoption of technology and innovation around green buildings; capacity building and training of building professionals and other relevant stakeholders; awareness raising of importance and benefits of green building standards to humans and environment; legal ban human settlements on wetlands; and safe, cost effective and climate resilient building materials should be adopted. In addition, a robust institutional framework with clear roles and responsibilities of each institution as well as coordination mechanisms and exchange of information and knowledge are required.

6 Baseline assessment of building performance

6.1 Overview

For the assessment process, it was initially envisaged to collect data from existing sources such as research, government building audits, Green Building Council audits, etc, as well as direct data collection from a number of buildings to ensure a comprehensive understanding of the current state of building energy performance. However, this approach faced significant challenges. Existing data on building performance was found to be non-existent, complicating efforts to establish a robust baseline. Furthermore, the direct data collected from buildings proved to be sparse and lacked the necessary detail, being both incomplete and not sufficiently detailed for rigorous analysis.

To overcome these limitations, the assessment had to rely heavily on best practice modelling assumptions. This approach included the use of modelled and proxy data of building performance, enabling the project to proceed with developing insights and recommendations despite the data gaps.

Despite the challenges with the completeness of performance data, the assessment was able to identify the most used building materials and building practices within the local construction sector. This crucial insight facilitates a direct comparison between current local practices and international good practices. By understanding the prevalent materials and methods used in construction, it becomes feasible to tailor recommendations that are not only practical but also culturally and economically viable for the region. These recommendations will aim to enhance building performance, focusing on increasing energy efficiency and sustainability, thus providing a clear pathway for improvements in building practices in Zimbabwe.

Due to the incomplete data on the specific energy consumption and emissions a top-down analysis approach was employed to provide indicative figures of energy consumption and emissions into the future. This methodology, while characterized by broader margins of error, proved instrumental in providing a generalized overview of the current and future trends in energy consumption and emissions within the building sector. By analysing aggregate data, the team was able to extrapolate the potential impact of prevailing building practices and project the likely future scenarios under various policy and practice changes. Importantly, this approach also enabled the identification of the scale of possible energy savings and emissions reductions that could be achieved through the adoption of sustainable construction methods. Thus, despite its limitations, the top-down analysis offered valuable insights that are critical for strategic planning and for setting realistic targets for improving the energy efficiency and sustainability of buildings in the region.

6.2 Methodology

6.2.1 Building assessment

The building assessment involved planned visits to a selection of buildings of the four key building classes selected for this study: residential, warehouses, multi-storey buildings, and institutional buildings. During these visits, observations and assessments were made regarding the types of building materials used and the construction practices adopted. Added to this, data was requested from the building owners regarding building performance include the demand for electricity, the building plans, and details material descriptions, however this data was not available or not provided during this process.

This qualitative data collected through the visits provided rich insights into the prevalent architectural styles and engineering practices, despite the lack of quantitative performance data. The information gathered is pivotal for understanding the current landscape and will serve as a foundational element for developing tailored recommendations aimed at enhancing energy efficiency and sustainability across these building categories.

The selection of the four building classes—residential, warehouses, multi-storey buildings, and institutional buildings—for focused study was strategic, based on their anticipated impact on future energy demand in the building sector. By concentrating on these types of buildings, the assessment aimed to pinpoint where the greatest energy demand surges might occur and thus where targeted interventions could most effectively mitigate energy consumption and associated emissions.

The results of the information collected is detailed in section 6.3 below including a general description and images of the materials and building features.

6.2.2 Data collected from buildings

Mixed methods were employed in conducting the baseline energy assessment on the selected buildings. Walk through audits were conducted to obtain energy profiles of the buildings based on the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) level one energy audit methodology. The ASHRAE level 1 audit encompasses a walk-through assessment, collection of energy data as well as interviews with operations and maintenance staff. Secondary data on electricity consumption were obtained from the individual buildings utility bills and the Zimbabwe Electricity Transmission and Distribution Company (ZETDC). ZETDC provided data were 100 randomly selected residential houses (20 in each suburb) but walk through audits could not be conducted because of legal and confidentiality limitations with the property owners. Ten consenting residential houses in total (two in each suburb) were then selected to assess their electricity consumption. The data collected were on electricity purchases made during each month over one year. Highrise buildings and warehouses electrical consumption data were collected from the utility (ZETDC). Site visits were done to measure floor area, assess shading elements, the cooling and heating loads and get floor plans and building elevations.

As such, the data collected provides insight for the development of recommendations for green building standards but are not sufficient to consistently model the performance of buildings by changing the parameters of construction and materials.

The following results provide a summary of this exercise

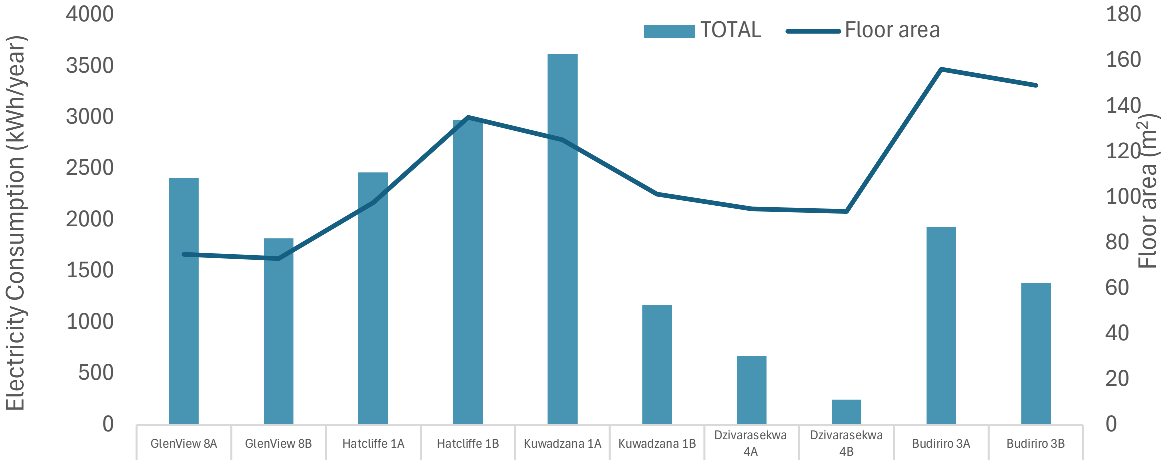
6.2.2.1 Residential buildings

Residential data obtained comes from prepaid meters, hence the collected data does not represent actual consumption in the designated period but rather signifies the household energy purchasing pattern. From the collected data it appeared, that tenants in Kuwadzana, Budiriro and Dzivarasekwa would not purchase electricity for some months due to adequate units and/or prolonged load shedding. During the walk-through audits residents cited instances where load shedding was for 16-18hrs starting from as early as 4am. Floor areas and window sizes were also collected during the walk through.

Figure 3**Fehler! Verweisquelle konnte nicht gefunden werden.** shows no direct relation between energy consumption and the floor area. None of the buildings had installed air conditioners hence the consumption was attributed to the use of various household appliances, such as lighting, TV, refrigerators, electrical stoves, among others.

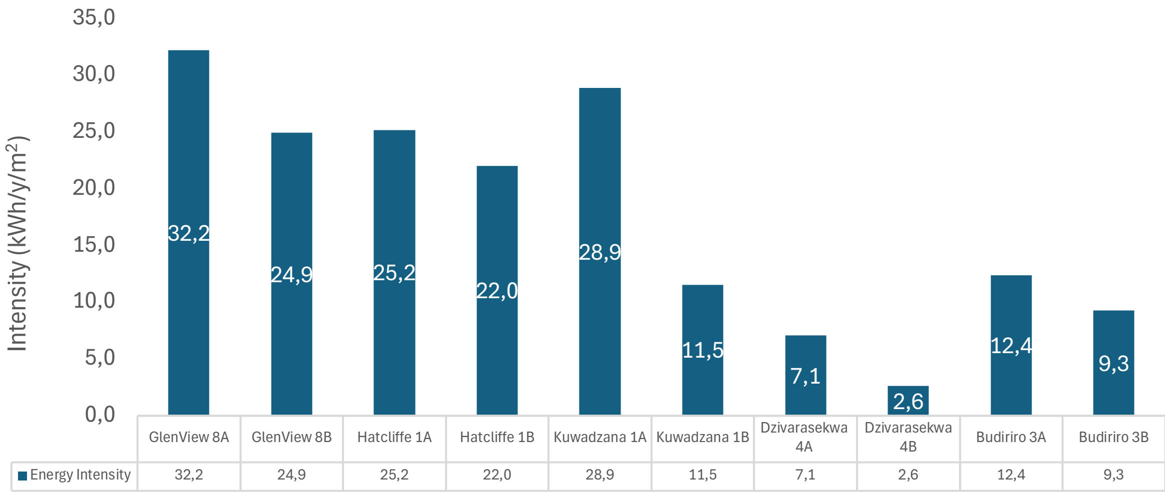
In terms of energy intensity, no was found across the suburbs owing to different consumption patterns and inconsistent power supply. The consumption patterns vary from 2.6kWh/m2/yr to 32.2kWh/m2/yr the lower consumption in some suburbs had houses going for months without electricity purchases owing to whilst the upper consumption there was consistent power supply (Figure 4).

Figure 3:Electricity consumption of selected high-density houses.



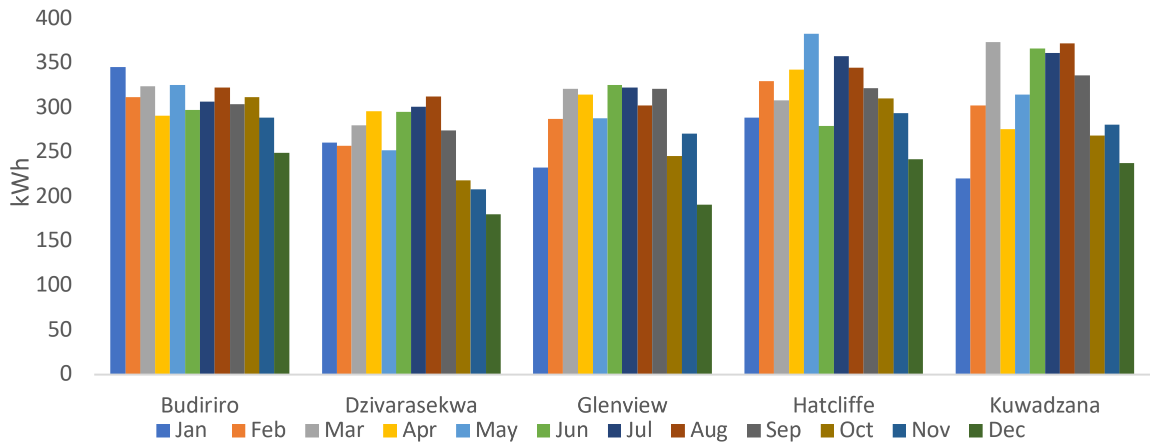
	GlenView 8A	GlenView 8B	Hatcliffe 1A	Hatcliffe 1B	Kuwadzana 1A	Kuwadzana 1B	Dzivarasekwa 4A	Dzivarasekwa 4B	Budiriro 3A	Budiriro 3B
TOTAL	2414,7	1823,7	2468,4	2983	3624,6	1172	671,8	244,8	1938,64	1386
Floor area	75	73,2	98	135,4	125,6	101,5	95	93,8	156,5	149,5

Figure 4: Energy intensity of selected residential houses



In terms of annual demand distributions, the aggregated data indicates that consumption in each suburb gradually increases from January to March (main rain season) dropping in April (post rain season) as temperatures also increase. Consumption rises again from May, peaking in August (cool season) before dropping off for the remainder of the year where temperatures are highest (hot season) (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The heating load is common from May to August whilst the cooling load is expected from October to December. Households switch on radiant bar heaters and utilize more hot water during winter season as compared to the usage of pedestal fans and natural ventilation during the hot season.

Figure 5: Average consumption for 20 selected households in each suburb.

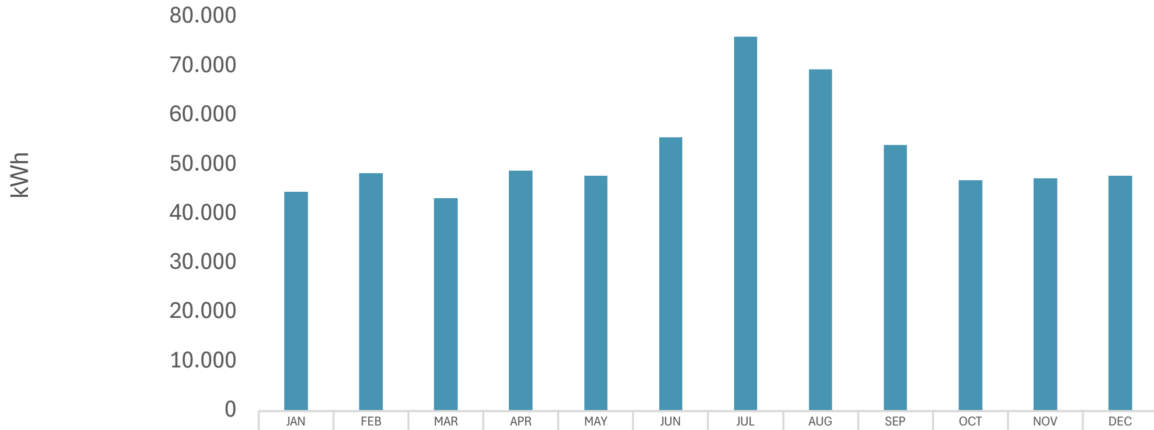


6.2.2.2 Commercial buildings

For the specific buildings for which data was collected, the results are presented below.

The New Makombe building is a central registry building where national identity cards, passports, birth, and death certificates are issued. The building is not affected by load shedding and has no centralized air conditioners or heating systems. Consumption of electricity peaks up during winter months as occupants prioritize keeping warm (Figure 6). The energy intensity is 23 kWh/m²/year. This is in sharp contrast to the consumption pattern for Joina City in fig 8 below with an intensity of 232kWh/m²/year.

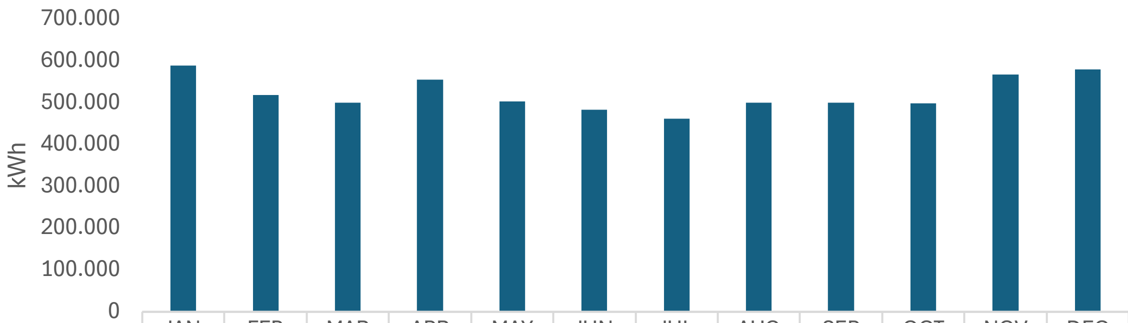
Figure 6:New Makombe building consumption.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
New Makombe (Muchecheterwa Chiwashira)	44490,65	48255,32	43216,6	48783,82	47731,31	55560,62	75933,12	69353,25	53965,48	46853,99	47181,07	47731,58

Joina City has retail spaces on the first three floors and has an office tower. The building has centralized cooling in all the areas with a few split air conditioners for key tenants such as banks and cinemas. Demand for this building peaks in hotter months of the year. The building and its windows are not shaded exposing it directly to sunlight. The facility gradually switches on more chillers during this period.

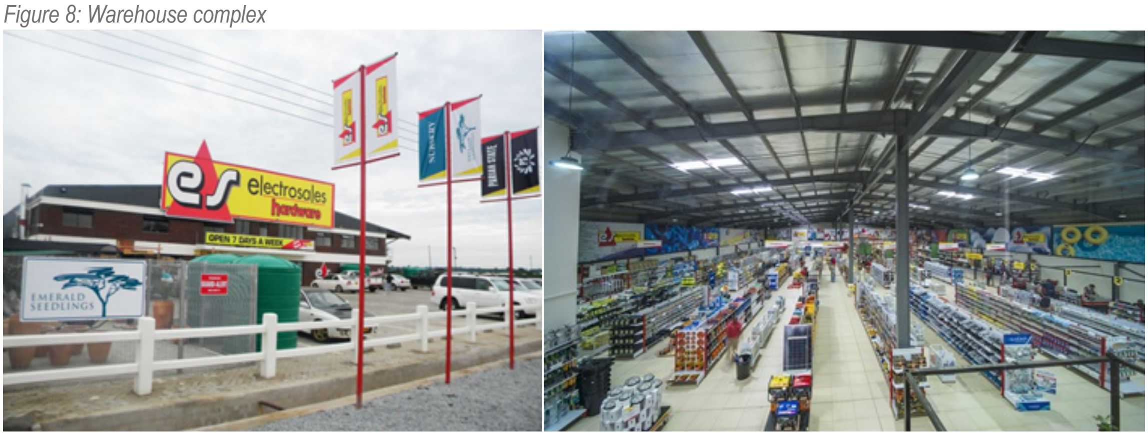
Figure 7: Joina City electricity consumption.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Joina City	589671	519167	501047	556205	504454	483594	463233	501331	500277	499993	569009	580579

The warehouse complex surveyed is a modified structure from an existing building, that was mid-way through construction and required significant remedial works to be converted into a warehouse and retail area. The design included retrofitting the existing distribution warehouse, into a retail hardware store, combined with a cafe/restaurant, and garden nursery. The space is well lit with t8 LED tubes and translucent sheets. The building has air conditioners installed but no information was provided regarding their technical specifications or use. The energy intensity of the building is 35 kWh/m²/year.

Figure 8: Warehouse complex



The public clinic audited was a peri urban off-grid facility in the low-income neighbourhood of Hopley, in southern Harare. The facility has a floor area of $1075m^2$ offering outpatients, dental, pre and postnatal care to 200,000 inhabitants in the area. The clinic is powered by a 10kW off grid solar system for office equipment and lighting. Water is pumped utilizing a solar pump on site and hot water is catered for utilizing 2 roof top solar water geysers. The clinic is a brick-and-mortar structure under gypsum ceiling and Inverted Box Rib metallic roofing sheets with no insulation.

Figure 9: Photograph of Hopley Clinic.

6.2.3 Macroeconomic assessment

To estimate the overall energy consumption of the building sector in Zimbabwe, a top-down approach was utilized, leveraging macroeconomic statistics including GDP, population figures, and general energy demand data. This method involved correlating economic growth rates and demographic trends with energy usage across the sector, providing a macro-level insight into how these factors collectively influence building energy consumption. By examining these broad indicators, the assessment could extrapolate the energy demand attributable to buildings in the context of national economic activities and population dynamics. This approach, while less granular, is relevant to paint a broad picture of the sector's energy footprint and is useful in developing energy demand and emissions reductions scenarios where detailed building-specific data is lacking. This method supports a more informed approach to the development of the Green Building Standard.

Key data used for the development of the top-down macroeconomic estimate:

1. Population statistics:
    a. Total population – World Bank.
    b. Population projections until 2050 – World Bank
    c. Number of households in the country – Zimbabwe UNFPA
    d. People per household - Zimbabwe UNFPA
2. Economic statistics
    a. Constant price GDP – World Bank
    b. GDP growth assumptions – Estimated and assumed from the available GDP statistics.
3. Electricity statistics
    a. Total electricity generation – IRENA Zimbabwe Energy Profile
    b. Consumption by sector (residential and commercial) – African Energy Commission (AFREC).
    c. Assumptions of electricity demand increases by sector (residential and commercial) – Assumed from population and economic statistics.
    d. Electronification rates – World Bank
4. Emissions factors –
    a. Grid emissions factor for Zimbabwe – United for Efficiency
    b. Price of electricity – ZESA (ZETDC)Electricity Tariffs 2024.

The methodology employed begins on analysing electricity consumption from the commercial and residential sectors, estimating the total electricity demand per household. This estimate is derived from the overall electricity generation data and the proportion of this total consumed by the residential sector. This is then divided by the estimated number of households in the country. It's assumed that electricity demand will increase in line with the growth in the number of households and as the country develops and household incomes rise, it is also assumed that the per household electricity demand will increase.

For commercial buildings, due to the lack of specific data on the total square meters of commercial space, the growth in energy demand is estimated by analysing the overall commercial electricity demand. This demand is then adjusted based on a growth factor correlated with GDP growth, which is assumed at 3% based on historical trends. This rate considers periods of both above-average growth and years of economic contraction within the last decade.

6.3 Results

6.3.1 Energy demand in the residential and commercial sectors

While modern energy carriers such as coal and gas are consumed in the built environment in Zimbabwe, their amount is very small compared to electricity. At the same time, the country's households are highly reliant on traditional biomass for the thermal activities in the residential and commercial sectors as 51% of the population remains disconnected from the electricity grid[37].

This reliance on traditional biomass is undesirable as it is unsustainable and has extensive environmental impacts such as land degradation, destruction of biodiversity habitats, etc. Similarly, this reliance often involves the perpetuation of poverty and gender inequality due to the significant time resources needed for its collection (usually by women) for usage. As such, it is assumed development policies, including the GBS, will focus transitioning away from traditional biomass and onto green, modern, energy in the form of electricity.

6.3.1.1 Electricity demand and GHG emissions in buildings in Zimbabwe

Around 51% of the country's electricity is used in buildings (29% residential and 22% commercial/others), resulting in approximately 4,450 GWh of electricity consumption which based on the .36 $kgCO_2e$ grid emissions factor for Zimbabwe, this results in just over 1.6 $MtCO_2e$ of GHG emissions.

Of this total, 2,530 GWH were used in the residential sector in 2022, or 1,352 kWh per HH for each of the roughly 2 million HH connected to the grid. This resulted in 900 $ktCO_2e$ of GHG emissions.

For the commercial sector (which includes public buildings), the total consumption of electricity was 1,920 GWh in 2022 resulting in 691 $ktCO_2e$ of GHG emissions.

6.3.1.2 Projections to 2050

For the projections of energy demand and emissions to 2050, the number of grid-connected households in Zimbabwe increases from around 2 million in 2022 to just over 6 million. This is a three-fold increase based on population increase, HH reduction size, and an increase in electrification to 80% up from the current 49%. At the same time, consumption per HH increases by 52% to 2,051 kWh as the country develops and HH increase the number of electric appliances and the use they make of them. This is particularly the case for appliances such as ACs.

For the commercial sector, it was assumed that electricity demand increases a at similar rate to GDP as the commercial sector is key to economic growth and there is a well-established link to energy demand.

With the compounding growth of HH and consumption per HH, total demand in the residential sector increases from 2,530 GWh in 2022 to 12,397 GWh, and almost five-fold increase. The commercial sector electricity demand increases to 1,581 GWh a 230% increase from 2022. Overall, electricity demand in

[37] https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZW

buildings increases from 4,450 GWh in 2022 to 16,789 GWh in 2050, an almost four-fold increase in the period.

In terms of emissions, the grid emissions factor is assumed to remain constant throughout the period in the absence of concrete plans to transition to a renewable electricity system. As such, the growth in emissions for each of the sectors is directly proportional to the increase in energy demand. As such, residential emissions increase by almost 500% while the commercial sector experiences a 230% increase for an overall buildings emissions increase of 3.8 times compared to 2022 for a total of 6,044 ktCO_2e.

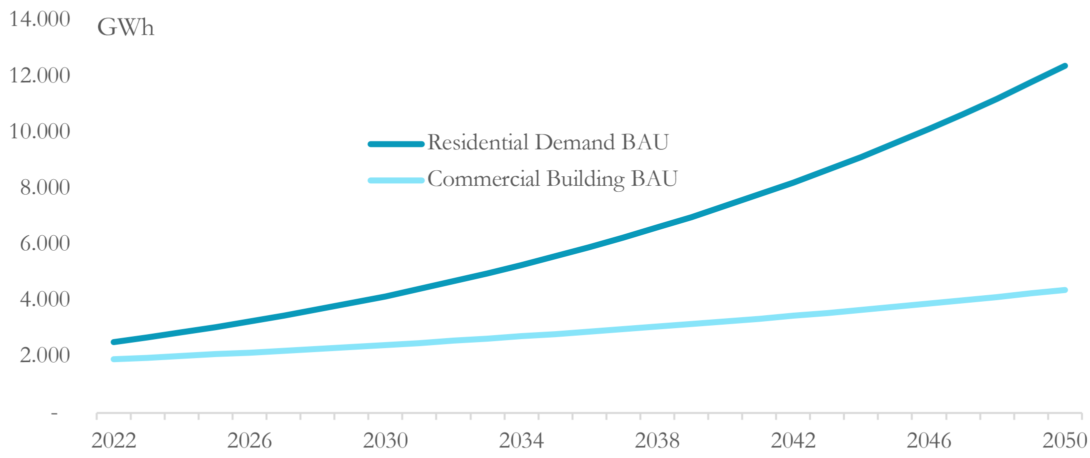


Figure 10: Electricity consumption trend in buildings in Zimbabwe 2022-2050 (Source: HEAT Analysis).

6.3.1.3 Emissions reductions from the implementation of the GBS

As mentioned before, the development and implementation of green buildings standards would achieve reductions in several energy end-uses in buildings from lighting to space conditioning, water heating, and cooking. The application of these standards will have different results in different environments and considering the lack of data collected from actual buildings in Zimbabwe, it is not possible to estimate savings on a per end-use basis. However, it is accepted that green buildings can achieve electricity demand reductions of 50% or more depending on the climate, appliances, and building types, but for Zimbabwe, an assumption of 20% reduction was applied for the projection. The rationale for the 20% assumption stems from the following principles:

- The ambition of the initial GBS is not expected to be as high as leading standards and it is not practical to go from no standards to leading standards.
- The ability to enforce the standards will be limited in the beginning leading to lower gains that it would otherwise be possible.

Based on the 20% reduction assumption, and assuming a building replacement rate of 50 years, the expected energy demand reductions for the buildings sector is 2,886 GWh by 2050 or 17% reduction of the projected demand in the BAU case. This results in the reduction of GHG emissions of 1 million tonnes of CO_2 equivalent.

The residential sector accounts for 2,203 GWh of the projected electricity demand reduction from the application of a GBS reach representing 793 ktCO_2e or 18% of the of the emissions reductions compared to the BAU projections for 2050. On the other hand, the demand reductions from the commercial sector account for 683 GWh and 246 ktCO_2e of the emissions reductions.

The residential sector experiences a much larger growth than the commercial sector during this period, and therefore, the projected savings are also significantly larger. It is important to note that these figures are indicative, however the trends depicted are valuable and should hold true and represent a plausible development scenario for the buildings sector.

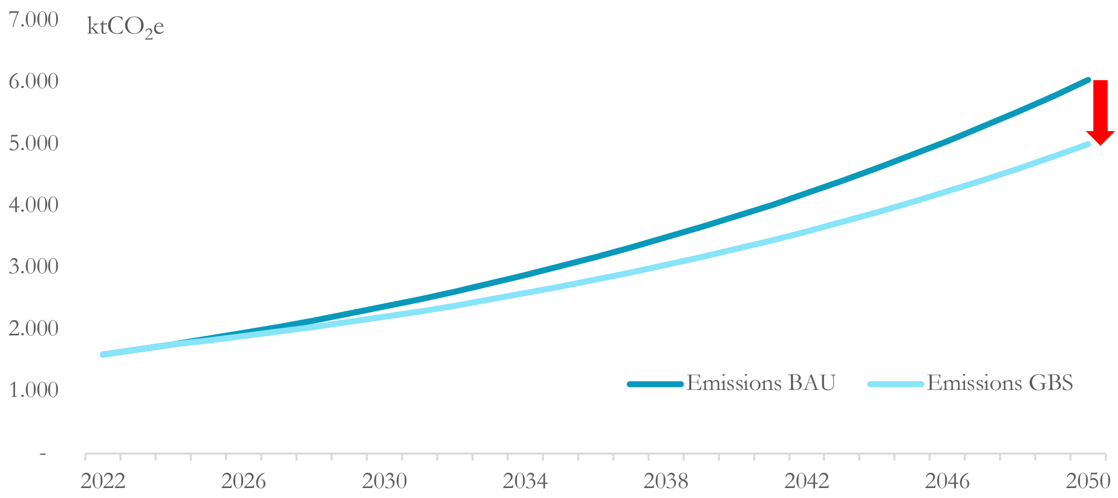


Figure 11: GHG Emissions projections for the building sector BAU vs GBS scenario 2022-2050 (source: HEAT Analysis).

6.3.2 Current design and construction practices in Zimbabwe

This section includes a summary of the current building practices and materials in the development of the selected building types for this project: warehouse buildings, residential buildings, and multi-storey commercial buildings.

The section also includes a summary of the types of lighting and air conditioning products as key sources of energy demand as well a solar water heaters as a growing source of demand replacement in buildings.

6.3.2.1 Lighting, air conditioning and solar water heating products

Zimbabwe is ensuring the quality control of lighting, air conditioning and solar water heating products through enacting legislation, standards, and adoption of energy labels from countries of product origin. The government of Zimbabwe, in 2015 regarded Bureau Veritas to undertake consignment-based conformity assessment (CBCA). This entails inspecting all imports including renewable energy supporting products in their country of origin and ensuring the necessary certification and documentation is shipped with the consignment in compliance with the national standards.

Lighting

Lighting is predominantly provided by bayonet type luminaires (b22) although screw types (e14, e27) are also found in the market. The use of incandescent lights is banned through SI 21 of 2017 Inefficient Lighting Products Ban & Labelling Regulations. The common types are CFL, Led bulbs and tubes and solar flood lights. The lights range from 2000K to 6500K in colour temperature and $0.5 to $5 in cost depending on brand and wattage.

Air conditioners

Room air conditioners are typically used in offices, hotels and other public places and have not been popular in residential areas. In the residential sector the use of air conditioning has been limited with to fans. In Zimbabwe air conditioners are tested to IEC 54511-3 energy consumption (cooling mode only) standard and domestic fans to IEC 60879:1986 energy performance standard. The common sizes available on the market are 12000, 18000 and 24000 Btu/hr units. The table below shows the available prices for wall mounted split air conditioners (Table 6).

The inverter type is more dominant although some customers are still opting for the non-inverter type because of price. The prices differ depending on the brand and scale of distributer.

Table 6: Typical air conditioner ratings and prices

Size in Btus/hr	Inverter Type Prices	EER ratings
12000	$400-550	3.11 to 6.1
18000	$600-800	3.21 to 13.4
24000	$700-1200	3.15 to 3.36

Solar water heaters

Solar water heaters (SWH) commonly found in Zimbabwe are of the evacuated tube type. Solar water heaters are either the pressure type or the gravity type and have the option of a back electrical element. The government through the Zimbabwe Energy Regulatory Authority (ZERA) and the Standards Association of Zimbabwe (SAZ), is building capacity to test these units. The government is also in the process of incorporating the SAZ standards in the solar water heating regulations. SI 235 of 2019 makes it mandatory for new residential buildings to be fitted with solar water heaters before connection of electricity supply by the power utility. Solar water heaters range from $200 to $1200 depending on capacity and type.

6.3.2.2 Warehouses

Floors

The floors are predominantly made from reinforced concrete (RC) slabs, sometimes with tiles. Reinforced concrete is a combination of adequate reinforcement (usually steel bars with raised lugs called deformations) and concrete designed to work together to resist applied loads. Properly placed reinforcement in concrete improves its compressive and tensile strength. The main advantages of RC lie in the durability, low maintenance requirements, versatility, cost effectiveness and heat resistance.

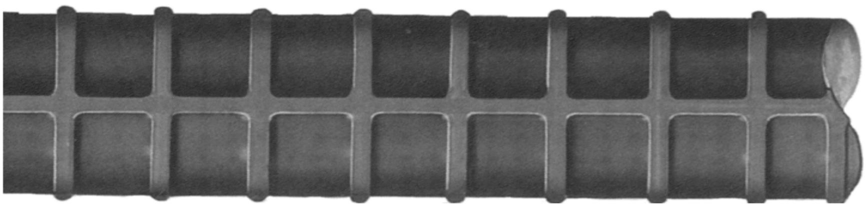


Figure 12 - Reinforcing bar for RC floors. Source: (Bell, et al., 2006)

Ceramic tiles are commonly used for finishing RC slabs. These tiles are made from a mixture of clay, minerals, and water, which is then fired at high temperatures to create a durable and versatile material.

Walls

Walls for most warehouses are made from corrugated metal sheeting. Sometimes the first three meters are plastered or built from face brick 230mm masonry. The corrugated metal sheeting or cladding material consists of corrugated metal panels. The material is commonly used for its durability, strength, and cost-effectiveness.

Ceilings

The ceilings are mostly made of corrugated metal sheeting with alu-cushion insulation.

Figure 13 - Schematic view of corrugated metal roofing. (Source: Bell, et al., 2006)

Strong, light and flexible materials with excellent tear resistance, effective in a temperature range from -20C° to 80°C, is often used. The alu-cushion materials used for insulation and also offers an aesthetically pleasing finish with good light reflectance.

Roofs

Roofs are corrugated metal sheeting with alu-cushion insulation. The sheets are made from various metals, such as steel, or zinc, and are shaped into a series of alternating ridges and valleys. This design provides the sheets with increased strength, rigidity, and water resistance. The corrugated metal sheeting is preferred due to its durability, affordability, and versatility. Galvanized, or zinc-coated, steel is among the most popular materials used. Zinc is also used because of its natural patina, which protects the metal from corrosion and can last beyond 80 years.

6.3.2.3 Residential

Floors

RC slabs with screed and ceramic or porcelain tiles/ vinyl/ timber parquet or planks are used. Suspended timber flooring is rarely used. The concrete is a flat, horizontal component and provides a load-bearing surface for floors, roofs, and other similar structures.

Walls

The walls are plastered wall or face brick. Typical construction walls are 200-230mm masonry. Low-income houses sometimes use 115mm thick walls. The bricks are either kiln fired clay or cement bricks. These materials are commonly used in building construction for both interior and exterior walls.

Ceilings

Gypsum plasterboards sometimes with mineral wool above Gypsum plasterboards, sometimes with mineral wool above, are commonly used ceilings. This combination provides a variety of benefits such as fire resistance, thermal insulation, and soundproofing. Isoboard, made from expanded polystyrene (EPS) I also used. EPS is lightweight and versatile and is widely used for its insulation properties. Plastered RC slabs, also known as plastered reinforced concrete slabs, can also be used, serving both functional and aesthetic purposes.

Roofs

Roofs for residential houses can be made of corrugated metal or asbestos sheeting with alu-cushion insulation. The combination provides both weather protection and thermal insulation for the building. Concrete/other tile roofing with alu-cushion insulation are also common. The combination of concrete or tile roof coverings with alu-cushion insulation material provides both weather protection and thermal insulation for the building. RC slabs can be combined with waterproofing measures to prevent water infiltration and protect the underlying structure. Waterproofing is essential for areas such as basements, roofs, balconies, or any other surfaces exposed to moisture or potential water penetration.

6.3.2.4 Multi-storey buildings

Floors

Popular flooring options include wood, engineered flooring materials, vinyl, tile, timber, carpet, and RC slabs with screed and ceramic or porcelain tiles.

Walls

There are various types of walls which are constructed in the multi-storey segment of Zimbabwe. For multi storey, most main building walls are masonry walls, that are built of individual blocks of materials (brick, clay, stones or concrete) and bonded together with properly mixed mortar. In some instances, these can be cavity walls, retaining walls and core walls. For partitioning in mainly commercial buildings, walls are generally constructed as a frame of materials such as timber, wood, steel, or aluminium, with facing or sheeting on one or both sides of the frame. For beautification the outside walls are sometimes plastered with cement or face brick is used (200-230mm) masonry with windows. Large glass facades with little or no shading elements can in some instances also be observed.

Ceilings

There are various ceiling materials used in the Zimbabwean market. Wooden boards are used to make strong, durable, and appealing ceilings. Decoration moulding can be used and made from wood. Plaster Board made of similar material like wood is also used and normally prefabricated into sheets that attach to the ceiling with screws and then are sealed. Fall Ceilings are used below the roof slab on suspended supports and is usually provided for temperature control, light installation, electrical stuff, and other networking cables and too-high ceilings. Fall ceilings can be gypsum ceilings, plaster ceiling, fibre ceiling, wooden ceiling, and glass ceiling.

Roofs

Corrugated metal sheeting with alu-cushion insulation is the most common type of metal roof. Aluminium, IBR or steel roofing panels meet in raised seams that interlock to keep moisture out. Metal roofs of all kinds are increasingly popular in all upmarket multi storey structures. Concrete/other tile roofing with alu-cushion insulation are moulded from standard sand-mix concrete coloured to different hues are desired. A variety of profiles are available, some that resemble rolled clay tiles and others that are low-profile. Concrete tile is sometimes finished with a decorative coating. RC slabs with waterproofing. Built-up roofing (BUR) is one of the oldest types of roofing materials for flat roofs or low-pitch roofs used in the country. BUR systems are constructed with several layers of roofing felt impregnated with asphalt that is applied hot. The felt is applied in overlapping layers to form a barrier two to four layers thick. Then, a layer of finely crushed stone is embedded in hot tar over the top to create a very durable and impenetrable roof.

6.3.2.5 Institutional buildings

Floors

The floors are made up of RC Slabs with screed and ceramic or porcelain tiles/ vinyl/ timber parquet or planks depending on application.

Walls

Walls are 200-230mm masonry plastered cement/clay bricks or face brick with windows. Some institutional buildings utilise large glass facades with little or no shading elements.

Ceilings

Typical ceilings are made using Plastered RC slabs, gypsum ceilings, plaster ceiling, fibre ceiling and wooden ceiling depending on function and aesthetics.

Roofs

Most institutional buildings have pitched roofs which are made up of corrugated metal sheeting or concrete/other tile roofing with alu-cushion insulation. Flat roofs are also common utilising RC slabs with waterproofing.

7 Advanced energy efficiency building materials and technologies database

This BEEC represents a significant step toward improving building performance and improving the sustainability of the nation's built environment. As major consumers of energy, particularly electricity and biomass, it is important that buildings in Zimbabwe to adopt advanced technologies that enhance energy efficiency, reduce greenhouse gas emissions, and align with global climate goals. The BEEC emphasizes energy efficiency and conservation across various building components, including the building envelope, HVAC systems, lighting, water heating, renewable energy integration, and the implementation building systems and controls.

For this, a database has been developed to provide an overview of advanced technologies that are aligned with the standards set forth in the code. These technologies are intended to guide architects, engineers, builders, and developers in selecting and integrating energy-efficient solutions that meet or exceed the performance requirements of the BEEC.

7.1 Purpose of the Database

The purpose of this database is to serve as a practical resource for stakeholders involved in the design, construction, and operation of buildings in Zimbabwe. It offers detailed information on state-of-the-art technologies that can be applied across various components of a building to enhance energy efficiency, reduce operational costs, and promote environmental sustainability.

Each entry in this database includes the following key details:

- **Technology Name:** The specific name of the technology.
- **Component**: The relevant building component (e.g., HVAC, Lighting, Renewable Energy).
- **Description**: A brief explanation of how the technology works and its benefits.
- **Application**: Practical applications of the technology within different building types.
- **Impact**: The environmental and economic impacts of implementing the technology.

- **Certification/Standard Alignment**: This sector shows that alignment with the BEEC and other well recognized international green building standards such as LEED and BREEAM.

7.2 Scope and Structure

The database is structured around the key energy components that are outlined in the BEEC, reflecting the critical areas where energy savings and efficiency can be maximized:

- **Building Envelope**: Technologies that improve the insulation, glazing, and overall thermal performance of building exteriors.
- **HVAC Systems**: Advanced heating, ventilation, and air conditioning solutions that reduce energy consumption and enhance indoor comfort.
- **Lighting**: Energy-efficient lighting technologies and controls that reduce electricity usage while maintaining optimal lighting quality.
- **Water Heating**: Systems that provide efficient and sustainable hot water solutions, leveraging renewable energy where possible.
- **Renewable Energy**: Integration of renewable energy sources such as solar PV and battery storage to reduce reliance on non-renewable energy.
- **Building Systems and Controls**: Automation and control systems that optimize the operation of building energy systems to minimize waste and improve performance.

It is important to note that this data base is not intended as a final, static component, but rather a living document that is maintained to reflect changes in technology, changes in the BEEC, changes in the key priorities of the government of Zimbabwe, and changes in the building environment.

7.3 BEEC database

7.3.1 Building Insulation

This category comprises advanced insulation materials with high R-values, providing superior thermal resistance, thereby reducing heat loss in cold climates and heat gain in warm climates. Key examples include:

Type	Examples	Description	Application	Performance
High-performance insulation material	Aerogel Insulation	Aerogel is a lightweight material with high insulating properties, consisting of over 90% air trapped in a silica matrix. It has one of the highest R-values per inch of any insulation material, making it ideal for applications where space is limited but high insulation performance is required.	Used in walls, roofs, and floors in both new construction and retrofit projects. It's particularly effective in high-performance building envelopes and areas requiring minimal thickness. Significantly reduces thermal bridging and overall heat transfer, contributing to lower energy consumption for heating and cooling.	R-10 to R-30 per inch of thickness

Spray foam insulation (open-cell and closed-cell)	Expanding foam insulation	Spray foam insulation expands upon application, filling gaps and providing a continuous barrier that reduces air leakage. Closed-cell spray foam is denser and offers a higher R-value per inch, making it suitable for areas where space is at a premium. Open-cell spray foam is less dense and offers soundproofing benefits along with insulation.	Commonly used in walls, roofs, and floors, particularly in irregular spaces where traditional insulation might not fit well. Provides superior air sealing, reducing thermal bridging and improving overall building energy efficiency.	• Open-Cell: R-3.5 to R-4.0 per inch • Closed-Cell: R-6.0 to R-7.0 per inch
Vacuum insulated panels (VIPs)	High-Performance Insulation Panels	VIPs consist of a core of fumed silica encased in a gas-tight envelope, creating a vacuum that provides outstanding thermal insulation. These panels are thin yet highly effective, making them ideal for applications where space is limited.	Used in walls, roofs, and floors, particularly in retrofits where adding thick insulation might be impractical. Reduces heat transfer, making it possible to meet strict energy codes without sacrificing interior space.	R-25 to R-30 per inch
Rigid foam insulation (polyisocyanurate, extruded polystyrene, expanded polystyrene)	Rigid Board Insulation	Rigid foam insulation boards are available in various types, each offering different levels of thermal resistance and moisture control. Polyiso has the highest R-value per inch among rigid foams and is often used in above-grade walls and roofs. XPS and EPS offer good insulation with varying levels of moisture resistance.	Suitable for walls, roofs, and foundations. They are often used in continuous insulation applications to reduce thermal bridging.	• Polyisocyanurate (Polyiso): R-6.0 to R-6.5 per inch • Extruded Polystyrene (XPS): R-5.0 per inch • Expanded Polystyrene (EPS): R-3.6 to R-4.0 per inch
Mineral wool insulation	Fibrous insulation material	Mineral wool, made from natural or recycled materials, offers both thermal insulation and fire resistance. It is available in batts or rigid boards and is	Ideal for walls, roofs, and floors where both thermal and fire resistance are important. It is also commonly	• R-3.7 to R-4.2 per inch

		known for its ability to withstand high temperatures.	used in acoustic insulation. Provides a balance of thermal performance, soundproofing, and fire protection, contributing to overall building safety and energy efficiency.	
Reflective insulation and radiant barriers	Reflective Foil Insulation	Reflective insulation and radiant barriers use reflective materials to reduce heat transfer by reflecting radiant heat rather than absorbing it. These materials are particularly effective in hot climates, where they help to keep buildings cool by reflecting solar radiation away from the building envelope.	Commonly used in attics, walls, and roofs, particularly in regions with high solar exposure. Reduces cooling loads in hot climates, contributing to lower energy consumption and increased occupant comfort.	Varies; primarily reduces radiant heat gain.

7.3.2 Windows

Windows affect not only the aesthetics of a building but also its energy efficiency, indoor comfort, and overall environmental impact. Choosing the right type of window glazing—whether double or triple glazing—can significantly influence a building's thermal performance, daylighting, and energy costs.

Type	Examples	Description	Application	Performance
Double-glazed windows		Double-glazed windows consist of two panes of glass separated by a spacer filled with air or inert gas (such as argon or krypton). This design reduces heat transfer through the window by trapping air between the glass layers, which acts as an insulator. Low-E (low emissivity) coatings can be applied to one or more panes to further reduce heat	Often applied to residential and commercial buildings to achieve moderate energy savings while maintaining affordability.	**U-Value:** Typically, 1.6 to 3.0 W/m²K. Lower U-values indicate better insulation. **Solar Heat Gain Coefficient** (SHGC): Usually ranges from 0.3 to 0.6, balancing solar heat gain with natural light.

		loss and improve energy efficiency. Double glazing improves energy efficiency, soundproofing, and daylighting although not as effectively as triple glazing, but provides significant gains at a lower cost.		
Triple Glazing		Triple-glazed windows consist of three panes of glass with two spacers filled with air or inert gas. This design provides even greater insulation than double glazing, making it ideal for buildings in colder climates or those aiming for very high energy efficiency standards. Low-E coatings and gas fillings (argon or krypton) further enhance the performance by reducing heat transfer and improving overall energy efficiency.	**Residential Buildings**: Used in high-performance homes, such as passive houses, where maximum energy efficiency is a priority. **Commercial Buildings**: Installed in office buildings and educational facilities aiming for the highest energy performance standards, particularly in colder climates or noise-sensitive areas.	**U-Value**: Typically 0.15 to 1.2 W/m²K, offering superior insulation. **Solar Heat Gain Coefficient (SHGC)**: Typically ranges from 0.2 to 0.4, providing better control over solar heat gain.
Wall-to-window ratio (WWR)	Building design feature.	WWR is the proportion of a building's exterior wall area that is made up of windows. This ratio is a critical factor in the thermal performance of a building's envelope, as windows generally have lower insulation values (higher U-values) compared to walls. Optimizing the WWR involves balancing natural light and views with energy efficiency, ensuring that the building minimizes	Residential and commercial buildings: Relevant for all building types, especially in climates with significant temperature variations or where energy efficiency is a priority. The WWR should be carefully considered during the design phase to optimize both daylighting and thermal performance.	For energy efficiency, a WWR of 30-40% is recommended in many climates. This allows for adequate daylight while minimizing excessive heat loss or gain. Higher WWRs (e.g., above 40%) increase the need for enhanced glazing options, such as double or triple glazing to maintain energy efficiency.

		heat loss in colder climates and reduces heat gain in warmer climates.		Lower WWRs (below 30%) may reduce the need for advanced glazing but limit natural light, increasing lighting needs.
Dynamic glazing (electrochromic windows)	Electrochromic Glazing (Smart Windows)	Dynamic glazing allows windows to change their tint in response to light conditions, heat, or even manual controls. This technology enables users to optimize the amount of light and heat entering a space without the need for blinds or shades. The glass can darken to reduce solar heat gain during the day or clear to allow maximum light during cloudy conditions.	**High-Performance Buildings**: Used in buildings where control over solar gain and glare is critical, such as office buildings with large glass facades. **Commercial and Institutional Buildings**: Ideal for spaces where occupant comfort and energy efficiency are high priorities, such as educational institutions and healthcare facilities.	**U-Value**: Typically, 0.29 to 0.5 W/m²K depending on the base glazing used (double or triple glazing). **Solar Heat Gain Coefficient** (SHGC): Variable, ranging from 0.1 to 0.5, depending on the level of tint.

7.3.3 Cool roofs

Cool roofs are another strategy for improving the energy efficiency of buildings, particularly in warm climates like Zimbabwe's. These roofs are designed to reflect more sunlight and absorb less heat than standard roofs, which can significantly reduce the cooling load on buildings, lower indoor temperatures, and enhance occupant comfort.

The key performance metrics are:

- **Solar Reflectance Index (SRI)**: SRI is the key performance metric that combines solar reflectance and thermal emittance into a single value. In the Zimbabwean context, cool roofs with an SRI of 78 or higher for flat roofs and 29 or higher for sloped roofs are ideal. The higher the SRI, the better the roof is at reflecting solar radiation and staying cool.
- **Thermal Emittance**: This is the ability of the roof material to release absorbed heat. High thermal emittance indicates that that the roof does not retain heat.

Type	Examples	Description	Application	Performance
Reflective coatings	Acrylic-based reflective coating	Reflective coatings are applied to existing roofs to improve their solar reflectance. These coatings are typically	Suitable for both new and existing buildings, especially those with flat or low-sloped roofs.	Can achieve a Solar Reflectance Index (SRI) of 78 or higher, significantly

		white or light-colored and contain special reflective pigments that can bounce back a significant portion of the sun's rays.	Reflective coatings can be applied to a variety of roofing materials, including asphalt, metal, and concrete.	reducing roof surface temperatures by up to 50°C compared to standard roofs
Cool roof membranes	Thermoplastic Polyolefin (TPO) Membrane	These are prefabricated roofing materials made from single-ply membranes, such as thermoplastic olefin (TPO) or polyvinyl chloride (PVC), that are naturally reflective. They are typically installed on flat or low-sloped roofs.	Ideal for commercial and institutional buildings with flat roofs. These membranes are durable and offer high reflectivity and thermal emittance.	Typically have an SRI of 82 or higher, providing excellent solar reflectance and reducing the need for air conditioning.
Cool roof shingles	Asphalt Shingles with Reflective Granules	Cool roof shingles are similar to standard asphalt shingles but are manufactured with specially coated granules that provide better solar reflectance.	Commonly used in residential buildings with sloped roofs. Cool shingles are easy to install and provide a familiar aesthetic while offering improved energy performance	SRI values typically range from 29 to 60, making them more reflective than standard shingles but less so than membranes or coatings
Cool metal roofing	Pre-Painted Metal Roofing Panels	Metal roofing materials, such as aluminum or steel, can be finished with reflective coatings to enhance their solar reflectance. These roofs are durable and can be designed to reflect a significant portion of solar radiation.	Suitable for both residential and commercial buildings, particularly in areas where long-term durability and low maintenance are desired.	Metal roofs can achieve SRI values of 70 or higher, making them highly effective at reducing heat gain.

7.3.4 HVAC

Heating, Ventilation, and Air Conditioning (HVAC) systems are an essential component of building design as they are required to maintain comfortable indoor environments, particularly in climates like Zimbabwe's, where temperatures can vary significantly between day and night. Aside from that, HVAC systems are major energy consumer and as such a key consideration of the BEEC to help to reduce energy consumption and improve indoor air quality and occupant comfort.

The key performance metrics in HVAC systems are:

- **Coefficient of Performance (COP)** is a measure of a heating or cooling system's efficiency. It is calculated as the ratio of useful heating or cooling provided to the electrical energy consumed. A higher COP indicates greater efficiency.

- **Energy Efficiency Ratio (EER)** measures the efficiency of cooling systems, calculated as the ratio of cooling output (in BTUs per hour) to the electrical input (in watts). A higher EER represents better energy efficiency under specific conditions.
- **Heat Recovery Efficiency** indicates the percentage of heat recovered from exhaust air and transferred to incoming fresh air in a Heat Recovery Ventilation (HRV) system. Higher percentages mean more energy is reclaimed, reducing heating or cooling loads.
- **Natural Ventilation Rate (ACH - Air Changes per Hour)** is a measure of how many times the air within a space is replaced with fresh air in one hour. It indicates the effectiveness of passive or mechanical ventilation systems in providing adequate fresh air.
- **Cooling Seasonal Performance Factor (CSPF)** CSPF is a comprehensive metric that measures the seasonal efficiency of an air conditioning system, particularly in variable climates. It is calculated as the ratio of the total annual cooling provided (in watt-hours) to the total annual energy consumed (in watt-hours) by the system. A higher CSPF indicates better overall efficiency throughout the cooling season.

Type	Examples	Description	Application	Performance
Advanced HVAC Systems	Variable speed drives Variable refrigerant flow	Variable Refrigerant Flow (VRF) systems allow for precise control of refrigerant and power flow to multiple indoor units, enabling individual temperature control in different zones of a building, depending on occupancy, temperature, etc. VRF systems are highly efficient because they can adjust each indoor unit based on the current demand, which reduces energy wastage. These systems can provide both heating and cooling, and they are capable of simultaneous operation, meaning some zones can be cooled while others are heated.	**Commercial Buildings**: Ideal for office buildings, hotels, and large commercial spaces with diverse thermal needs across multiple zones. **Residential Buildings:** Increasingly popular in large homes or apartment complexes where zoned temperature control is beneficial.	Coefficient of Performance (COP): Can range from 3.5 to 5.0, indicating high energy efficiency. Energy Efficiency Ratio (EER): Typically between 12 and 20, depending on system configuration and operating conditions.
Heat recovery ventilation (HRV) systems	N/A	Heat Recovery Ventilation (HRV) systems are designed to improve indoor air quality by providing continuous ventilation while minimizing energy loss. HRV systems work by capturing heat from	Residential and Commercial Buildings: Suitable for any building type, especially those in cooler regions of Zimbabwe or in urban areas where	Heat Recovery Efficiency: Typically exceeds 70-80%, meaning most of the heat from the exhaust air is recovered.

		the stale exhaust air and using it to preheat the incoming fresh air, reducing the load on the heating system. This is particularly beneficial in climates where there is a significant difference between indoor and outdoor temperatures.	air quality is a concern.	
Passive ventilation	Designs from the design stage rather than specific technology.	Passive Ventilation relies on natural forces, such as wind and thermal buoyancy, to circulate air throughout a building without the use of mechanical systems. This design strategy takes advantage of building orientation, window placement, and venting systems to maximize airflow and maintain comfortable indoor temperatures.	**Residential Buildings**: Especially effective in single-story homes, where cross-ventilation can be easily achieved. **Commercial Buildings**: Can be integrated into the design of offices, schools, and public buildings through the use of atriums, vented facades, and high ceilings.	Typically measured in air changes per hour (ACH), effective passive designs can achieve adequate ventilation rates (e.g., 5-10 ACH) depending on the building design and external conditions.
High-efficiency Chillers	Chillers for larger AC systems in commercial buildings.	High-efficiency chillers are used in larger buildings to provide cooling. These systems use advanced technologies, such as variable speed drives (VSDs) and magnetic bearing compressors, to improve energy efficiency.	Commercial Buildings: Commonly used in large commercial buildings, hospitals, and industrial facilities where substantial cooling is required. Institutional Buildings: Suitable for schools, universities, and government buildings where reliability and energy efficiency are critical.	COPs of high-efficiency chillers can achieve 6.0 to 7.0 or higher, depending on the system design and conditions. The EER of these chillers can reach 20 or more, particularly when operating under part-load conditions.

7.3.5 Lighting

Lighting also directly influences both energy consumption and occupant comfort. Advances in lighting technologies have made it possible to significantly reduce energy use while enhancing the quality of light in buildings. Among these technologies, LED (Light Emitting Diode) lighting stands out as the most efficient and sustainable option, and it should be a priority in all green building projects. Generally speaking, LED is not only more energy efficient, but they are more durable, and the costs are now more accessible.

Type	Examples	Description	Application	Performance
LED Lighting	Solid-State Lighting	LED lighting is the most energy-efficient and rapidly developing lighting technology available. LEDs use semiconductors to convert electricity into light, resulting in a highly efficient light source that consumes significantly less energy than incandescent or fluorescent bulbs. LEDs are available in a variety of colors and intensities, offering flexibility in lighting design.	Suitable for residential, commercial, industrial, and institutional buildings. LEDs can be used for general lighting, task lighting, accent lighting, and outdoor lighting.	**Lumens per watt (lm/W):** Modern LEDs can achieve over 150 lm/W, far surpassing the efficiency of traditional lighting technologies. **Lifespan**: LEDs typically last between 50,000 to 100,000 hours, significantly longer than incandescent or fluorescent bulbs.
Daylight harvesting systems	Automated lighting control	Daylight harvesting systems automatically adjust the artificial lighting in a space based on the amount of natural light available. These systems use sensors to detect daylight levels and dim or brighten electric lights, accordingly, ensuring consistent lighting levels while reducing energy consumption.	Commercial and institutional buildings: Particularly effective in office buildings, schools, and retail spaces where daylight is plentiful.	Lighting power density (LPD) reductions can reach 20-60%, depending on the availability of natural light. Energy savings: daylight harvesting systems can save 35-60% of lighting energy use in well-lit spaces.
Adaptive Lighting Systems	Smart Lighting Control	Adaptive lighting systems adjust the intensity and color temperature of lights in response to environmental factors, such as time of day, occupancy, and daylight levels. These systems use advanced sensors and algorithms to optimize lighting for energy efficiency and comfort	Commercial and Institutional Buildings: Ideal for offices, healthcare facilities, and educational institutions where lighting needs change throughout the day.	Energy savings can reach 30-70% depending on the complexity of the system and building usage patterns. Lighting quality: Adaptive systems maintain optimal lighting conditions, adjusting to the

				needs of the space and occupants.

7.3.6 Water heaters

Water heating is a significant energy consumer in both residential and commercial buildings. Implementing energy-efficient water heating technologies is crucial for reducing overall energy consumption, lowering greenhouse gas emissions, and improving the sustainability of a building. Below are key water heating technologies that green buildings should prioritize.

Type	Examples	Description	Application	Performance
Tankless (on-demand) water heaters	N/A	Tankless Water Heaters, also known as on-demand water heaters, heat water only when it is needed, rather than storing hot water in a tank. These systems use gas or electricity to heat water directly as it flows through the unit, providing an endless supply of hot water without the standby energy losses associated with traditional tank heaters.	Residential and commercial buildings: suitable for homes, apartments, and businesses with varying hot water demand. Particularly effective in small spaces where the footprint of a storage tank is a concern.	The energy factor: Typically ranges from 0.8 to 0.95 for gas models and 0.98 or higher for electric models, indicating high efficiency.
Heat pump water heaters (HPWHs)	N/A	Heat pump water heaters work by transferring heat from the surrounding air or ground to heat water, rather than generating heat directly. These systems are much more efficient than conventional electric or gas water heaters, especially in moderate climates.	Residential and Commercial Buildings: Ideal for buildings in moderate climates or where solar water heating is less feasible. Commonly used in residential settings, hotels, and small commercial buildings.	COPs of HPWHs typically have a COP of 3.0 to 4.5, meaning they produce three to four times more heat than the electrical energy they consume. Energy Factor: Typically ranges from 2.0 to 3.5, indicating overall efficiency
Low-flow fixtures	Conservation measure	Low-flow fixtures include faucets, showerheads, and aerators designed to reduce water flow without compromising performance. By restricting the amount	Residential and Commercial Buildings: Suitable for bathrooms, kitchens, and any area where hot water is used regularly.	Low-flow showerheads typically have flow rates of 5.7 to 7.6 liters per minute (L/min), compared to standard

		of water that flows through, these fixtures significantly reduce the amount of hot water used, thereby decreasing the energy required to heat it.		showerheads, which can use up to 9.5 L/min or more. Low-flow faucets typically reduce flow to 1.9 to 5.7 L/min.
Hot water recirculation systems	Efficient water distribution	Hot water recirculation systems circulate hot water through the plumbing system so that it is always readily available at the tap. This minimizes the time spent running water while waiting for it to heat up, thereby reducing both water and energy waste. These systems can be controlled by timers, sensors, or demand-based controllers to further optimize efficiency.	Residential and commercial buildings: Particularly useful in large buildings or homes with long plumbing runs where it takes significant time for hot water to reach the fixtures.	Energy savings: Modern systems with efficient pumps and controls can reduce water heating energy use by 10-30%.
Insulating hot water pipes	Conservation measure	Pipe insulation involves wrapping hot water pipes with insulating materials to reduce heat loss as water travels through the plumbing system. This helps maintain water temperature, reduces the energy needed to reheat water, and minimizes wait times for hot water at the tap.	Residential and Commercial Buildings: Applicable to all types of buildings, especially those with long plumbing runs or where pipes are exposed to cooler environments.	Energy savings: Can reduce heat loss by 25-45%, depending on the thickness and material of the insulation.
Temperature control settings	Thermostat adjustment	Adjusting the thermostat on water heaters to a lower, more efficient temperature can significantly reduce energy use. The recommended temperature for most domestic hot water systems is 49°C. This temperature is sufficient for most household needs and reduces the	Residential and commercial buildings: Applicable in all settings where hot water is used, particularly in households, hotels, and institutional buildings.	Energy savings: Lowering the water heater temperature by 5.5°C can reduce energy use by 3-5%. Safety: Reduces the risk of scalding injuries, especially in homes with

		risk of scalding, while also minimizing energy consumption.		children or elderly residents.
Water heater timers	Energy management device	Water heater timers allow users to control when their water heater is active, ensuring it only operates during times of high demand. This prevents energy wastage during periods when hot water is not needed, such as overnight or during work hours.	Residential and commercial buildings: Ideal for homes and businesses where hot water demand can be predicted or scheduled.	Energy Savings: Can reduce water heating energy use by 5-12% depending on the building's occupancy patterns and hot water usage.

7.3.7 Renewable energy systems in green buildings

Renewable energy systems are an important element of green building design, helping to reduce reliance on fossil fuels, lower greenhouse gas emissions, and achieve energy independence. Solar energy, in particular, offers a versatile and abundant resource that can be harnessed in various ways to meet a building's energy and water heating needs. Below is an overview of key solar technologies that should be prioritized in green building projects.

Type	Examples	Description	Application	Performance
Solar Photovoltaic (PV) Systems	PV Panels PV Windows	Solar Photovoltaic (PV) Systems convert sunlight directly into electricity using semiconductor materials, typically silicon-based solar cells. These systems can be installed on rooftops, building facades, or ground-mounted arrays, and are suitable for both on-grid and off-grid applications. Solar PV systems can be designed to meet part or all of a building's electricity needs, significantly reducing dependency on grid electricity. There are different technological options for the implementation of PV including the	Residential, Commercial, and Institutional Buildings: Ideal for homes, offices, schools, and industrial facilities. PV systems are versatile and can be scaled according to the energy demands of the building.	Panel efficiency: Modern solar PV panels achieve efficiencies of 15-22%, with some advanced technologies exceeding 22%. Annual energy production: In Zimbabwe, a well-designed PV system can produce over 1,500 kWh/m²/year, depending on location and solar radiation levels.

		blending of PV components into roofing, window, and other materials.		
Solar water heating (SWH) systems	Solar thermal applications.	SWH Systems use solar collectors to capture and transfer solar thermal energy to heat water. These systems typically consist of flat-plate collectors or evacuated tube collectors and a storage tank. Solar water heaters can be used in both residential and commercial buildings to provide a significant portion of the hot water demand.	Residential and commercial buildings: Suitable for homes, hotels, hospitals, and any building with high hot water demand. Particularly effective in sunny climates like Zimbabwe.	Solar fraction: Typically provides 50-80% of a building's hot water needs. Efficiency: High-performance systems can achieve efficiencies of 60-70%, converting a significant portion of solar energy into usable heat.
Solar tubes or tubular daylighting devices (TDD)	Solar daylight applications	Solar tubes or TDDs capture and channel natural sunlight through reflective tubes into interior spaces. These devices are highly efficient in bringing natural light into areas that lack direct access to windows, reducing the need for artificial lighting during the day and thereby saving energy.	Residential and commercial buildings: Ideal for interior rooms, hallways, bathrooms, and spaces with limited access to natural light.	Light output: TDDs can deliver the equivalent of up to 1,000 watts of incandescent light during peak daylight hours. Energy Savings: Solar tubes can significantly reduce the need for artificial lighting, leading to substantial energy savings, especially during daytime hours.

7.3.8 Building sensors and controls for energy efficiency

Building sensors and controls are an important component in the management of modern green buildings, enabling precise monitoring, control, and optimization of energy use across a variety of systems (importantly HVAC, lighting, and water heating). These technologies enhance energy efficiency by ensuring that heating, ventilation, air conditioning (HVAC), lighting, and other building systems operate only when and as needed. Whole-building management systems integrate these controls to provide comprehensive oversight and optimization of a building's energy performance.

Type	Examples	Description	Application	Performance

Building energy management systems (BEMS)	Whole-building energy management	Building energy management systems (BEMS) are integrated systems that monitor and control a building's energy consumption across all end-uses, including HVAC, lighting, water heating, and other systems. BEMSs collect data from various sensors installed throughout the building and use this information to optimize the operation of energy-consuming systems. This can involve adjusting settings based on occupancy, time of day, weather conditions, and energy demand.	Commercial, industrial, and large residential buildings: BEMS are ideal for complex buildings with multiple systems requiring coordinated control to optimize energy use.	Energy savings: BEMS can reduce overall energy consumption by 10-30% by ensuring systems operate at peak efficiency. Real-time monitoring: Provides continuous data on energy use, enabling proactive management and quick identification of inefficiencies.
Occupancy Sensors	Lighting and HVAC controls	Occupancy sensors detect the presence or absence of people in a room and automatically adjust lighting, HVAC, and other systems accordingly. These sensors use infrared, ultrasonic, or microwave technologies to detect occupancy and can be used to turn off lights, reduce HVAC operation, or adjust other systems when spaces are unoccupied.	All building types: Commonly used in offices, conference rooms, restrooms, corridors, and any area with variable occupancy.	Energy savings: Occupancy sensors can reduce lighting and HVAC energy use by 20-50%, depending on the building's occupancy patterns. Response time: Modern sensors provide near-instantaneous response to changes in occupancy, minimizing energy wastage.
Smart thermostats	HVAC Control	Smart Thermostats provide advanced control over HVAC systems by learning user preferences and automatically adjusting heating and cooling based on occupancy, weather, and other factors. These thermostats can be controlled remotely via	Residential and commercial buildings: Suitable for any building where precise control of HVAC systems can improve energy efficiency and comfort.	Energy savings: Smart thermostats can reduce heating and cooling energy use by 10-20% by optimizing system operation based on real-time conditions. Learning algorithms: Many

		mobile devices and often integrate with BEMS or other smart home systems.		smart thermostats learn user behavior over time, further enhancing energy efficiency and comfort.
Daylight sensors	Lighting control	These sensors (or daylight harvesting sensors) automatically adjust the intensity of artificial lighting based on the amount of natural light available. These sensors help maintain consistent lighting levels while minimizing the use of electric lights during daylight hours.	Commercial and institutional buildings: particularly effective in office spaces, schools, and retail environments where daylight can be harnessed to reduce energy consumption.	Energy savings: Can reduce lighting energy use by 20-60% depending on the amount of natural light available. Lighting quality: Ensures optimal lighting levels are maintained, improving occupant comfort and productivity.
Advanced metering systems	Energy monitoring and reporting	Advanced metering systems provide detailed monitoring of energy consumption for electricity, gas, water, and other utilities. These systems enable real-time tracking of energy use, identifying inefficiencies and areas for improvement. They are often integrated with BEMS for comprehensive energy management.	All building types: Suitable for buildings of all sizes, particularly those aiming for high levels of energy efficiency and sustainability certification.	Energy savings: Advanced metering can help identify and eliminate inefficiencies, potentially reducing overall energy use by 5-15%. Data accuracy: Provides precise, real-time data that can be used to optimize energy use and reduce costs.

7.3.9 Low-carbon building materials

Low-carbon building materials are essential in green building design, significantly reducing the carbon footprint associated with construction and building operations. These materials are characterized by their low embodied energy, minimal greenhouse gas emissions during production, and often by their ability to sequester carbon. Utilizing locally sourced and sustainable materials further enhances their environmental benefits by reducing transportation emissions and supporting local economies. Below are key low-carbon building materials, with a focus on those that are locally relevant and sustainable.

Type	Examples	Description	Application	Performance

Compressed stabilized earth blocks (CSEB)	Locally sourced and manufactured building material	CSEB are made from a mixture of soil, sand, and a small amount of cement or lime, which is then compressed into blocks. CSEB offers a sustainable alternative to traditional fired bricks, with much lower energy requirements for production. These blocks can be produced on-site or near the construction site, reducing the need for transportation and associated emissions.	Residential and commercial buildings: Ideal for walls, partitions, and load-bearing structures in residential and low-rise commercial buildings. CSEB is particularly suitable for buildings in regions with abundant natural soil resources, such as rural areas of Zimbabwe.	Thermal insulation: CSEB offers good thermal mass, helping to regulate indoor temperatures by absorbing and slowly releasing heat. Significantly lower embodied carbon compared to fired bricks or concrete blocks, as the production process requires minimal energy. CSEB supports local industries and reduces the environmental impact of transporting materials over long distances
Recycled aggregates	Recycled building material	Recycled aggregates are made from crushed concrete, bricks, and other demolition waste. These materials can be used in new concrete production, road bases, and other construction applications. Using recycled aggregates reduces the need for virgin materials, conserves natural resources, and decreases the environmental impact of construction activities.	Infrastructure, Residential, and Commercial Buildings: Used in concrete production, road construction, and as a base material for foundations and pavements.	Strength: Recycled aggregates can achieve comparable strength and durability to traditional aggregates when properly processed and used in the right proportions. Sustainability: By reusing construction waste, recycled aggregates reduce the environmental impact of both waste disposal and the extraction of natural resources.
Low-carbon concrete	Sustainable construction material	Low-Carbon Concrete incorporates alternative materials and production methods to	Residential, Commercial, and Infrastructure Projects: Used in	Carbon footprint: Reduces embodied carbon by up to 30-50% depending

		reduce its carbon footprint. This includes the use of supplementary cementitious materials (SCMs) such as fly ash, slag, and silica fume, which partially replace Portland cement—one of the most carbon-intensive components of traditional concrete. Low-carbon concrete can also include recycled aggregates and innovative techniques such as carbon capture and storage during production.	foundations, slabs, columns, and other structural components where traditional concrete is commonly applied.	on the proportion of SCMs and other low-carbon technologies used. Resource efficiency: Promotes the use of industrial by-products and reduces reliance on virgin materials.
Recycled steel	Recycled building material	Recycled steel is steel that has been recovered and reprocessed from old buildings, vehicles, and other sources. Using recycled steel significantly reduces the energy required for production compared to producing new steel from iron ore. Recycled steel can be used in the same applications as new steel, including structural frameworks, reinforcements, and building components.	Commercial, industrial, and residential buildings: Commonly used in structural framing, reinforcements, roofing, and cladding.	Reduces embodied carbon by up to 70% compared to new steel production, as recycling steel requires significantly less energy. Reduces the need for mining and processing raw materials, promoting the circular economy.
Green steel (low carbon steel)	Low-carbon construction material	Green steel refers to steel produced using processes that significantly reduce carbon emissions compared to traditional steelmaking methods. This can be achieved through several innovative approaches, such as using hydrogen instead of carbon as a reducing agent in steel production, utilizing renewable energy sources for electric arc	Residential, commercial, and industrial buildings: Used in structural frameworks, reinforcements, roofing, cladding, and various other construction applications where steel is typically employed.	Significantly reduces embodied carbon by up to 90% compared to traditional steelmaking. Contributes to decarbonizing the construction industry, which is crucial for achieving global climate goals. Green steel production also encourages the

		furnaces, and incorporating carbon capture and storage (CCS) technologies. Green steel aims to maintain the high performance and durability of conventional steel while minimizing its environmental impact.		development of sustainable supply chains.

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