

Modelling Protocol Guidelines

Development of Green Building Standards for Zimbabwe

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1 Scope

This document outlines the standard inputs and assumptions required for modelling the building envelope, cooling systems, lighting, and other internal loads of buildings. These standard inputs include operational usage and occupancy profiles, which enable a consistent basis for comparing different building designs.

The document is based on the proposed Zimbabwe Building Energy Efficiency Code (BEEC), which sets out the methodology needed to comply with building energy requirements through a performance-based route to compliance. This approach ensures that building designs are evaluated on their actual energy performance against established benchmarks, facilitating a practical pathway to meet the energy efficiency standards set out in the code.

2 Definitions

The terms and definitions given in the following section apply to support the modelling principles in this manual.

Building energy performance

This refers to the total annual energy consumption per square meter that is permitted for each building class in accordance with the BEEC and the standards that were established to serve the BEEC. This is expressed as an energy intensity by dividing the annual energy use by the net floor area of the building under design.

Certified thermal modelling software

This refers to Software tools that have met one of the following quality testing procedures requirements to ensure that the results are significant:

- Passed the BESTEST 1 validation test
- European Union draft standard EN13791 July 2000, or
- be tested in accordance with ANSI/ASHRAE Standard 140- 2001

Coefficient of performance (COP)/Energy Efficiency Ratio (EER)

This is measure of the efficiency of heating and cooling equipment for a building. This measure describes the ratio of cooling or heating power that is provided by a compressor system compared to input power measured under standard conditions for unitary air-conditioning units, for water chillers and for air to water heat pumps.

Net floor area

The net floor area is the total building area, excluding the area occupied by vertical elements, including enclosed lift wells and enclosed stairs. This is a measure of the total useful area in a building.

Building energy performance assessment

This is an assessment by a qualified operator of the adequacy of performance of a solution in relation to the requirements including, as necessary, a process of reasoning, calculation and consideration of accepted analytical principles, based on a combination of deductions from available information, research and data, appropriate testing and service experience.

3 General methodology

3.1 Key principles of energy modelling

Energy modelling in this context refers to the generation of computer simulations of the energy performance of buildings and their energy systems to estimate energy consumption and compare it to the requirements in the standards. For the purposes of the Zimbabwe Building Energy Efficiency Code

(BEEC), this process involves developing simulation models for both the proposed building design and a reference building with the same geometry as the proposed design. The inputs for these models need to follow the parameters specified by the BEEC to ensure consistency.

Building materials for both the proposed and reference buildings must be modelled accurately, and all equipment installations should be controlled through schedules that define how and to what extent equipment is used throughout each hour of a standard modelled year (8,760 hours). The simulation should incorporate climate data that reflects representative values for temperature, solar radiation levels, and other climatic variables for the location of the buildings to allow for a more accurate analysis of annual energy usage.

Comparisons between the proposed and reference buildings must be conducted using certified computer modelling software, ensuring that the results are consistent and reliable. The BEEC provides a number of suitable options for this process.

3.2 Modelling the reference case

To enable the comparison of performance in different scenarios of construction, a reference case is required. The reference building is a building in the same location, with the same orientation and with the same geometry and functionality as the proposed building. The building is modelled using certified thermal calculation software with areas of glazing, shading design and building fabric and the performance thereof in accordance with the minimum prescriptive requirements of the BEEC and as codified in this document. Climatic data, systems operating schedules and occupancy assumptions shall be in accordance with the requirements of this document.

3.3 Modelling of the proposed building

The proposed building refers to the building design submitted by the architects or developers to the regulatory authority (local or city council is proposed) for approval, which includes the architectural, mechanical, and electrical designs. The key parameters in the design must be modelled using certified thermal calculation software.

The climatic data, systems operating schedules, and occupancy assumptions for the proposed building must be calculated in accordance with the requirements outlined in this document, using the actual systems and materials specified by the respective professionals involved in the project. This approach ensures that the proposed building's energy performance is accurately assessed and aligns with the standards set forth in the BEEC.

In effect, this means that the modelling principles should be the same for both, the reference building and the proposed building with only variations happening in the parameters of the actual building design such as insulation, materials used, WWR, etc.

3.4 Energy Performance reporting

Energy performance reporting should be conducted by calculating the annual average monthly energy demand per square meter, as well as the total annual energy consumption per square meter of the building's net floor area. These metrics are expressed in kilowatt-hours per square meter per annum (kWh/m²/year) and collectively referred to as the building's annual energy intensity.

To ensure consistency and accuracy, both the energy performance results, and the simulation inputs must be entered into the BEEC energy calculator. This tool standardizes the reporting process by allowing users to input data on energy use, system operations, and building specifications. The BEEC energy calculator then processes this information to produce a comprehensive energy performance report, facilitating comparisons across different designs and helping to verify compliance with the energy efficiency requirements of the BEEC.

3.5 General modelling requirements

The table below provides a general set of requirements for different components of the modelling process

Table 1: General modelling requirements

Parameters	Requirements	Reporting requirements
Simulation package	That meets the requirements for one of the following: <ul style="list-style-type: none"> • BESTEST 1 validation test. • The European Union draft standard EN13791 July 2000 • ANSI/ASHRAE Standard 140-2001. 	Declaration of which form of certification is met
Weather data	A test reference year (TRY), if the building location is within 50 km of a TRY location; or A TRY generated by suitable software for the building location or within 50 km thereof.	Type of data Weather station location
Overshadowing	Show correct implementation of overshadowing by adjacent structures and landscape in report.	Details of how overshadowing from the external environment has been represented in the model.
Space type breakdown	Demonstration that the correct space types have been allocated in the building, and that the correct areas have been used.	Description thereof in report.
Building orientation	Provide information of the building orientation in the report.	Image of orientation from drawings

3.6 Building envelope requirements

The settings the parameters for the reference building and the proposed building are explored in the following table:

Table 2: Building envelope parameters for the reference and proposed buildings.

Parameter	Reference building	Proposed building	Reporting requirements
Geometry	Building form and size shall be in accordance with the proposed building design.	The building form and size shall be in accordance with the proposed building design. All elements of the proposed building shall be modelled in accordance with the design documents. Where assumptions are made,	Details of how the building's physical shape has been represented in the model. Details of any simplifications in the model, demonstrating a conservative approach

		they shall be shown to be conservative.	
All floors	Shall be the same as the proposed building.	Shall be in accordance with the proposed building design.	Image of section and material description
Exterior wall construction	Standard 300mm concrete block with R-value of 0.3 m ² -K/W	As per design but aiming to meet BEEC requirements. If proposed building uses standard concrete blocks, the same input parameters as reference case are to be used.	Image of section and material description.
Roof	Aluminium roof with 50mm of insulation. Insulation to have a k-value of 0.04 W/m-K	Shall be indicated in accordance with the proposed building design.	Image of section and material description.
Vertical glazing window to net floor area	The reference building glazing shall be 20 % fenestration area to wall area per storey, no shading is to be included for the reference case	Actual fenestration requirements shall be indicated. Only permanent, external shading devices shall be considered in the model, The effect of internal blinds shall not be considered.	Elevations and sections showing glazing area and shading.
Vertical glazing performance	U-Value: 5.6 (W/m ² K) SHGC: 0.8	Actual glazing specifications, window sizes, shading devices and positions shall be used. Where data sheets are not available, the reference case inputs are to be used.	Description of glazing specification and indication of U –value and SHGC.
Skylight/roof lights	No skylights are to be included in the reference case.	Skylight glazing area shall be in accordance with the actual design. Thermal performance shall be in accordance with the actual design.	Description of glazing specification and indication of U –value and SHGC.

3.7 Internal load inputs

In terms of the energy loads relating to lighting, cooling, and other energy related activities for the reference building and the proposed buildings also need to be consistent to ensure that the results are comparable. The proposed settings are the following table:

Table 3: Setting for internal building energy demand.

Parameter	Reference building	Proposed building	Reporting requirements
Indoor design temperature setpoint	Cooling setpoint of 24 0C.	Cooling setpoint of 24 0C	State in report
Occupancy	As per proposed design	As per design.	State in report
Internal lighting- residential	6 W/m2	In accordance with the proposed building lighting design	Lighting power density to be reported in W/m2
Internal lighting - office	8 W/m2	In accordance with the proposed building lighting design	Lighting power density to be reported in W/m2
Equipment allowance - Residential	3 W/m ²	As per reference building	State in report.
Equipment allowance - Residential	11 W/m ²	As per reference building	
Fresh air rates	As per proposed building	As per design	State relevant fresh air rates in report
Design occupancy times	Operational schedules in accordance with Appendix A	As per reference building	State in report

3.8 HVAC systems

It is generally assumed that all areas of the building with a useful purpose are required to be modelled with air conditioning. However, certain spaces can be exempted from this requirement include:

- Toilets and bathrooms
- Storage spaces

3.8.1 Proposed building HVAC systems

All HVAC components must be modelled exactly as designed, using the actual equipment capacities specified by the mechanical engineer. These capacities should be accurately reflected in the simulation and documented in the report.

The HVAC system simulation must include considerations for:

- a) The coefficient of performance (COP) of the equipment.
- b) Energy consumption by fans
- c) Energy consumption by pumps, if applicable.

3.8.2 Naturally ventilated buildings

For buildings or specific areas that will not have artificial ventilation, heating, or cooling, theoretical heating and cooling energy must be calculated as if such systems were installed. This ensures that the building or relevant areas can achieve thermal comfort within the temperature ranges specified in this document.

3.8.3 Reference building cooling systems

The reference building is required to be modelled with a cooling system, regardless of whether the proposed building includes such equipment. The cooling system for the reference building should be a split unit type with a coefficient of performance (COP) of 2.5, to provide a consistent basis for comparison.

4 Schedules of Operation

Another factor to ensure the comparability of the modelling is to ensure that the load factors in terms are the usage of equipment statistics. This annex provides a recommended schedule:

Table 4: Residential schedule of operation.

Hour of the day	Lighting	Equipment	HVAC
1	0	0.2	1
2	0	0.2	1
3	0	0.2	1
4	0	0.2	1
5	0	0.2	1
6	0.2	0.2	1
7	0.4	0.7	1
8	0.5	0.7	1
9	0.3	0.2	1
10	0.1	0.2	1
11	0.1	0.2	1
12	0.1	0.7	1
13	0.1	0.2	1
14	0.1	0.2	1
15	0.1	0.2	1
16	0.1	0.6	1
17	0.1	0.6	1
18	0.2	0.7	1
19	0.5	0.7	1
20	1.0	0.7	1
21	1.0	0.6	1
22	0.5	0.6	1
23	0.5	0.2	1

Table 5: Non-residential schedule of operation

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