Multi Unit Residential
v1

Green Star SA - Multi Unit Residential v1

DTS & ENERGY MODELLING PROTOCOL GUIDE

Version 1.0

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GREEN BUILDING COUNCIL
OF SOUTH AFRICA

Green Star SA Multi Unit Residential v1

DTS & Energy Modelling Protocol Guide

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Contents

1 Introduction

The Green Star SA – Multi Unit Residential rating tool has been developed to evaluate the predicted performance of multi unit residential developments based on a variety of environmental criteria.

With regards to the credits Ene-0 Conditional Requirement and Ene-1 Greenhouse Gas Emissions – Heating & Cooling, to enable alternative compliance routes for projects which may not have the resources to completed detailed energy modelling, two 'Compliance Routes' have been provided for in Ene-1 Greenhouse Gas Emissions;

- ***Compliance Route 1 (CR1)***; This compliance route requires Project Teams to complete detailed computer modelling to determine the proposed or constructed building or dwelling's energy efficiency improvement and greenhouse gas emissions reduction from a notional building or dwelling. This is similar to the requirements of the existing Green Star SA rating tools (Office v1 and Retail Centre v1). This compliance route provides for accurate analysis of a proposed or constructed building or dwelling's passive performance (i.e. building fabric and orientation) and the building or dwelling's active systems (i.e. active heating or cooling systems), with the maximum points available for improved performance as 10 points;

  OR

- ***Compliance Route 2 (CR2)***; This compliance route offers Project Teams an alternative, less complicated method of claiming points within the Ene-1 credit and is 'deemed-to-satisfy' (DTS) route. In this route, specific design initiatives are itemised and points awarded upon meeting the prescribed requirements. Although this is a less complex compliance route, the prescriptive nature of a DTS approach is limited in design flexibility. Hence the maximum number of points awarded within this compliance route is 6 points.

This DTS & Energy Modelling Protocol Guide is separated into two main sections, one pertaining to Compliance Route 1 (CR1) and the other pertaining to Compliance Route 2 (CR2). The user should reference this Guide as per the compliance route selected.

2 Acknowledgements

The Green Building Council of South Africa acknowledges the work of technical consultant Arup in development of the Deemed-to-Satisfy (DTS) and Modelling Methodology for the South African Green Star SA Multi Unit Residential v1 tool.

Compliance Route 1 - Modelling

3 CR1 - Modelling Methodology

3.1 Overview

The Energy Calculator within the Green Star SA – Multi Unit Residential v1 tool compares the predicted energy consumption of heating and cooling systems within the building or dwellings to a benchmark based on a notional (reference) building or notional (reference) dwelling of the same size as the actual building or dwellings and in the same location and complying with various standards and schedules (including aspects of SANS 204:2011). The greenhouse gas emissions associated with the heating and cooling system consumption are determined by the calculator, and points are awarded to buildings or dwellings which improve upon the notional building or dwelling benchmark (i.e. lower greenhouse gas emissions).

To use the calculator, the predicted energy consumption of both the actual dwellings and the notional dwellings must be calculated. The key component of this calculation is the heating and cooling energy consumption of the dwellings, which must be determined using computer modelling. This guide specifies standard inputs to be used when modelling the heating and cooling systems.

Please note that, unlike the GBCSA Green Star SA Office v1 and Retail Centre v1 tools, in the Green Star SA Multi Unit Residential v1 tool, the Ene-1 credit only includes energy use from heating and cooling systems. Energy used for producing hot water, for lighting, for appliances and for common property is covered by other credits, and is therefore excluded from the energy modelling in Ene-1.

Finally, this guide includes information on how to enter the simulation outputs into the Green Star SA Multi Unit Residential v1 rating tool Energy Calculator. The calculator converts the energy use into greenhouse gas emissions and indicates the percentage improvement of the actual dwellings compared to the notional dwellings. Points are awarded based on 0 points for no improvement, up to a maximum of 10 points for a building with 75% reduction in operating emissions.

Improvement beyond the notion building or dwelling performance can be achieved through either, or a combination of, passive design initiatives (i.e. building fabric and orientation) or improved active performance (i.e. improved efficiency of active heating or cooling systems).

3.2 Simulation Requirements

For compliance route 1 the dwellings must be simulated using computer modelling software in order to determine the predicted energy consumption of their Heating, Ventilation and Cooling (HVAC) systems.

It is acceptable for dwellings with non-centralised systems such as split units to determine the total cooling and heating electricity use simply by using the seasonal COP of the unit and the predicted total heating and cooling (both sensible and latent) required. Larger central systems that have significant auxiliary energy requirements such as pumps and fans require thorough calculations which take into account all energy uses.

Only one instance of each dwelling type as defined in the Green Star SA – Multi Unit Residential v1 Technical Manual needs to be modelled.

If several dwelling types are contained within one building, it is acceptable to model the dwellings together as one model provided that the HVAC systems are accurately reflected. If modelling dwellings individually, walls between dwellings may be considered to be adiabatic (i.e. no energy flow from one dwelling to another).

3.3 Model Notional (reference) Dwellings

Dwellings in the same location and with the same geometry as the actual dwellings are modelled, with defined areas of glazing, fixed fabric performance, natural ventilation and HVAC systems performance. The dwellings must be modelled in accordance with the requirements and specifications for the notional dwelling as put forward in this document.

3.4 Model Actual Dwellings

The actual dwellings area modelled, using exactly the same simulation software and weather data as the model of the notional dwellings, but with the actual building fabric and HVAC systems.

3.5 Energy Calculator

The energy use predicted by the models above for the notional and the actual dwellings are entered into the calculator. The calculator produces an estimate of the greenhouse gas emissions ($kgCO_2/m^2/year$) for both the notional and the actual dwellings HVAC systems.

The final Ene-1 point score is awarded based on the percentage improvement of the actual building compared to the notional building in terms of “base building” greenhouse gas emissions, on a linear scale with 0 points representing no improvement and 10 points representing a building with 75% reduction in HVAC operating emissions.

3.6 Dwellings without HVAC systems

Please refer to *Section 8 Passive Cooling & Heating Systems* for details on modelling dwellings provided with passive heating or cooling systems.

3.7 Occupied Space Below Ground

If the actual building contains regularly occupied (habitable) space below ground, the notional building should be modelled as if the lowest regularly occupied floor were at ground level. Note that car parking is not counted as regularly occupied space.

4 CR1 - Guidelines for Modelling Parameters

The parameters for simulation of energy consumption of a Multi Unit Residential building or dwelling are given in this section. These are standard criteria that must be adhered to in ordered to comply with the Green Star SA – Multi Unit Residential Ene-1 Compliance Route 1 credit requirements. The outputs from this simulation will then be entered in the calculator, as outlined in the following section.

Whenever assumptions are used, they must be justified in the Energy Report and must be conservative assumptions.

4.1 General Modelling Parameters

The following requirements refer to both the modelling of the notional dwellings and the actual dwellings. The same simulation package and weather data must be used for both models.

Modelling Parameter	*Criteria*	*Documentation Requirements*
Simulation Package	• Passed the BESTEST[1] validation test; or • The European Union draft standard EN13791 July 2000; or • Be tested in accordance with ANSI/ASHRAE Standard 140-2001. AND • Be capable of simulating natural ventilation and mixed mode HVAC operation. Please contact the Green Building Council of South Africa if none of the above options can be complied with.	Energy Report: • Simulation brief for assessor (see Appendix A).

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[1] The International Energy Agency, working with the U.S. National Renewable Energy Lab, has created a benchmark for building energy simulation programs. This benchmark is entitled "BESTEST – International Energy Agency Building Energy Simulation Test and Diagnostic Method".

Weather Data	- A Test Reference Year (TRY) if the building location is within 50km of a TRY location; or - In the absence of local TRY weather data, an actual year of recorded weather data from a location within 50km of the building location and 200m altitude of the building location; or - In the absence of TRY or actual weather data within 50km, interpolated data based upon 3 points within 250km of the building location. Weather data can be obtained using the Meteonorm software.	Energy Report: - Type of data (TRY / year / interpolated). - Weather station location.

Table 1.1: General Parameters Table

4.2 Space Breakdown

Modelling Parameter	*Criteria*	*Documentation Requirements*
Space Type Breakdown	- Demonstrate that the correct space types have been allocated in the building, and that the correct areas have been used.	Verification Documents: - Design or as-installed (where appropriate) floor plans showing the location of each different space type as used in the calculator. Energy Report: - Details of how each relevant space type was chosen for each section of the building.

4.3 Building Envelope

	Notional (reference) Building	Actual Building
Geometry	Geometry based on actual geometry of building	Geometry based on actual geometry of building
Orientation	Model in four orientations (actual, actual+90°, actual+180° and actual+270°) and take the average heating and cooling energy use.	Use actual orientation.
Fabric	• External walls to be brick cavity walls with insulation to comply with the compulsory requirements of Compliance Route 2 Part A. • Internal walls to be 100mm brick. • Roof insulated to comply with the Compliance Route 2 part C.	Fabric as actual fabric
Glazing	• Windows U value 5.6 and SHGC 0.77 (clear single glazing, timber framed). Windows to be distributed on all sides of the building such as to achieve both the following requirements of Compliance Route 2 Part D. ○ C_U compulsory requirement ○ C_{SHGC} requirement	Use actual glazing properties
Infiltration rate	0.5 air changes per hour.	0.5 air changes per hour or as per façade design specification.

Table 1.2: Building envelope parameters - Specific

4.3.1 Modelling infiltration in buildings with natural ventilation

Certain programs calculate infiltration dynamically using flow coefficients and it is not possible to apply a constant air change rate. An example is DesignBuilder that applies a crack template when dynamically calculated natural ventilation is selected, which may be required for the actual building model.

In these cases project teams should either:

- Justify that the coefficients used are applicable to their building based on the façade design specification and that all background ventilation systems (such as air bricks) have been included; OR
- Include a mechanical ventilation system to simulate infiltration. The fan pressure rise should be set to zero such that no heat from the fan motor enters the air stream and no fan energy should be included in the results.

Modelling Parameter		*Criteria*	*Documentation Requirements*
Geometry	Building Form	• Demonstrate that the simulation model is an accurate representation of the building's shape; • Demonstrate that all floors in the building are modelled; and • Show that there are limited simplifications to the building form.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. Energy Report: • Details of how the building’s physical shape has been represented in the model. • Details of any simplifications in the model and their effect, demonstrating a conservative approach.
	Shading	• Demonstrate that all shading of windows and external building fabric are accurately represented. • Shading devices need not be included in the notional building if their primary purpose is to provide shade. Accessible balconies and similar structures should be included in both the notional and actual models.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. Energy Report: • Details of how window shading and external building fabric are represented in the model.
	Overshadowing	• Demonstrate that overshadowing from the surrounding environment has been taken into account in the model.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings or an aerial photograph showing surrounding buildings. Energy Report: • Details of how overshadowing from the external environment has been represented in the model.
Orientation		• Demonstrate that the building orientation has been included in the model.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. Energy Report: • Details of how the orientation has been represented in the model.

Fabric	Construction	• Demonstrate that the construction makeup for walls, ceilings and floors has been accurately represented.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural section drawings; OR • Design or as-installed (where appropriate) materials schedule showing the construction makeup. Energy Report: • Details on how the material properties have been represented in the model.
	Insulation	• Demonstrate that insulation in the walls, ceiling and floors has been accurately represented.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings; OR • Design or as-installed (where appropriate) materials schedule. Energy Report: • Details on how the insulation properties have been represented in the model.
Glazing	Properties	• Demonstrate that glazing is modelled using the following parameters: ○ Solar transmission; ○ Internal and external solar reflectance; and ○ Emissivity. It is acceptable to model simplified glazing only using the U-value and Solar Heat gain coefficient if the software does not have the capability to model individual panes.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the glazing or façade specification. Energy Report: • Details of how glazing has been modelled. Demonstrate the total U-value and Solar heat Gain Coefficient (SHGC) used.
	Windows sizes	• Demonstrate that the sizes of windows and spandrel/frames are accurately represented.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. Energy Report: • Details of the window and spandrel sizes that have been used in the model.

Infiltration		- Demonstrate that the infiltration rate for the actual dwelling has been modelled to reflect façade design specification or the default value of 0.5 ach. - Demonstrate that the infiltration rate for the notional building is 0.5 air changes per hour.	Verification Documents: Where non-default infiltration rates are used: - Design or as-installed (where appropriate) relevant architectural drawings. - Relevant pages from the façade specification that show infiltration or façade sealing characteristics. Energy Report: - Clearly state how infiltration has been modelled. - If flow coefficients are used to dynamically calculate infiltration, justify the coefficients based on the façade documentation.

Table 1.3: Building envelope parameters – general

4.4 Internal Design Criteria

The dwelling and common areas should be separated into the following zones as defined in Appendix B:

- Kitchen
- Living Area
- Bathroom
- Bedroom
- Common area

	Notional (reference) Building	Actual Building
Internal design temperatures	ASHRAE-55 adaptive comfort 80% Acceptability Limits based on average annual temperature.	ASHRAE-55 adaptive comfort 80% Acceptability Limits based on average annual temperature.
Occupancy	As estimated in the GSSA Multi Unit Residential tool “Building Input” sheet.	As estimated in the GSSA Multi Unit Residential tool “Building Input” sheet.
Lighting	4 W/m²	4 W/m² or as actual design if fitout included in works
Equipment loads	4 W/m²	4 W/m²

Kitchen loads	150 W/occupant sensible 90W/occupant latent	150 W/occupant sensible 90W/occupant latent
Fresh Air rate	2 ach when windows are open (natural ventilation)	Actual design rate

Table 1.4: Internal Design Criteria - Specific

Hourly profiles of these loads as well as the split between latent and sensible loads must be as per the schedules given in Appendix C of this protocol.

4.4.1 Design temperatures

The cooling and heating setpoints are be based on the ASHRAE-55 adaptive comfort 80% Acceptability Limits to account for the fact that dwelling occupants are less likely to use an active heating or cooling system if they are used to the external conditions. The limits should be calculated as follows:

- Cooling Setpoint $T_{min} = 0.3 \times T_{ave} + 14.5$
- Heating Setpoint $T_{max} = 0.3 \times T_{ave} + 21.5$

Where T_{ave} is the average annual air temperature (for 24 hours per day) calculated from the weather file data.

4.4.2 Open plan areas

Open plan layouts that include living areas, kitchens and bedrooms may be combined into one zone if there are no walls separating the two. In this case the internal loads given in Appendix C for each zone type should be used.

Note that if a bedroom zone is included together with a kitchen or living area zone the HVAC profile should be active all day and night. The lighting profile for bedrooms differs from that in other areas and thus the profiles should be added together, when adding the profiles the peak remains e.g. between 7 am and 8am the load profiles for living areas and bedrooms are 60% and 50%, but the combined total is 100%.

4.4.3 Occupancy and Load Calculations

Occupancy is determined in the Multi Unit Residential tool input sheet, which estimates occupant numbers as follows:

- Dwelling Occupants = no. of bedrooms + 1

If a dwelling has several bedrooms or a combination of kitchens and living areas, the occupancy for each space is determined as:

- Bedroom occupancy (m^2/person) = Dwelling occupants ÷ combined area of all bedrooms.
- Kitchen or living room occupancy (m^2/person) = Dwelling occupants ÷ combined area of kitchen and living area(s).

Kitchen loads in are based on the number of dwelling occupants. Project teams may choose to enter loads on a per m^2 basis by using the following formula:

- Load in W/m^2 = Load in W/occupant ÷ Kitchen or living room occupancy

If a project has similar dwelling types, it is acceptable to calculate one living area occupancy [or one bedroom occupancy] that can be applied to all dwelling types as long as each dwelling has the same number of occupants and the combined kitchen/living area [or combined bedroom area] differs by less than 10%.

E.g. Three 2 bedroom dwelling types with a total of 9 occupants and combined kitchen/living areas of 100m^2, 102m^2, 105m^2 respectively can use a single occupancy of: (100+102+104)/9 = 34 m^2/person for kitchen/living areas.

However if the combined bedroom areas are 60 m^2 65 m^2 and 70 m^2 then a single occupancy cannot be used for all bedrooms.

This option is included to simplify the load inputs for projects with many dwellings that differ enough to prevent them from being selected as a single dwelling type, but not sufficiently to affect internal loads significantly.

Modelling Parameter	*Criteria*	*Documentation Requirements*
Internal design temperatures	• Demonstrate that the design temperature setpoints have been calculated based on the ASHRAE-55 80% Acceptability Limits using the average annual temperature.	Energy Report: • Details of the calculated setpoints. • Details on how the setpoint temperatures were calculated
Occupancy	• Demonstrate that the occupancy loads are split between similar zone types based on zone floor area. • Demonstrate that the appropriate occupancy profiles (see Appendix C) have been used in the model.	Verification Documents: • Area schedule. Energy Report: • Details of space type areas using the definitions in Appendix B • Details on how the loads have been modelled including the breakdown of latent and sensible loads. • Details on the occupancies used. Where a single occupancy has been calculated for several dwelling types a table demonstrating that the dwelling areas comply and showing the calculation for the single occupancy.
Lighting	• Demonstrate that lighting is calculated based on floor area. • Demonstrate that the appropriate operational profiles (see Appendix C) have been used in the model.	Verification Documents: If actual design values are used: • Area schedule. • Design or as-installed (where appropriate) Reflected ceiling plans showing each typical lighting layout. • Lighting calculations demonstrating lighting power density. Energy Report: • Details of space type areas using the definitions in Appendix B. • Details of how the lighting power densities have been modelled. • Details of how the operational profiles have been modelled.

Cooking & Equipment	• Demonstrate that all cooking/equipment loads are calculated based on occupancy and split between similar zone types based on zone floor area. • Demonstrate that the cooking/appliance loads are modelled using the operational profiles as prescribed in Appendix C.	Verification Documents: • Area schedule. Energy Report: • Details of space type areas using the definitions in Appendix B. • Details of the operational profiles used for cooking/appliances

Table 1.5: Internal Design Criteria – general

4.5 HVAC Systems Simulation

The HVAC system energy simulation for the notional building should include for a mixed mode system that allows for both natural ventilation at moderate temperatures and active heating and cooling at hot and cold temperatures. System zoning for the notional building should be as per the actual building.

	Notional (reference) Building		Actual Building
Cooling	Cooling is to be provided by split units with a total system seasonal COP (SCOP) of 3.0		As actual design
Heating	Heating is to be provided by heating heat pump with a total system seasonal COP (SCOP) of 3.4		As actual design
Ventilation	Constant natural ventilation rate of 2 ach in all habitable zones when windows are open as defined by controls below.		As actual design
HVAC system controls	Each zone with active heating or cooling must be controlled by a thermostat corresponding to air temperature within that zone as follows:		As actual design
	Temperature criteria:	Active system:	
	Low temperatures • $T_{zone} \leq T_{min}$	Heating	

	Moderate temperatures • $T_{zone} > T_{min} + 2.5$; AND • $T_{zone} > T_{external}$	Open windows	
	High temperatures • $T_{zone} \geq T_{max}$	Cooling	
	T_{zone} is the air temperature in each zone $T_{external}$ is the external air temperature T_{min} and T_{max} are the setpoint temperatures defined in 4.4.1		

Table 1.6: HVAC system parameters – Specific

Seasonal COP

If the seasonal COP is not known, it can be approximated through the following relationship[2]:

$$COP = -0.06824 \times SCOP^2 + 1.12 \times SCOP$$

Thus:

$$SCOP = \frac{1.12 - \sqrt{1.25 - 0.273 \times COP}}{0.1365}$$

Using this relationship the nominal COP for the notional building is 2.75 in cooling mode and 3.0 in heating mode, which is equivalent to a European D Energy Rating.

Common District Plant

If a common district plant is shared by the development pursuing certification and another building or space, the district plant must be treated as follows:

1) The size of the district plant used for the energy calculations in this rating tool must be assumed as equivalent to the peak demand of the development pursuing certification;

2) The part load curves for the actual district plant shall be applied proportionally to the plant used for the energy calculations.

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[2] Building America House Simulation Protocols, Oct 2010. http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/house_simulation_revised.pdf

3) The hourly loads must be based on the total building load. I.e. the load from each dwelling type must be multiplied by the number of dwellings of that type to determine the total Multi Unit Residential development load at each timestep.

Any apportioning of the central plant should be confirmed with the GBCSA through a Credit Interpretation Request.

Systems not fully addressed

The guide aims to cover the majority of HVAC systems, but cannot cover all. If the proposed building system is not addressed by the current tool a Credit Interpretation Request is required that demonstrates the steps suggested to model the system.

4.5.1 General requirements for all projects

Modelling Parameter	*Criteria*	*Documentation Requirements*
HVAC System design	• Demonstrate that the HVAC system modelled represents the system design for each dwelling.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from mechanical specification and mechanical drawings which accurately and thoroughly describe the basic HVAC system design. Energy Report: • Details of how the HVAC system has been represented in the model.
Zoning	• Demonstrate that all HVAC zones represented in the thermal model accurately reflect system performance.	Energy Report: • Details of how all HVAC zones have been represented in the model, and how these zones accurately represent the mechanical design drawings and specification (if applicable).
Temperature control bands	• Demonstrate that the temperature control bands of the system accurately reflect the thermal model.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the design specification for the thermal model Energy Report: • Details of how the temperatures control bands have been modelled. For the notional building this should include the temperatures where heating, natural ventilation and cooling occur.

Table 1.7: HVAC system simulation – general requirements for all projects

4.5.2 Requirements for projects with dedicated mechanical ventilation or natural ventilation

Mechanical ventilation in this section is purely for systems that supply un-tempered outside air. Other systems are addressed in section 5.4.4.

Natural ventilation for the notional building is modelled simply by applying a constant natural ventilation rate when the system control schedule requires windows to be open. For the actual building simulation all openings such as windows are to be modelled explicitly based on the openable area.

Doors that provide access from a public or communal space into the dwelling cannot be used to provide natural ventilation in the model unless they are fitted in combination with a security screen door that maintains security to the dwelling while the door to the public communal area is open and door catches;

Modelling Parameter	*Criteria*	*Documentation Requirements*
Natural ventilation	For the notional building: • Demonstrate that natural ventilation has been modelled by applying a constant air change rate when the system controls require open windows. For actual building: • Demonstrate that operable windows, vents and doors are modelled accurately in the model.	Verification Documents: • Design or as-installed (where appropriate) relevant façade drawings showing all operable windows, vents and doors. • If external doors are included in the model, tender documentation indicating that each door is provided with a security screen door or showing that the door does not provide access to a public or communal space. Energy Report: • Details of how natural ventilation has been included in the model.
Mechanical Ventilation	For constant volume fans: • Demonstrate that fan performance is calculated conservatively based on the maximum power of the fan and the time that the HVAC system profile is on for each room type. For variable volume fans: • Demonstrate that fan performance is calculated conservatively based on 80% of maximum fan power and the time that the HVAC system profile is on for each room type. OR • Demonstrate that fan performance curves are accurately represented in the model and;	Verification Documents: • Design or as-installed (where appropriate) pages from the mechanical specification showing fan performance curves (if used in the model) and fan size. Energy Report: • Details of how mechanical ventilation has been included in the model

	- Demonstrate that index run pressure drops are accurately represented to include the total static inclusive of filters and diffusers (where an index run refers to the duct (or 'run') with the highest pressure drop).	

Table 1.8: HVAC system simulation – dedicated ventilation

4.5.3 Requirements for projects with unitary or packaged direct expansion heating or cooling equipment (including electric resistance heating)

Modelling Parameter	*Criteria*	*Documentation Requirements*
Cooling and heating efficiency	- Determine electrical energy use either in the energy modelling software or in post processing using total (latent and sensible) cooling and heating system loads calculated in the simulation and the seasonal COP in a spreadsheet tool. - Demonstrate that the heating and or cooling electrical load has been calculated based on the total system seasonal efficiency. If the SCOP is not available from the supplier this can be approximated using the Seasonal COP equation above. Note that several manufacturers refer to the cooling SCOP as an SEER and heating efficiency as the SCOP.	<u>Verification Documents:</u> - Design or as-installed (where appropriate) relevant pages from the mechanical specification showing the unit size and SCOP requirement. - Documentation from unit supplier showing the SCOP or SEER for the system <u>Energy Report:</u> - Details of how the system SCOP has been used in the model or in post processing calculations.

Table 1.9: HVAC system simulation – requirements for unitary or packaged equipment

4.5.4 Requirements for projects with central heating or cooling equipment

All heating or cooling systems that do not comply with 0 above require thorough modelling demonstrated through the documentation requirements below for each relevant system.

Modelling Parameter	*Criteria*	*Documentation Requirements*
Chiller plant	• Demonstrate that the chiller plant size is accurately reflected in the model. • Demonstrate that the actual efficiency curves of the installed plant are used in the model. • Water cooled equipment: Demonstrate that chiller data is specified under conditions that reflect the intended condenser water temperature controls. • Air cooled equipment: Demonstrate that the air cooled chiller COP profiles have been accurately modelled with regard to loading and ambient conditions	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification showing the chiller plant size and any condenser water operation. • Documentation from chiller supplier giving part load curves (and condenser water temperatures where applicable). Energy Report: • Details of how the chiller plant size has been represented in the model. • Details of how the actual efficiency curves have been used in the model. • Details of how the chiller data is relevant to the intended condenser water temperature controls.
Boiler plant	• Demonstrate that the boiler plant size, thermal efficiency and distribution efficiency are accurately reflected in the model.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification which show details of the boiler plant size, thermal efficiency and distribution efficiency. Energy Report: • Details of how the boiler has been modelled.
Supply Air and Exhaust Fans	• Demonstrate that fan performance curves are accurately represented in the model. • Demonstrate that index run pressure drops are accurately represented to include the total static inclusive of filters, coils and diffusers (where an index run refers to the duct (or 'run') with the highest pressure drop).	Verification Documents: • Design or as-installed (where appropriate) pages from the mechanical specification showing fan performance curves and fan size. Energy Report: • Details of how the index run pressure drops have been calculated. • Details of how these have been modelled.
Cooling Tower Fans	• Demonstrate that allowance for energy consumption from cooling tower fans has been made, based upon the annual cooling load of the building and the supplementary cooling load for tenancy air conditioning.	Energy Report: • Details of how the cooling tower fans have been modelled.

Cooling Tower and Condenser Water Pumping	• Demonstrate that allowance for energy consumption from cooling tower and condenser water pumping has been made, based upon the annual cooling load of the building.	Energy Report: • Details of how the cooling tower and condenser water pumping have been modelled.
Chilled water	• Demonstrate that chilled water pumping is calculated using the building cooling load, the static pressure of the chilled water pumps (typically 250kPa) and the flow rate in L/s.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the hydraulic and mechanical specifications showing chilled water pump data – static pressure and flow rate in L/s. Energy Report: • Calculation of chilled water pumping.
Heating hot water	• Demonstrate that the hot water pumping is calculated using the building heating load, the static pressure of the hot water pumps (typically 250kPa) and the flow rate in L/s.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the hydraulic and mechanical specifications showing hot water pump data – static pressure and flow rate in L/s. Energy Report: • Calculation of hot water pumping.
Controls - Outside Air	• Demonstrate that outdoor air flows have been modelled as documented in the mechanical design drawings and specifications, and in compliance with the appropriate standards.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from mechanical specification, giving details on the correct minimum outside air flow Energy Report: • Detail of how outside air flow has been represented in the system
Controls - Economy Cycle	• Demonstrate that economy cycles have been modelled to reflect system specification noting any enthalpy/temperature cut-off and control point.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from mechanical specification giving details on the economy cycle of the system Energy Report: • Detail of how the economy cycle has been modelled
Controls - Primary duct	• Constant Volume Systems: Demonstrate that modelling has allowed supply air temperatures to vary to meet loads in the space	Verification Documents: • Design or as-installed (where appropriate) relevant pages from mechanical specification giving details of the design

temperature control	• <u>Variable Volume Systems</u>: Demonstrate that modelling has allowed supply air volumes to vary to meet loads in the space • Demonstrate that set points have been rescheduled as specified. Note that simplifications may be made to consider average zone temperature in lieu of high/low select.	temperature and HVAC cooling and heating setpoints <u>Energy Report:</u> • Detail of how design temperatures and setpoints have been modelled
Controls - Airflow	• Demonstrate that control logic describing the operation of the dampers to control outside and re-circulated airflow is inherent in the model and accurately reflects the airflow characteristics of the system.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the operation of the dampers to control outside and recirculated air <u>Energy Report:</u> • Details of how these have been represented in the model
Controls - Minimum turndown	• Demonstrate, where relevant, that the minimum turndown airflow of each air supply is accurately reflected in the model.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the minimum turndown airflow of each air supply <u>Energy Report:</u> • Details of how the minimum turndown is modelled for each air supply
Chiller staging	• Demonstrate that for systems that employ multiple chillers with a chiller staging strategy, the correct controls are modelled to reflect the actual relationship between the chillers.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the chiller staging strategy <u>Energy Report:</u> • Details of how chiller staging has been modelled

Table 1.10: HVAC system simulation – requirements for central HVAC systems

5 CR1 - Guidelines for Other Parameters

5.1 Extract Fans

The energy use associated with toilet/bathroom extract fans needs to be entered into the calculator unless they are provided with automatic controls which ensure they are only used when required. The automatic control may be linked to the light switch (with a run on period) or alternatively linked to an occupancy sensor or humidity sensor.

For kitchen extract fans serving an individual dwelling, if the fans are provided with an accessible on/off switch they need not be included in the simulation. Other types of kitchen extract fans should be included.

If there is a central extract fan with a variable speed drive and dampers linked to accessible switches that allow air to only be drawn from each dwelling when required, the fan energy calculated should be based on the power requirement of the variable speed drive at the minimum turndown ratio.

Note that fans used for car park ventilation should NOT be included as these are covered by Ene-8.

	Notional SANS204 Building	Actual Building
Extract Fans	None	As actual design

Table 1.11: Mechanical Exhaust parameters – specific

Modelling Parameter	*Criteria*	*Documentation Requirements*
Extract Fans	• Demonstrate that the energy requirements for extract fans are estimated using the following parameters: ○ Operation of 24 hours per day; AND For constant volume fans: ○ Maximum fan power For variable volume fans: ○ 80% of maximum fan power; OR ○ If there is a central extract fan with a VSD drive and dampers with switches provided for each dwelling, the fan power requirement at the minimum turndown ratio.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification showing details of mechanical exhaust systems. This needs to include the provision for switches if applicable. Energy Report: • Details of how the energy requirements for mechanical exhaust systems are calculated. • A note on whether switches are provided for kitchen or bathroom fans.

Table 1.12: Mechanical Exhaust parameters - general

6 CR1 - Passive Cooling and Heating Systems

It is important that buildings with either passive cooling or heating are comfortable and that reasonable temperatures are experienced during hot and cool weather, or else it is likely that cooling or heating systems will be retrofitted in the future, increasing the building's energy use.

To minimize the risk of future retrofits, all habitable zones modelled with passive cooling or heating must meet the criteria for obtaining two points in the IEQ-9 Thermal Comfort credit (i.e. the operative temperature in all zones must be within the ASHRAE 55-2004 80% Acceptability Limits for 85% of the time).

This should be demonstrated as follows:

Modelling Parameter	*Criteria*	*Documentation Requirements*
Thermal Comfort for Passive Buildings	• Demonstrate that every zone modelled with a passive heating or cooling system has met the thermal comfort criteria set out in IEQ-9.	• Thermal comfort report demonstrating which habitable zones within dwellings comply with the IEQ-9 criteria for two points.

Table 1.13: Documentation requirements for dwellings that are modelled with passive cooling or heating systems

If a habitable zone within a dwelling does not meet the criteria, then a cooling (or heating) system of identical performance to the notional dwellings must be included for the zone in the actual dwelling model. In this case the zone is modelled as mixed mode and passive design features can still be used in conjunction with the active system.

If only a particular zone (e.g. a bedroom) within a dwelling does not meet the criteria, only this zone needs to include the notional building systems.

If there is no active heating or cooling in the actual dwelling zone, but the criteria can be met by only including either the notional heating or cooling system, then only this system needs to be included in the model. In this case the project team will need to demonstrate that with the notional heating or cooling system the comfort criteria can be satisfied.

In some developments, HVAC and other services within dwellings are installed by the future owner rather than by the landlord/developer's professional team. These will also need to follow the above procedure.

7 CR1 - Renewable Energy and Cogeneration

7.1 Electrical Energy from on-site generation

Any electrical energy generated on site (e.g. photovoltaic, cogeneration etc) is rewarded under credit Ene-09, and should NOT be entered into the calculator.

7.2 Heat Energy from low carbon sources (e.g. cogeneration and solar)

Any heat generated from renewable sources or from the cogeneration plant (e.g. solar water heating used for space heating) should be subtracted from the heat energy use required for the building. This energy is treated as carbon neutral.

For cogeneration systems the designer should confirm that an analysis has been carried out to ensure that the heat demand coincides with times when the cogeneration plant will be in operation and that peak demands are within the capacity of the cogeneration plant.

8 CR1- Modelling Errors/Simplifications

Full details of any warnings obtained when running the software, or any defaults which have been overridden (for example number of hours when the stated internal design temperatures were not achieved) must be provided. It should be confirmed that all warnings would not lead to inaccuracies in the model.

9 CR1 - Fuel CO_2 factors

An average fuel factor for South African mains electricity is used by the calculator, which is defined as 1.2kgCO_2/kWh by ESKOM[3], a relatively high figure due to the large number of coal fired power stations. As newer, more efficient power stations are built, it will be necessary to revise the fuel factors in future Green Star SA tool and versions.

10 CR1 - Guidance for Use of Calculator

The compliance path for the Energy Conditional Requirement is selected on the main Energy category worksheet. The inputs only become available if Compliance Route 1 has been selected.

In the case of buildings with no active cooling or heating systems, confirm whether the building thermal comfort criteria has been met (refer to section 6 *CR1 - Passive Cooling and* **Heating Systems** for more information).

Select whether the building HVAC energy use is to be entered for each dwelling type or as a building total. The latter option is only available if all the dwellings are contained in one building (refer to section 3 *CR1 -* **Modelling Methodology**)

The input sheet for entering HVAC energy use for each dwelling type is shown on the following page.

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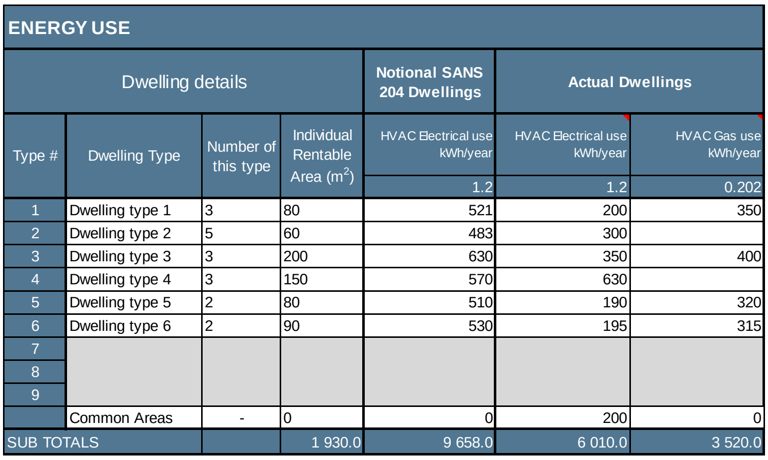
[3] ESKOM Annual Report 2007, footnote to Table 3 ENVIRONMENTAL IMPLICATIONS OF USING/SAVING ONE KILOWATT-HOUR OF ELECTRICITY, page 189

Enter the energy use predictions for both the notional building and the actual building. If gas is used for heating or cooling (e.g. absorption chillers) then the amount of gas used should be entered in the third column.

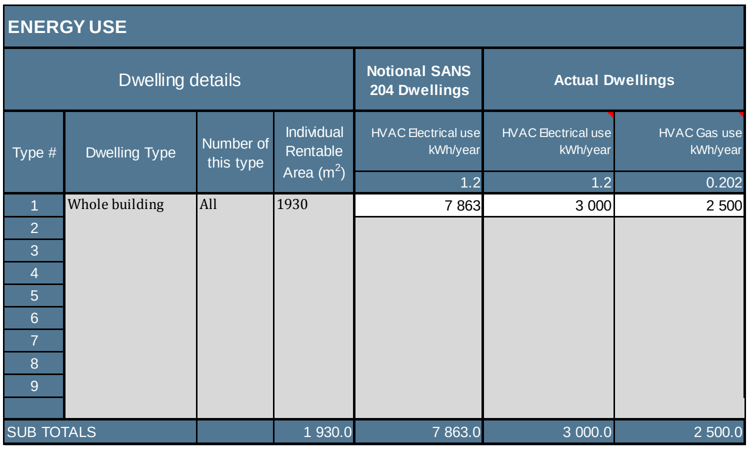


ENERGY USE

Dwelling details				Notional SANS 204 Dwellings	Actual Dwellings	
Type #	Dwelling Type	Number of this type	Individual Rentable Area (m^2)	HVAC Electrical use kWh/year	HVAC Electrical use kWh/year	HVAC Gas use kWh/year
				1.2	1.2	0.202
1	Dwelling type 1	3	80	521	200	350
2	Dwelling type 2	5	60	483	300	
3	Dwelling type 3	3	200	630	350	400
4	Dwelling type 4	3	150	570	630	
5	Dwelling type 5	2	80	510	190	320
6	Dwelling type 6	2	90	530	195	315
7						
8						
9						
	Common Areas	-	0	0	200	0
SUB TOTALS			1 930.0	9 658.0	6 010.0	3 520.0

Figure 1. Energy modelling results input page (individual dwelling modelling).

If the dwellings are modelled together as one building only the total energy use for the notional and actual building is required.

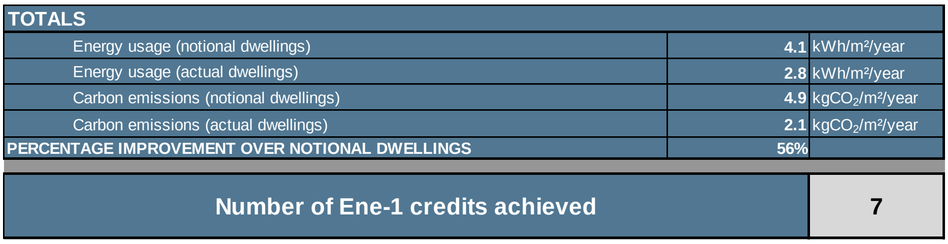


ENERGY USE

Dwelling details				Notional SANS 204 Dwellings	Actual Dwellings	
Type #	Dwelling Type	Number of this type	Individual Rentable Area (m^2)	HVAC Electrical use kWh/year	HVAC Electrical use kWh/year	HVAC Gas use kWh/year
				1.2	1.2	0.202
1	Whole building	All	1930	7 863	3 000	2 500
2						
3						
4						
5						
6						
7						
8						
9						
SUB TOTALS			1 930.0	7 863.0	3 000.0	2 500.0

Figure 2. Energy modelling results input page (whole building modelling).

The calculator displays the energy usage and carbon emissions of the notional and actual buildings. These are compared and the percentage improvement figure used to calculate the number of points achieved.



TOTALS		
Energy usage (notional dwellings)	4.1	kWh/m²/year
Energy usage (actual dwellings)	2.8	kWh/m²/year
Carbon emissions (notional dwellings)	4.9	kgCO$_2$/m²/year
Carbon emissions (actual dwellings)	2.1	kgCO$_2$/m²/year
PERCENTAGE IMPROVEMENT OVER NOTIONAL DWELLINGS	56%	
Number of Ene-1 credits achieved	7	

Figure 3. Energy calculator results output.

Compliance Route 2 - DTS

11 CR2 – Deemed to Satisfy (DTS) Methodology

11.1 Overview

This compliance route offers Project Teams an alternative, less complicated method of claiming points within the Ene-1 credit and is 'deemed-to-satisfy' (DTS) route. In this route, specific design initiatives are itemised and points awarded upon meeting the prescribed requirements. Although this is a less complex compliance route, the prescriptive nature of a DTS approach is limited in design flexibility. Hence the maximum number of points awarded within this compliance route is 6 points.

11.2 Defining the Thermal Envelope

Prior to commencing 'Compliance Route 2', project teams are strongly recommended to define a 'thermal envelope' for each dwelling. The 'thermal envelope' should contain all habitable rooms that are, or reasonably could be, actively heated or cooled. All walls, ceilings/roofs, floors, glazing elements and doors which make up the 'thermal envelope' of the dwelling are therefore included within the scope of this compliance route.

It is up to the designer's discretion as to whether other spaces such as garages are included inside the 'thermal envelope' or not. Where fabric element(s) which are deemed part of a dwellings' thermal envelope are shared with other dwellings which also consider the same element(s) as part of their thermal envelope, these elements are excluded from the scope of Compliance Route 2 as it is deemed that minimal heat transfer occurs through these elements (i.e. adiabatic).

12 Deemed-to-Satisfy Requirements

12.1 PART A – External Wall Thermal Resistance (1 point)

The thermal resistance (R-value) of a wall is a measure of how difficult it is for heat to be conducted through the wall. A cavity wall or insulated wall will have a higher thermal resistance than a solid un-insulated wall. Walls with high thermal resistance reduce heat loss from dwellings during cold periods, meaning that less energy is required to heat the dwelling to maintain comfort.

Thermal Resistance (R-Value)

The thermal resistance or R-Value (m^2K/W) of a material or composite wall (i.e. multiple materials) can be calculated as follows:

$$R = \sum d / \lambda + \text{surface resistances}$$

Where d is a materials thickness (in metres) and λ is the thermal conductivity (W/mK) of the material.

Surface resistances are the resistances provided by thin air films (or boundary layers) on the inner and outer surfaces of the material or wall. Note that this equation must not be used for materials such as reflective foil insulation.

The thermal resistance (R-value) of a material is inversely proportional to its thermal conductivity (U-value). If the U-value of a construction is known, then the R-value may be determined from the relationship:

$$R = 1/U$$

Some examples of R-values for common fabric constructions are given in Table F.1 through Table F.5 in Appendix F to this Guide.

The values for wall thermal resistance required for Compulsory Initiative A (outlined in Table 2.1) are based on those for masonry constructions which satisfy the requirements of SANS-204:2011.

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Climatic Zone	**1 (Joburg)**	**2 (Pretoria)**	**3 (Nelspruit)**	**4 (Cape Town)**	**5 (Durban)**	**6 (Upington)**
Compulsory Initiative A	1.2	1.0	1.0	1.2	0.7	1.2
For 1 point	2.2	1.9	1.9	1.9	1.9	2.2

Table 2.1 *Minimum values of Thermal resistance R in m²K/W (Note: the values for 1 point are based on the higher R value requirements in SANS204:2011)*

12.2 PART B – Thermal Mass (1 point)

Most areas of South Africa have a climate with large daily variations in external temperature (diurnal variation). So on a winter's day, while the temperature may be very cold during the night, by lunchtime it is pleasantly warm. If the building fabric could trap this warmth, then potentially energy used for heating could be reduced. Similarly, in summer time, if the building fabric can absorb some heat at the hottest time of the day, this will make the building more comfortable and reduce the energy needed to cool the building.

While the thermal capacity (C) gives a measure of the overall mass of the building fabric, without modification it is not a good measure of the useful thermal mass since it does not reflect whether or not the mass is accessible for heat transfer. A heavyweight surface does not provide useful thermal mass if it is insulated from the interior of the dwelling by a lightweight layer such as plasterboard, carpet, internal insulation, etc.

For the Green Star SA Multi Unit Residential v1 tool, the measure used to quantify accessible thermal mass is Admittance (Y). This is measured in W/m²/K which is the same unit as U-value.

In simplified terms, while the U-value is a measure of how easy it is for heat to be transferred from one side of the construction to the other (e.g. inside the dwelling to outside), the Admittance value is a measure of how easy it is for heat to be absorbed/emitted by the construction. More formally it is defined as the rate of heat flow between the internal surface of the structure and the environmental temperature in the space, for each degree of deviation of the space temperature about its mean value. For thin structures composed of a single layer, the Admittance is approximately equal to the U-value. The method of calculation of admittances is defined in BS EN ISO 13786.

Examples of admittance values for typical constructions are given in Table F.1 through Table F.5 in Appendix F to this Guide.

All surfaces visible to the occupants contribute thermal mass (i.e. the inside surfaces of external walls, internal walls, floors and ceilings).

In order to achieve the point the weighted average of the admittances for the interior surfaces in a dwelling must be calculated, and shown to be no less that the values in Table 2.2 (below).

The weighted average is calculated by:

Average Admittance = (A1 Y1 + A2 Y2 + A3 Y3 +…) / total internal surface area

Where A1 is the surface area in m² of surface 1 with admittance Y1 in W/m²K etc

Climatic Zone	**1 (Joburg)**	**2 (Pretoria)**	**3 (Nelspruit)**	**4 (Cape Town)**	**5 (Durban)**	**6 (Upington)**
For 1 point	3.5	3.0	3.0	3.0	3.0	3.5

Table 2.2 *Minimum values of average Admittance in W/m²K.*

12.3 PART C – Roof/Ceiling Insulation (0 points – Compulsory Initiative only)

Insulating roofs/ceilings is a very effective way of reducing energy use and making a dwelling more comfortable both during cold and hot weather.

Due to the constructions and the behaviour of air as an insulator roofs/ceilings will have different R-values depending on the direction of heat flow. In summer, heat flows downwards from outside to the inside. However in winter, heat flows upwards from the inside to the outside. The direction selected to determine compliance with the requirement is based upon whether the local climate is a heating climate or a cooling climate.

Climatic Zone	**1 (Joburg)**	**2 (Pretoria)**	**3 (Nelspruit)**	**4 (Cape Town)**	**5 (Durban)**	**6 (Upington)**
Compulsory Initiative C	3.7 (up)	3.2 (up)	2.7 (down and up)	3.7 (up)	2.7 (down)	3.5 (up)

Table 2.3 *Minimum values of Thermal resistance R in m²K/W, as defined in SANS-204:2011. (parenthesis indicate direction of heat flow).*

The Compulsory Initiative values for roof resistance in the Table 2.3 are based on those in SANS-204:2011 edition.

Note that roof lights do not need to be included in R-value calculation. For more information on R-values for typical roof constructions, refer to SANS-204:2011 and Table F.1 through Table F.5 in Appendix F to this Guide.

12.4 PART D – Window Conductance and Solar Heat Gain (1 point)

Optimising windows and glazing elements is a key feature in designing energy efficient dwellings. Windows provide daylight and views for occupants, but also lead to significant heat losses in winter and have the potential for allowing significant solar heat gains in summer.

Conductance (U-values)

In order to achieve the compulsory Initiative, the windows must comply with the maximum Conductance limits given in Table Ene-1.6. The Conductance should be calculated as explained in SANS-204:2008 Part 2.

The conductance per unit floor area is defined as:

$$(A1\ U1 + A2\ U2 + A3\ U3 + \ldots) / \text{total habitable floor area}$$

Where A1 is the surface area (in m²) of window 1, which has U-value U1. Note that the area of a window or glazing element includes the frame, so the outer dimensions of a window or glazing element should be used to determine the area.

Based on the above calculation, the target can be achieved either by improving the U-value of the glazing or reducing the glazing element area.

Solar Heat Gain

While large windows may be attractive, unless well shaded and orientated appropriately they are likely to lead to overheating in dwellings.

The Solar heat gain should be calculated as explained in SANS-204:2011

The solar heat gain per unit floor area is defined as:

$$(A1\ S1\ E1 + A2\ S2\ E2 + A3\ S3\ E3 + \ldots) / \text{net floor area}$$

Where A1 is the surface area (in m²) of window 1, which has solar heat gain coefficient S1 , and solar exposure factor E1 etc.

Thus, the target can be achieved either by improving the solar heat gain coefficient S (e.g. by coating or tinting the glass) or improving the shading of the window (i.e. using overhangs or minimising glazing on inappropriate orientations) or else reducing the window area.

If manufacturer's information is not available, the values for solar heat gain coefficient (S) should be obtained from Table 6 in SANS-204:2011 2.

The Solar Exposure factor (E) should be obtained from Annex C of SANS-204:2011 for the relevant climatic zone.

Climatic Zone	Factor	1 (Joburg)	2 (Pretoria)	3 (Nelspruit)	4 (Cape Town)	5 (Durban)	6 (Upington)
Compulsory Initiative D	C_U	1.2	1.4	1.4	1.4	1.4	1.2
For 1 point	C_U	1.0	1.2	1.2	1.2	1.2	1.0
	C_{SHGC}	0.15	0.12	0.10	0.13	0.11	0.13

Table 2.4 *Maximum values of Conductance C_u per unit floor area in W/m²K, and Solar heat gain per unit floor area C_{SHGC} in m²K/W, as defined in SANS-204:2011.*

The Compulsory Initiative D values in Table 2.4 are based on those in SANS-204:2011 edition. The values for 1 point are based on improving the conductance values by 20%. In order to achieve one point, the project glazing must meet both the Conductance and the Solar Heat gain requirements given in Table 2.4

12.5 PART E – Airtightness (0 points – Compulsory Initiative only)

While many parts of South Africa have mild climates, it is still important to control air leakage in dwellings to avoid discomfort due to draughts and varying internal temperatures, or increased energy use to maintain thermal comfort. High leakage rates can easily undo all the efforts made to reduce heat loss by insulating ceilings and walls etc., and is particularly important in dwellings which have active cooling or heating systems.

The measures to improve airtightness in the Green Star SA Multi Unit Residential v1 rating tool are based on those included in SANS-204:2011.

The test protocol is SANS 613 Fenestration products - Mechanical performance criteria "Specifies the criteria for the performance in respect of wind action (deflection and structural strength), water penetration, air penetration and operation of fenestration products (such as windows, doors, curtain walls and roof lights), within the confines of the perimeter of the main frame, irrespective of the framing material. "

12.6 PART F – Heating & Cooling Systems (3 points)

This component aims to reward buildings which have efficient heating/cooling systems installed or that have sufficient passive performance to avoid the installation of such systems. Points are awarded according to Table 2.5 and Table 2.6 and the compliance notes detailed within.

Climatic Zone	1 (Joburg)	2 (Pretoria)	3 (Nelspruit)	4 (Cape Town)	5 (Durban)	6 (Upington)
No heating system (Note 1)	2pts	2pts	1pt	2pts	1pt	2pt
High efficiency heating system (Note 2)	1pt	1pt	0pts	1pt	0pts	1pt

Table 2.5 *Points available for heating systems in each climate zone.*

Compliance Note (1):

Dwellings must not have any heating system(s) and must achieve one point within Compliance Route 2 of the 'IEQ-9 Thermal Comfort' credit.

Compliance Note (2):

Dwellings must have a heating system installed, which has a nominal COP of greater than 3.5 (European 'B' energy rating) or where the fuel used for the majority of space heating is either gas, wood, charcoal, heat from cogeneration plant or other fuel with carbon emissions less than 0.3 kgC0$_2$e/kWh. Thermostat and time-clock control must be provided for the heating system. This point can only be claimed if such heating system(s) are installed within the scope of the main project contract.

Climatic Zone	1 (Joburg)	2 (Pretoria)	3 (Nelspruit)	4 (Cape Town)	5 (Durban)	6 (Upington)
No cooling system (Note 3)	1pt	1pt	2pts	1pt	2pts	1pt
High efficiency cooling system (Note 4)	1pt	1pt	1pts	1pt	1ps	1pt

Table 2.6 *Points available for cooling systems in each climate zone.*

Compliance Note (3):

Dwellings must not have any cooling system other than propeller (i.e. ceiling) fans and must achieve one point within Compliance Route 2 of the 'IEQ-9 Thermal Comfort' credit.

Compliance Note (4):

To claim these points, dwellings must have a cooling system installed, which has a nominal COP of greater than 3.1 (European 'B' energy rating) or is based on evaporation of water. Thermostat and time-clock control must be provided. These points can only be claimed if such cooling systems are installed within the scope of the main project contract.

APPENDIX A

SIMULATION BRIEF FOR ASSESSORS

In order to assess the validity of the final results, it is critical that the assessor and the simulator understand the limitations of the simulation package which has been used. The simulator must provide the assessor with a briefing of the simulation package and model used which shows that the following requirements have been met:

- The simulation package has passed external validation standards such as BESTEST and be able to model natural ventilation;
- The model analyses building performance on an hourly basis for a full year;
- Two buildings have been modelled – the Notional building and the Actual building;
- The Notional building model has the correct assumptions on building fabric and HVAC systems, and has the same occupancy, equipment, lighting etc as the Actual building;
- The Notional building has been modelled with operable windows to allow natural ventilation to be used when the external conditions are favourable.
- The Actual building model accurately represents:
  - Glazing on the building;
  - The proposed HVAC system;
  - The HVAC controls which are to be used;
  - The performance curves and sizes for plant items (if applicable);
- The actual model has used the simplified requirements for dwellings with packaged heating and cooling units or the more thorough process for centralized systems such as those using large chillers.
- All other aspects of the building have been modelled correctly, with no significant compromises made.
- All assumptions that are made must be conservative.

If these requirements are not met, then the reasons will need to be adequately justified.

APPENDIX B

SPACE TYPE DEFINITIONS & GLOSSARY

The following provides definitions of the space types used within the Green Star SA – Multi Unit Residential v1rating tool Energy Calculator.

Dwelling/Building:

- Actual or Proposed Building – the building as designed and modelled by the project team.
- Notional or Reference Building – a hypothetical building of the same shape and form as the actual building, but with fenestration, building fabric and building services as specified in this protocol.

Internal zone definitions

- Living area – habitable area occupied during the day excluding the kitchen and bathrooms. These include the lounge, study and passages.
- Kitchen – Area equipped for preparing and cooking food.
- Bedroom – Area occupied at night.
- Bathroom – Toilet and bathroom areas.
- Common area – Internal areas not part of dwellings (e.g. lift lobby, common passage).

APPENDIX C

MULTI UNIT RESIDENTIAL PROFILES

General

When calculating the energy consumption of the Multi Unit Residential development the following general schedule should be applied to the models:

Load:	**Kitchen - Sensible Load**	**Kitchen - Latent Load**	**Equipment Load**
Area: **Sensible:** **Latent:**	Kitchen 150W/occupant -	Kitchen - 90W/occupant	Living area 4W/m^2 -
0 to 1	10%	0%	5%
1 to 2	10%	0%	5%
2 to 3	10%	0%	5%
3 to 4	10%	0%	5%
4 to 5	10%	0%	5%
5 to 6	10%	0%	5%
6 to 7	10%	0%	5%
7 to 8	100%	60%	30%
8 to 9	10%	0%	30%
9 to 10	10%	0%	5%
10 to 11	10%	0%	5%
11 to 12	10%	0%	5%
12 to 13	10%	0%	5%
13 to 14	10%	0%	5%
14 to 15	10%	0%	5%
15 to 16	10%	0%	5%
16 to 17	10%	0%	25%
17 to 18	50%	25%	25%
18 to 19	100%	100%	50%
19 to 20	100%	100%	100%
20 to 21	10%	0%	100%
21 to 22	10%	0%	100%
22 to 23	10%	0%	5%
23 to 24	10%	0%	5%

Table C.1: Kitchen and equipment profiles

Load:	**Lighting**			**Occupants**	
Area:	Living area, Kitchen, Bathrooms	Bedrooms	Common area	Living area, Kitchen	Bedroom
Sensible:	4W/m^2	4W/m^2	4W/m^2	75W/occupant	50W/occupant
Latent:	-	-	-	25W/occupant	25W/occupant
0 to 1	0%	0%	0%	0%	100%
1 to 2	0%	0%	0%	0%	100%
2 to 3	0%	0%	0%	0%	100%
3 to 4	0%	0%	0%	0%	100%
4 to 5	0%	0%	0%	0%	100%
5 to 6	0%	0%	50%	0%	100%
6 to 7	0%	100%	50%	0%	100%
7 to 8	60%	50%	100%	50%	50%
8 to 9	60%	0%	100%	100%	0%
9 to 10	0%	0%	100%	50%	0%
10 to 11	0%	0%	100%	50%	0%
11 to 12	0%	0%	50%	50%	0%
12 to 13	0%	0%	50%	50%	0%
13 to 14	0%	0%	50%	50%	0%
14 to 15	0%	0%	50%	50%	0%
15 to 16	0%	0%	50%	50%	0%
16 to 17	0%	0%	50%	50%	0%
17 to 18	50%	0%	100%	75%	0%
18 to 19	100%	0%	100%	75%	0%
19 to 20	100%	50%	100%	75%	0%
20 to 21	100%	50%	100%	75%	10%
21 to 22	100%	50%	100%	75%	25%
22 to 23	0%	50%	100%	0%	100%
23 to 24	0%	0%	50%	0%	100%

Table C.2: Lighting and Occupancy Profiles

Area:	**Living areas Kitchens Bathrooms***	**Bedrooms**	**Common Areas***
0 to 1	Off	On	Off
1 to 2	Off	On	Off
2 to 3	Off	On	Off
3 to 4	Off	On	Off
4 to 5	Off	On	Off
5 to 6	Off	On	Off
6 to 7	Off	On	Off
7 to 8	On	On	On
8 to 9	On	Off	On
9 to 10	On	Off	On
10 to 11	On	Off	On
11 to 12	On	Off	On
12 to 13	On	Off	On
13 to 14	On	Off	On
14 to 15	On	Off	On
15 to 16	On	Off	On
16 to 17	On	Off	On
17 to 18	On	Off	On
18 to 19	On	Off	On
19 to 20	On	Off	On
20 to 21	On	On	On
21 to 22	On	On	On
22 to 23	Off	On	On
23 to 24	Off	On	On

Table C.3: HVAC Profiles

* The HVAC profile only applies to bathrooms and common areas that have heating or air conditioning and should NOT be included in the notional dwellings.

APPENDIX D

ENERGY MODELLING REPORT FORMAT

It is recommended that the Energy Modelling Report be submitted in the following format. The description below is not thorough, but provides a template to follow. Refer to the sections 5 to 8 of this protocol document for details of what documentation should be included in each part.

The text *in italics* illustrates where the user should enter details of the project.

General Modelling Parameters (4.1)

• Project	*XYZ*
• Location	*Johannesburg*
• SANS 204 Climate Zone	*1*
• Simulation Software Used	*DesignBuilder 3.0.0.048, EnergyPlus 6.0.0.023*
• Weather Data Used	*Meteonorm O.R.Tambo/Jan Smuts Airport 1996-2005*

Space Breakdown (4.2)

[*This section needs to be completed for each dwelling type as well as the common areas.]*

Dwelling Type	**No. of dwellings**	**No. of stories**	**Space**	**Type**	**Included in simulation?**	**Area (m^2)**	**Comments**
A	*14*	*2*	*Bedroom A*	*Bedroom*	*yes*	*15*	
			Bedroom B	*Bedroom*	*Yes*	*18*	
			Total Bedroom area:			*33*	
			Lounge	*Living area*	*yes*	*30*	
			Kitchen, dining room	*Open Plan (Living Area & Kitchen)*	*yes*	*36*	
			Total Kitchen and living area			*66*	
			Garage		*No*	*30*	*Outside dwelling thermal envelope*
			TOTAL			*99*	

[Comments should include justification for any areas of the dwelling excluded from the model]

Building Envelope (4.3)

- Geometry
  - Building Form:

    [Isometrics of the simulation model for both the Actual and the Notional Building showing the building shape and window locations, etc, that allows easy comparison with architectural drawings. Include details of simplifications made.]
  - Shading

    [Details of building shading devices included in simulation]
  - Overshadowing

    [Isometrics of the simulation model showing the surrounding buildings or other surrounding shading]
- Orientation

  [Evidence that orientation of the building has been taken into account.]

- Fabric

	Notional Building	**Actual Building**
Exterior Wall Construction	*Brick, insulation, cavity, brick R = 1.2*	*concrete block, insulation, block R = 2.5*
Interior Wall Construction	*100mm brick*	*Drywall*
Roof	*Insulated R= 2.7*	*tile, membrane, void, insulation R = 2.7*
Floor	*Carpet, 150mm concrete slab, 50mm insulation. R=0.95*	*Carpet, 150mm concrete slab, 50mm insulation. R=0.95*

- Glazing
  - Properties

	Notional Building	**Actual Building**
Window Construction	*Single Glazing*	*Double Glazing:* *Outer pane: 6mm Clear* *Cavity: 12mm air* *Inner pane: 6mm Low-E*
Average U value including frame and dividers	*5.6*	*2.2*
SHGC	*0.77*	*0.51*

  - Window sizes:

[Include a calculation table demonstrating compliance of the notional building with the two glazing limits for naturally ventilated buildings in SANS 204 – C_U and C_{SHGC}]

- Infiltration

	Notional Building	**Actual Building**
Infiltration rate	*0.5 ach*	*0.25 ach*

[Include a description on how infiltration was modelled.

E.g. The infiltration rate for both the notional and actual building was applied as a mechanical ventilation rate. The fan pressure rise was set to zero such that no heat from the motor entered the air stream and no fan electrical energy use was included in the results]

Internal Design Criteria (4.4)

- Internal design temperatures

[Demonstrate that the internal design conditions for both the notional and actual building are calculated as set out in section 4.4.1]

	Notional Building	**Actual Building**
Annual average temperature	*15.85 °C*	*15.85 °C*
Design Temperature	Heating ≤ *19.25 °C* Cooling ≥ 26.25 *°C*	Heating ≤ *19.25 °C* Cooling ≥ 26.25 *°C*

- Occupancy

[To be determined based on the requirements in section 4.4.3. For this example where there are several bedrooms and living areas the occupancy should be presented as below.]

Dwelling Type	**Occupants**	**Total Bedroom Area**	**Bedroom Occupancy**	**Total Living and kitchen area**	**Living area and kitchen occupancy**
		(m^2)	**(m^2/person)**	**(m^2)**	**(m^2/person)**
A	*3*	*33*	*11*	*66*	*22*
B	*etc*				

- Internal Loads

Load	**Zone Type**	**Sensible Load**	**Latent Load**
Kitchen – Sensible Load	*Kitchen*	*150 W/occupant*	-
Kitchen - Latent Load	*Kitchen*	-	*90 W/occupant*
Equipment Load	*Living area*	*4 W/m^2*	-
Lighting	*All*	*4 W/m^2*	-
Occupants – Living area	*Living area* *Kitchen*	*70 W/occupant*	*25 W/occupant*
Occupants - Bedrooms	*Bedrooms*	*50 W/occupant*	*25 W/occupant*

[If Kitchen loads are included as W/m^2 include a calculation table showing the relationship between occupancy and load in W/m^2 as below]

Dwelling Type	**Living area and kitchen occupancy**	**Kitchen – Sensible Load**	**Kitchen – Latent Load**
	(m^2/person)	**(W/m^2)**	**(W/m^2)**
A	*22*	*6.8*	*3.64*
B	*etc*		

- Load Profiles

  [A screenshot from the simulation package showing the load profiles, to demonstrate that the profiles given in Appendix C have been used]

- Fresh air rate

  [Confirmation that the notional building has been modelled as naturally ventilated. State whether the actual building is naturally ventilated or if not, the design fresh air rate used]

HVAC Systems Simulation (4.5)

- *All projects need to follow sections 4.5.1 and 4.5.2.*
- *If a packaged heating or cooling unit is provided follow section 0. This will always be required for the notional building.*
- *Other systems should follow section 4.5.4*
- *Any calculations that are not included in the Energy Simulation, but in a spreadsheet or other tool needs to be fully demonstrated. For a project with split units the electrical energy use should be presented as follows (if the same system is provided for each dwelling and the dwellings are*

	Cooling			**Heating**		
Dwelling Type	**Thermal load**	**COP**	**Electrical Load**	**Thermal Load**	**COP**	**Electrical Load**
	(kWh)	**-**	**(kWh)**	**(kWh)**	**-**	**(kWh)**
A	*200*	*2.5*	*80*	*36*	*3*	*12*
B	*etc*					

Extract Fans (5.1)

[Details of the calculation showing kitchen and bathroom extract fan use if applicable. Details of the switches provided to fans if applicable]

Passive Cooling and Heating Systems (6)

[Details as per section 6 if applicable]

Heat from low carbon sources (7.2

[Details of heat generated from renewable sources or cogeneration (if applicable) and how this has been entered into the calculator]

Modelling Errors/Simplifications (8)

[Full details of any warnings obtained when running the software, or any defaults which have been overridden (for example number of hours when the stated internal design temperatures were not achieved)]

Sign off

[Confirmation of name and company of person carrying out the modelling, and signed confirmation that they believe the results to be accurate to the best of their knowledge]

APPENDIX E

LIFT/ELEVATOR ENERGY USE

Energy used by lifts etc is NOT to be included in the energy modelling results for the Green Star Multi Unit Residential v1 tool. Instead energy used by lifts is addressed by the separate credit Ene-8 Common Property Services Energy Use.

For credit Ene-8, the calculation procedure to be used is as follows:

1. Determine the lift power ratings **R** in kW from supplier specifications.

2. Determine the **S**tandby power from car lights and lift control system in kW from supplier specifications.

3. Calculate the **Yearly Energy Usage** using the following formula, and the data in Table 15 below.

$$E_l = \frac{R \times S \times T}{3600} + S_t \times H \times D$$

Where:

E_l = annual **E**nergy usage per lift (kWh/year)
R = Power **R**ating of the motor (kW)
S = number of **S**tarts per year
T = typical **T**rip time (seconds)
S_t = standby power – car lights and lift control systems (kW)
H = operational hours per day
D = number of operational days

4. Multiply by the number of lifts to get the total yearly energy usage, E.

5. The percentage improvement over the benchmark lift is determined as follows:

   % improvement = $(E_{benchmark} - E_{actual}) / E_{benchmark} \times 100\%$

	Parameter	Actual Building	Benchmark Building
R	Lift Power Rating (kW)	From lift supplier specifications. Figure to be reduced by 20% if the lift has regenerative brakes.	See table 16
S_t	Standby Power Rating (kW)	From lift supplier specifications	0.15kW
S	Number of starts per year	110,000	110,000
T	Typical Trip Time(s)	$\frac{\text{Max travel distance}}{2 \times \text{rated speed}}$	• Same travel distance as actual building. • Speed defined in Table 16
H	Operational Hours per day	• 24 hours (no power off feature) • 12 hours (for lifts with power off feature)	24 hours
D	Operational days per year	365	365

Table E.1 Parameters for the actual and benchmark lift calculations

Parameter:	Benchmark lift			
Maximum travel distance (m)	< 14	< 45	< 80	> 80
Lift Power Rating (kW)	7	10	17	25
Lift Speed (m/s)	0.63	1.0	1.75	2.5

Table E.2 Benchmark lift power and speed

APPENDIX F

THERMAL PROPERTIES OF TYPICAL CONSTRUCTIONS

The following table gives some typical thermal properties of common constructions.

External Walls

Construction (outside-inside)	***Admittance*** *W/(m^{2}K)*	***U value (1/R)*** *W/(m^{2}K)*	***Thermal Resistance (R)*** *m^{2}K/W*
220 solid brick, 13mm dense plaster	4.49	2.09	0.48
220 solid brick, 50mm mineral wool insulation, 12.5mm plasterboard	0.89	0.63	1.59
19mm render, 50mm EPS insulation, 220mm solid brick, 13mm dense plaster	4.23	0.54	1.85
105mm brick, 50mm airspace, 105mm brick, 13mm dens plaster	4.38	1.44	0.69
105mm brick, 50mm blown wool insulation, 105mm brick, 13mm dense plaster	4.51	0.59	1.69
105mm brick, 50mm blown fibre insulation , 100mm lightweight concrete block, 13mm dense plaster	2.97	0.52	1.92
105mm brick, 50mm airspace, 19mm plywood, 95mm mineral wool insulation, 12.5mm plasterboard	0.75	0.39	2.56

Table F.1 Typical thermal properties of common external wall constructions

Internal Walls

Construction (inside-inside)	***Admittance***	***U value (1/R)***	***Thermal Resistance (R)***
	W/(m^{2}K)	*W/(m^{2}K)*	*m^{2}K/W*
13mm light plaster, 105mm solid brick, 13mm light plaster	3.76	1.69	0.59
12.5mm Plasterboard, 50mm airspace, 12.5mm plasterboard	0.61	1.7	0.59

Table F.2 Typical thermal properties of common internal wall constructions

Roofs

Construction (outside-inside)	***Admittance***	***U value (1/R)***	***Thermal Resistance (R)***
	W/(m^{2}K)	*W/(m^{2}K)*	*m^{2}K/W*
0.4mm metal sheeting (steel) 150mm mineral wool insulation, 10mm hard board	1.27	0.25	4
0.4mm metal sheeting 150mm mineral wool insulation, 15mm cement board	1.86	0.25	4
concrete tiles, 150mm blown wool, 150mm concrete	5.7	0.25	4

Table F.3 Typical thermal properties of common roof constructions

Internal Ceilings

Construction (top-bottom)	***Admittance***	***U value (1/R)***	***Thermal Resistance (R)***
	W/(m^{2}K)	*W/(m^{2}K)*	*m^{2}K/W*
Carpet/underlay, 50mm screed, 150mm concrete	5.9	2.50	0.4
Carpet/underlay, 50mm screed, 150mm concrete, 150mm void, plasterboard	2.5	1.54	0.65

Table F.4 Typical thermal properties of common internal ceiling constructions

Floors

Construction (outside-inside)	***Admittance***	***U value (1/R)***	***Thermal Resistance (R)***
	W/(m^{2}K)	*W/(m^{2}K)*	*m^{2}K/W*
50mm polystyrene, 150mm concrete, 12mm tile	5.64	0.63	1.58
50mm polystyrene, 150mm concrete, 50mm screed, 10mm carpet/ underlay	2.23	0.53	1.89
50mm polystyrene, 150mm concrete, 50mm screed, vinyl	3.1	0.56	1.8
100mm mineral fibre, 19mm timber, 10mm carpet/underlay	1.15	0.31	3.2
Suspended timber floor (no carpet)	2.1	2.86	0.35

Table F.5 Typical thermal properties of common floor constructions