Green Star SA – Public & Education Building v1

ENERGY CALCULATOR & MODELLING PROTOCOL GUIDE

VERSION 1.0

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1 Executive Summary

The Green Star SA – Public & Education Building rating tool has been developed to evaluate the predicted performance of public and education buildings based on a variety of environmental criteria. The Energy Calculator within this tool compares the predicted energy consumption of a building to a benchmark based on a notional (reference) building complying with various standards and schedules (including aspects of SANS 204) of the same size as the actual building and in the same location. The carbon emissions associated with the energy consumption are determined by a calculator, and points are awarded to any facility which improves on the notional building benchmark.

To use the calculator, the predicted energy consumption of both the actual facility and the notional building must be calculated. Important components of this calculation are the heating and cooling energy consumption of the facility, which can be determined using computer modelling or Deemed To Satisfy ASHRAE criteria. This guide specifies standard inputs to be used when modelling the heating, ventilation and cooling (HVAC) systems of the facility. The standard inputs include operational profiles and internal heat loads.

The predicted ancillary load energy consumption, such as that from lighting, mechanical ventilation, domestic hot water and vertical transportation, must also be calculated. This guide includes details on how to calculate these loads in such a way that they can be fairly compared to the benchmark. The lighting energy can either be an output of the energy model or calculated using the lighting energy calculator, or a combination of both.

Finally, this guide includes information on how to enter the simulation outputs and the ancillary load calculations into the Green Star SA – Public & Education Building rating tool Energy Calculator. The calculator converts the energy use into carbon emissions and indicates the percentage improvement of the actual building compared to the notional building. Points are awarded based on 0 points for no improvement; up to a maximum of 20 points for a building with net zero operating emissions.

2 Acknowledgements

The Green Building Council of South Africa acknowledges the work of technical consultant Agama Energy, Spoormaker & Partners and Shared Energy Management in development of the Energy Calculator & Modelling Methodology for the South African Green Star SA – Public & Education Building v1 tool.

3 Introduction

The Green Building Council of South Africa (GBCSA) develop and manage a suite of rating tools to assess the environmental performance of buildings in South Africa. As part of this package, the Green Star SA – Public & Education Building v1 rating tool assesses the environmental performance of public and education buildings by measuring their environmental impact. Part of this assessment includes determining the predicted energy consumption of the building.

There are three methods to achieve points under the credit ENE1 – Greenhouse Gas Emissions:

- Route 1 – Energy Modelling.

- Route 2 – ASHRAE Deemed to Satisfy.

- Route 3 – SANS 204 Deemed to comply.

Project teams are encouraged to adopt route 1 – Energy modelling for their project when possible. The alternative routes 2 and 3 are provided as simplified approaches for smaller facilities.

This document provides guidance on how the calculations for each route must be carried out and how the data must be entered into the energy and lighting calculator spreadsheets so that a point score can be generated for this credit.

A points calculation method (Figure 1) is also included to provide a high level overview of the alternative routes and give an understanding of how the methods tie together.

When using route 1 the building must be simulated using computer modelling software in order to determine the predicted energy consumption of its Heating, Ventilation and Cooling (HVAC) system (which can also include lighting energy). In addition, the predicted energy consumption of the ancillary loads in the building must be calculated. (Thermal modelling must be done using software that complies with the requirements in this guide. Systems modelling may be done in a spreadsheet program or by hand, provided full details are submitted.)

Please note that the GBCSA does not keep a list of currently acceptable software packages and does not endorse any particular package or company. Any software program meeting the requirements in this guide is acceptable.

4 General Methodology

4.1 Route 1 – Energy Modelling

When using route 1 of this guide, the reduction in energy consumption of the building is predicted by comparing the consumption of the actual building against a notional building.

4.1.1 Model Notional (reference) Building

A building in the same location and with the same geometry as the actual building is modelled, with defined areas of glazing and fixed fabric performance and mechanical and electrical systems performance. The building must be modelled in accordance with the requirements and specifications for the notional building as put forward in this guide.

4.1.2 Model Actual Building

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

4.2 Route 2 – ASHRAE Deemed-toSatisfy (DTS)

When using route 2 of this guide, the reduction in HVAC energy consumption of the building is assumed to be 20% and no energy modelling is required.

The project team will be required to prove that the requirements for the building envelope and HVAC systems as set out in the ASHRAE Advanced Energy Design Guide for Small Office Buildings have been applied if the building is to be mechanically ventilated.

If the building is to be naturally ventilated, the project team will be required to prove compliance with ASHRAE Std 55-2004 – Adaptive comfort standards.

To assist the project team, this guide includes a table in appendix E which reflects the equivalent ASHRAE climate zone for various locations around South Africa and sets out the building envelope and HVAC system performance requirements in SI units.

4.3 Route 3 – SANS 204 Deemed-to-Comply (DTC)

When using route 3 of this guide, the notional and actual buildings are assumed to be air conditioned and the HVAC energy consumption of both buildings is assumed to be the same i.e. no reduction in HVAC energy consumption between notional and actual.

The actual building may however still score points for lighting, vertical transportation, domestic hot water, on-site renewable generation and other on-site generation.

The project team will be required to prove that the requirements of SANS 204 deemed to satisfy have been complied with.

4.4 Enter energy use into the energy calculator

When modelling (route 1 chosen), the HVAC energy use predicted for the notional building and the actual building, are entered into the calculator. When using route 2 or 3, the HVAC energy use is based on a benchmark. The other remaining energy uses (e.g. lifts, hot water, car park ventilation, internal and external lighting etc.) are calculated using this protocol. Once the total is obtained, any renewable energy sources and on site generation are taken into account. The calculator produces an estimate of the carbon emissions/m²/year for both the notional building and the actual building.

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" carbon emissions, on a linear scale with 0 points representing no improvement and 20 points representing a building with net zero operating emissions.

4.5 Nominated area definitions relevant to the energy calculator

HVAC and other services installations are not all always designed and directed by the landlord/developer's professional team, and are sometimes designed and directed by the tenants themselves. The developer/landlord is thus only in control of design for such tenants that his professional team is responsible for, and can thus claim potential Green Star SA points under the Green Star SA – Public & Education Building v1. For this reason it is necessary to define nominated areas which are defined according to the area that the developer/landlord's professional team are in control of.

Nominated Area (HVAC) - In terms of the HVAC system, the nominated area must include all common areas and the tenant HVAC systems (including potential naturally ventilated systems) that are designed by the landlord/developer's mechanical engineer, i.e. it would exclude all tenants that design their own HVAC systems. In cases where the landlord/developer has the responsibility for only parts of the design of a tenant's HVAC system (for example chilled water), the HVAC system for that tenant should be excluded from the energy model (and also excluded from the nominated area) – the nominated area must only include systems that are in totality under the landlord/developer's mechanical engineer's control. For the purposes of this tool this area is called '*Nominated Area (HVAC)*'.

Nominated Area (Lighting) - The nominated area for the lighting energy must relate to the area of the lighting design under the control of the landlord/developer's electrical engineer. For the purposes of this tool this area is called '*Nominated Area (Lighting)*'. This area can only include tenancies/areas where all lighting design in the specific tenancy/area is adequate (according to South African standards) and under the control of the landlord/developer's electrical engineer. Tenants might add lighting afterwards, but this should not be included in the calculations. Documentation must be provided with the submission of the building lighting design which the landlord's electrical engineer has designed. **Please refer to Appendix B for further definitions.**

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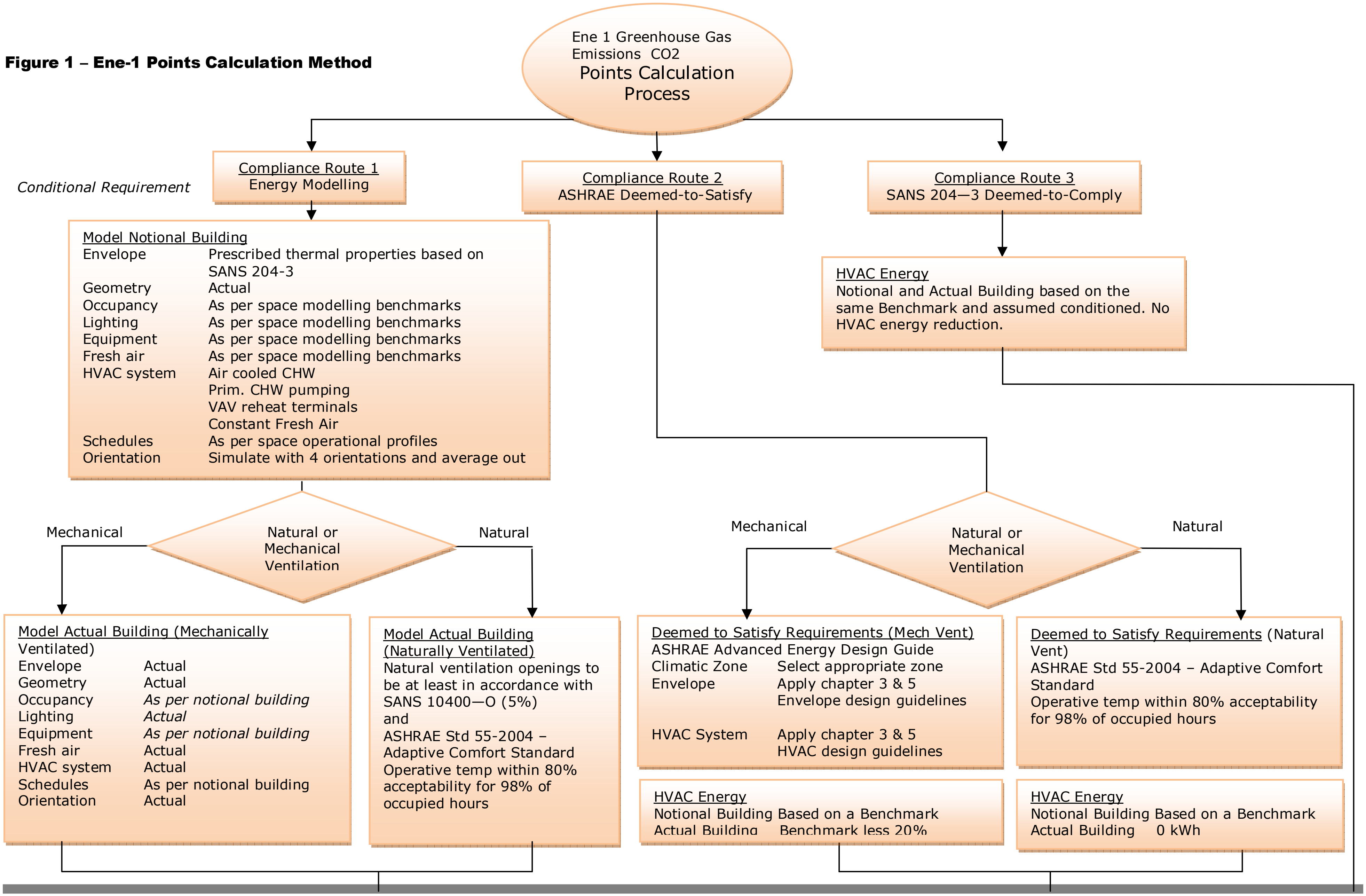
Figure 1 – Ene-1 Points Calculation Method



Enter HVAC Energy Modelling Results

	Notional Building	Actual Building
Heating	kWh from modelling	kWh from modelling
Cooling & Heat Rejection	kWh from modelling	kWh from modelling
Pumps	kWh from modelling	kWh from modelling
Fans	kWh from modelling	kWh from modelling
Total transferred to energy calculator	**Total HVAC kWh Notional Building**	**Total HVAC kWh Actual Bldg**

Enter data into Energy Calculator Sheet

Ene-0 conditional requirement met? Y/N
Select Compliance Route (1,2 or 3)
Naturally Ventilated building – thermal comfort criteria met? Y/N
ASHRAE deemed to satisfy requirements met (Y/N)

	Notional Building	Actual Building
HVAC	Total kWh from modelling or Benchmark	Total kWh from modelling or Benchmark (less saving)
Extract & Misc Fans Car Park Vent Exhaust vent	1st basement assumed natural then 1.1W/l/s. (07:00—22:00) 1.1W/l/s. (Bldg plant op hrs)	Actual Actual
Lighting	From Lighting Calculator	From Lighting Calculator
Vertical transport	25kW/pass. lift or 30kW/serv. lift, usage factor 0.75 and 4380 hrs/annum. 8kW/escalator, usage factor 0.75-1, 4380 hrs/annum.	Lifts use method with actual power Escalators use method with actual power and usage factor
Domestic Hot Water	Consumption based on benchmark per space type l/day/m², 20°C to 60°C, 90% efficiency.	Consumption and temperature as per Notional Bldg. Actual distribution and generation efficiencies

Enter on-site renewable electricity generation, enter other on-site electricity generation and fuel type

Enter data into Building Input Sheet
Project details including building type
Building areas by space type
System Descriptions

Enter data into Lighting Calculator Sheet

	Notional Building	Actual Building
Floor Areas	Building type and space breakdown taken from input sheet	As per notional building
Lighting load (W/m²)	Benchmark per space type	Actual
Lighting operating hours	Benchmark per space type and building type	A— Basic Control — as per notional building B – Local control and controls with timers or photo cells C—As above plus occupancy sensors D—As above plus daylighting—to be modelled

0 – 20 points calculated

5 Guidelines for Route 1 – Energy Modelling

The parameters for simulation of energy consumption of the facility are given in this section. These are standard criteria that must be adhered to in ordered to comply with the Green Star SA Energy credit 1 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.

5.1 General Modelling Parameters

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

Modelling Parameter	*Requirements*	*Documentation*
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. 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).
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; 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 or the Weather Analytics (WxA) platform.	Energy Report: • Type of data (TRY / year / interpolated). • Weather station location.

[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".

Overshadowing	• Demonstrate that overshadowing from the surrounding environment has been taken into account in the model or demonstrate that leaving it out in both the notional and actual building models is a conservative approach (i.e. showing that leaving it out gives a higher energy consumption in the actual building).	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. Energy 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.	Verification Documents: • Design or as-installed (where appropriate) colour coded 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.

Table 1: General Parameters Table

5.2 Building Envelope

	Notional (reference) Building	Actual Building
Geometry	Geometry based on actual geometry of building	Geometry based on actual geometry of building
Fabric	Fabric as follows: • Glazing System: Windows to have a U value 7.9 and a Solar Heat Gain Factor (SHGF) of 0.81 (based on clear single glazing, aluminium framed window taken from SANS204:2008 part 3 Table 6). Windows to be distributed on all sides of the building such as to achieve compliance with the SANS204 formula. • Walls insulated to R = 2.2 ('walls' refers to all vertical opaque surfaces, including walls, spandrels and doors) • Roof insulated to R = 2.7 to 3.7 depending on climatic zone – confirm using SANS204:2008 part 3. This R value would also apply to any atrium in the notional building. • Floor: specify the same floor structure and cross section as the actual building.	• Glazing System: Window U values to be modelled as per actual (Glass, frame and divider combined U value to be used). The glazing geometry and areas should be the same in both buildings (notional and actual). • Fabric to be modelled as per actual fabric (R values) • Floor: notional and actual building floor specification to be the same.
Orientation	• Model in four orientations (actual, actual $+90^0$, actual $+180^0$ and actual $+270^0$) and take average.	Use actual orientation.

Table 2: Building envelope parameters - Specific

Modelling Parameter	*Requirements*	*Documentation*
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.
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. • Design or as-installed (where appropriate) materials schedule. Energy Report: • Details on how the insulation has been represented in the model.

Glazing	• Demonstrate that glazing is modelled using the following parameters:
	  • Visible light transmission;
	  • Solar transmission;
	  • Internal and external solar reflectance; and
	  • Emissivity.
		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.

Windows and Spandrel	• Demonstrate that the sizes of windows and spandrel 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.

Modelling Parameter	*Requirements*	*Documentation*
Shading	• Demonstrate that all shading of windows and external building fabric are accurately represented. • No shading other than geometry related shading (e.g. balconies, overhangs, etc.) is to be included in the Notional building model. In the actual building model, any shading devices provided in the actual design must be included in the model.	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.
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.
Infiltration	• Demonstrate that infiltration has been modelled to reflect façade design specification. Typical default values are 0.5 air changes per hour for perimeter zones and zero air changes per hour for central zones.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) relevant pages from the façade specification that show infiltration or façade sealing characteristics. Energy Report: • Details of how the infiltration has been modelled.

Table 3: Building envelope parameters - general

5.3 Internal Design Criteria

	Notional (reference) Building	Actual Building
Internal design temperatures	24°C in summer 20°C in winter	as client brief or if no client brief than as per notional building
Occupancy	Refer to Appendix C	Refer to Appendix C (even if client brief is higher/lower)
Lighting	Refer to Appendix C	Actual design.
Lighting (car park and external areas)	Do not form part of model.	Do not form part of model.
Equipment (in tenant areas)	Refer to Appendix C	Refer to Appendix C
Fresh Air rate	Refer to Appendix C	Actual design rate

Table 4: Internal Design Criteria - Specific

Hourly profiles of these loads must be as per the schedules referred to in Appendix D of this guide.

Modelling Parameter	*Requirements*	*Documentation*
Lighting	• Demonstrate that lighting is calculated based on floor area. • Demonstrate that the appropriate operational profiles (see Appendix D) have been used in the model.	Verification Documents: • 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 for the building have been modelled.
Equipment	• Demonstrate that equipment is calculated based on floor area. • Demonstrate that the appropriate operational profiles (see Appendix D) 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 equipment load densities have been calculated. • Details on the operational profiles have been modelled.
Occupancy	• Demonstrate that all occupancies are calculated based on floor area. • Demonstrate that the occupancy profile used is that prescribed for each space type in Appendix D.	Verification Documents: • Area schedule. Energy Report: • Details of space type areas using the definitions in Appendix B • Details on how the occupancy loads have been modelled • Details on the profiles used for occupancy

Table 5: Internal Design Criteria - general

5.4 HVAC Systems Simulation

The HVAC system energy simulation for the notional building should include for:
1) Primary cooling generation and heat rejection;
2) Water side cooling distribution energy;
3) Air side air distribution energy and air side heating;
4) Ventilation air;
5) Distribution losses shall not be accounted for (heat loss from ducting and piping); and/or,
6) Leakage shall not be accounted for (air loss from ducting during distribution).

System zoning for the notional building should be as per the actual building.

	Notional (reference) Building	*Actual Building*
Primary cooling and heat rejection – heat rejection, compressor, evaporator	The whole building cooling load shall be served by an air cooled chiller with performance interpolated based on table 7 (Interpretation based on ASHRAE 90.1 – 2007 TABLE 6.8.1.C, minimum efficiency 2.80 COP, 3.05 Integrated Part Load Value (IPLV))	As actual design
Heating	Heating is to be provided by terminal electric reheat controlled such as to allow for 'Variable air volume (VAV) systems which, during periods of occupancy are designed to reduce the air supply to each zone to a minimum before re-heating, re-cooling or mixing takes place. This minimum volume should be no greater than 30 % of the peak supply volume.' (as taken from SANS 204:2011 4.8.7.3.3(a)) – note that zoning is to be as per the actual design.	As actual design
Chilled water system	Cooling will be distributed through a constant volume chilled water distribution system. Chilled water volume pumped shall be calculated based on a temperature difference of 6 ºC. Pump power shall be 349kW/1000L/s (Interpretation based on ASHRAE 90.1 – 2007 G3.1.3.10)	As actual design

	Notional (reference) Building	*Actual Building*
Supply air fans (Air Handling Units)	Supply air fan power shall be based on a variable air volume supply. The supply air temperature shall be 12ºC. The minimum supply air volume shall be the minimum fresh air ventilation rate. Heating fan power shall be calculated based on a variable air volume supply air temperature of 30 deg C (so that the air density can be calculated). Specific fan power to be 2.1W/l/s (per SANS 204-3:2008). The specific fan power is the sum of the design total circuit-watts, including all loses through switchgear and controls such as inverters, of all fans that supply air and exhaust it back outside the building (i.e., the sum of supply and extract fans), divided by the design ventilation rate through the building.	As actual design
Fresh air ventilation fans	Fresh air shall be delivered by constant volume fan systems. The fresh air volume delivered shall be as defined in the internal design criteria. Supply air fan power is to be calculated on the basis of 0.75W/l/s * *Note that the system to be modelled for the notional building consists of constant volume fresh air fans supplying fresh air to the building as well as variable volume indoor supply air fans supplying conditioned air.*	As actual design
Distribution losses	No ducting or piping heat loss should be accounted for in the notional building.	As actual design
Leakage	No duct leakage shall be accounted for in the notional building.	As actual design
HVAC system controls	to satisfy SANS204	As actual design

	Notional (reference) Building	*Actual Building*
<u>Specialised Areas:</u>		
Laboratories	Provision is to be made in the fresh air supply volume to laboratories for make-up to fume extract cabinets. For notional buildings, the make-up air to the cabinet will be supplied into the room via the room air conditioning system. The following assumptions must be applied when modelling laboratory areas containing fume extract cabinets: Number of cabinets: As per project requirements Size of cabinets: As per project requirements Recirculatory: No Sash opening size: As per project requirements Extract volume: 0.5m/s across the sash opening Extract volume control: Constant extract Extract system operating hours: Refer plant operating hours – Appendix D. Exhaust air heat recovery: No Extract fan power: Without HEPA filtration 1.5W/l/s With HEPA filtration 2.5W/l/s	When modelling the actual building, the make-up air to the cabinet will be supplied in accordance with the actual design philosophy. The following assumptions must be applied to the modelling of the actual building: Number of cabinets: As per project requirements Size of cabinets: As per project requirements Recirculatory: As actual design Sash opening size: As per project requirements Extract volume: As actual design Extract volume control: As actual design Extract system operating hours: As actual design Exhaust air heat recovery: As actual design Extract fan power: As actual design
Indoor swimming pools	Provision is to be made for the additional latent load and for dehumidification of air conditioned areas containing indoor swimming pools. The following assumptions must be applied when modelling areas containing indoor swimming pools: Room temperature: 26.0°C	The following will apply when modelling the actual building containing a swimming pool: Room temperature: As actual design Pool water temperature: As actual design Pool latent load: Calculated in accordance with

	Notional (reference) Building	*Actual Building*
	Pool water temperature: 27.0°C Pool latent load: 148W/m² pool area Maximum room humidity: 60% RH Operating hours: 24hr, 365 day/year	ASHRAE Applications Handbook 2007, 4.6, 4.7. Maximum room humidity: 60% RH Operating hours: 24hr, 365 day/year
Kitchens	Provision is to be made in the fresh air supply volume to food preparation areas (kitchens) for make-up to extract canopies. For notional buildings, the make-up air to the canopy will be supplied into the room via the room air conditioning system. The following assumptions must be applied when modelling kitchens containing extract canopies: Number of canopies: As per project requirements Size of canopies: As per project requirements Recirculatory: No Extract volume: 0.5m/s across the canopy opening Extract volume control: Constant extract Extract system operating hours: Refer plant operating hours – Appendix D. Exhaust air heat recovery: No Extract fan power: 1.5W/l/s	When modelling the actual building, the make-up air to the canopy will be supplied in accordance with the actual design philosophy. The following assumptions must be applied to the modelling of the actual building: Number of canopies: As per project requirements Size of canopies: As per project requirements Recirculatory: As actual designExtract volume: As actual design Extract volume control: As actual design Extract system operating hours: As actual design Exhaust air heat recovery: As actual design Extract fan power: As actual design

	Notional (reference) Building	*Actual Building*
Air conditioned space vs. mechanically ventilated space vs. naturally ventilated space	All spaces that are to be air conditioned in the actual building must be modelled as air conditioned in the notional building. All spaces that are naturally ventilated in the actual building and meet the comfort criteria of IEQ 9 – Thermal comfort for at least one point, must be modelled as air conditioned spaces in the notional building. If the IEQ-9 comfort criteria for one point are not achieved, then the space must be modelled as naturally ventilated in the notional building. All spaces that are mechanically ventilated in the actual building must be modelled as mechanically ventilated in the notional building	As actual design

Table 6: HVAC system parameters – Specific

	Load as % of Design Load									
Outside Air Temperature	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
35°C	2.80	2.80	2.87	2.92	2.93	2.97	3.08	3.18	3.16	3.14
20°C	2.80	2.92	3.02	3.07	3.09	3.13	3.24	3.35	3.32	3.30

Table 7: Cooling plant performance

Cooling plant Coefficient of Performance (COP) at varying load and outdoor air temperatures (based on COP ≥ 2.80 and IPLV (Integrated Part Load Value) ≥ 3.05 as per ASHRAE 90.1 – 2007 TABLE 6.8.1.C - the above values give an IPLV value of 3.15 which is marginally better than the minimum required).

If a common central plant is shared by the development pursuing certification and another building or space, the central plant must be treated as follows:
1) The size of the central 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 central plant shall be applied proportionally to the central plant used for the energy calculations.

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

Modelling Parameter	*Requirements*	*Documentation*
HVAC System design	• Demonstrate that the HVAC system modelled represents the system design for each part of the building for the nominated area.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from mechanical specification and mechanical drawings which accurately and thoroughly describe the basic HVAC system design. <u>Energy Report:</u> • Details of how the HVAC system has been represented in the model.

Modelling Parameter	*Requirements*	*Documentation*
Zoning	• Demonstrate that all air conditioning zones represented in the thermal model accurately reflect system performance and zonal solar diversity.	Energy Report: • Details of how the air conditioning zones have been represented in the model, and how these zones accurately represent the mechanical design drawings and specification.
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.

Modelling Parameter	*Requirements*	*Documentation*
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.	<u>Energy Report:</u> • 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.	<u>Energy Report:</u> • 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.	<u>Verification Documents:</u> • 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. <u>Energy Report:</u> • 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.	<u>Verification Documents:</u> • 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. <u>Energy Report:</u> • Calculation of hot water pumping.
Tenant condenser water	• If a tenant condenser water loop is provided, show that allowance has been made for the additional energy used for tenant supplementary condenser water pumping. • If relevant, demonstrate that the tenant condenser water loop pumping is calculated based on a tenant supplementary cooling load, the static pressure of the tenant condenser water pumps (typically 250kPa) and the flow rate in L/s.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from the hydraulic and mechanical specifications showing the tenant water condenser loop data (or lack thereof); static pressure and the flow rate in L/s. <u>Energy Report:</u> • If relevant, details on how the tenant condenser water loop pumping was calculated.

Modelling Parameter	*Requirements*	*Documentation*
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.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from mechanical specification, giving details on the correct minimum outside air flow <u>Energy Report:</u> • 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.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from mechanical specification giving details on the economy cycle of the system <u>Energy Report:</u> • Detail of how the economy cycle has been modelled
Controls - Primary duct temperature control	• <u>Constant Volume Systems:</u> Demonstrate that modelling has allowed supply air temperatures to vary to meet loads in the space • <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.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from mechanical specification giving details of the design 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

Modelling Parameter	*Requirements*	*Documentation*
Controls - Minimum turndown	• Demonstrate, where relevant, that the minimum turndown airflow of each air supply is accurately reflected in the model.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the minimum turndown airflow of each air supply Energy Report: • 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.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification giving details of the chiller staging strategy Energy Report: • Details of how chiller staging has been modelled
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 temperature control bands have been modelled

Table 8: HVAC system simulation – general

6 Guidelines for Route 2 – ASHRAE Deemed-to-Satisfy

The parameters set out below identify the documentation requirements for project teams opting to use route 2 – ASHRAE.

Parameter	*Requirements*	*Documentation*
Roof, walls, floors, slabs and doors	• Demonstrate that insulation in the roof, walls, floors, slabs and doors have been accurately represented for the appropriate climate zone.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) materials schedule. Short Report: • Details on which ASHRAE climate zone is appropriate and the required vs actual building element U-value calculation.
Vertical Glazing	• Demonstrate that window to wall ratio, glass thermal transmittance and glass solar heat gain coefficient are appropriate for the building orientation and climate zone and exterior sun control is applied as required.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) relevant pages from the glazing or façade specification. Short Report: • Details on which ASHRAE climate zone is appropriate and the required vs actual building vertical glazing requirements.
Skylights	• Demonstrate that skylight percentage of roof area, glass thermal transmittance and glass solar heat gain coefficient are appropriate for the climate zone.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) relevant pages from the glazing or skylight specification. Short Report: • Details on which ASHRAE climate zone is appropriate and the required vs actual building skylight requirements.

Table 9: Building envelope parameters

Parameter	*Requirements*	*Documentation*
HVAC Equipment Efficiency	• Demonstrate that the HVAC equipment specified for, or installed on the project achieves the minimum efficiency standards for the appropriate climate zone.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant pages from the mechanical specification showing the plant size. • Documentation from the equipment supplier giving the appropriate efficiency values. <u>Energy Report:</u> • Details of the equipment sizes and efficiency.
Economiser	• Demonstrate that economy cycles have been incorporated into the HVAC design when required for the appropriate climate zone.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant HVAC drawings indicating the economy cycles. • Design or as-installed (where appropriate) relevant pages from the HVAC controls specification setting out the control requirements for the economy cycles. <u>Short Report:</u> • Details on the economy cycles incorporated into the HVAC design.
Ventilation	• Demonstrate that outdoor air dampers and demand control ventilation are provided where required for the appropriate climate zone.	<u>Verification Documents:</u> • Design or as-installed (where appropriate) relevant HVAC drawings indicating the outdoor air dampers and controls. • Design or as-installed (where appropriate) relevant pages from the HVAC controls specification setting out the control requirements for the outdoor air dampers. <u>Short Report:</u> • Details on the outdoor air dampers and demand control ventilation design.

Parameter	*Requirements*	*Documentation*
Ducts	• Demonstrate that design, sealing, location and insulation of ducting meets the ASHRAE requirements for the appropriate climate zone.	Verification Documents: • Design or as-installed (where appropriate) relevant HVAC drawings indicating the ducting layouts. • Copies of duct sizing calculations indicating the friction rate for each section of ducting. • Design or as-installed (where appropriate) relevant pages from the HVAC specification setting out the sealing and insulation requirements of the ducting. Short Report: • Details on the ducting design friction rates, sealing, location and insulation level.

Table 10: HVAC system parameters

7 Guidelines for Route 3 – SANS 204 Deemed-to-Comply

The parameters set out below identify the documentation requirements for project teams opting to use route 3 – SANS 204 Deemed to Comply.

Note that this section references SANS 204:2008

Parameter	*Requirements*	*Documentation*
Building orientation, shading and building design	• Demonstrate that the requirements of SANS204 have been applied to the building orientation, floors, walls, fenestration, shading, roof assemblies and roof lights.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) materials schedule. Energy Report: • Details on the SANS204 requirement for each building element and confirmation that these requirements have been met.
Building sealing	• Demonstrate that the requirements of SANS204 for building sealing have been met.	Verification Documents: • Design or as-installed (where appropriate) relevant architectural drawings. • Design or as-installed (where appropriate) materials schedule. Energy Report: • Details on the SANS204 requirement for building sealing and confirmation that these requirements have been met.
Services and mechanical ventilation and air conditioning	• Demonstrate that the requirements of SANS204 have been applied to the building services and mechanical air conditioning and ventilation installations.	Verification Documents: • Design or as-installed (where appropriate) relevant drawings from the building services engineers. • Design or as-installed (where appropriate) relevant pages from the building services engineers specifications. Energy Report: • Details on the SANS204 requirement for building services and confirmation that these requirements have been met.

Table 11: SANS 204 deemed to comply parameters

8 Guidelines for Other Parameters

8.1 Extract & Miscellaneous Fans

Any fans not included in the building simulation (see above), must be accounted for in the "miscellaneous fans" section of the calculator. This includes toilet and kitchenette extract fans, car park ventilation fans, ceiling mounted propeller type fans (if provided by landlord) etc – refer also to Appendix C for the applicable operating profiles of the items below.

	Notional SANS204 Building	Actual Building
Car Park Ventilation	Assume no energy use for car parking on first basement (B1) levels and above (i.e. assume natural ventilation). For car parking on lower basements, use the same flow rates as the actual peak design, with a specific fan power of 1.1 W/l/s assumed to be constant volume. In instances where one or more basements are partially below ground level, the first basement level (B1) which is partially below ground should be assumed naturally ventilated (i.e. no car park ventilation energy use). For car parking on lower basements (below B1) which are partially below ground and mechanically ventilated in the actual design (if deemed to be required under SANS 10400 parts O & T), the same flow rates as the actual peak design, with a specific fan power of 1.1 W/l/s should be used. For car parking on lower basements which are partially below ground and naturally ventilated in the actual design (if deemed not to require mechanical ventilation under SANS 10400 parts O & T), these should be modelled as naturally ventilated (i.e. no car park ventilation energy use) in the notional SANS 204 Building.	As actual design
Exhaust Ventilation	Flow rates as actual design, with specific fan power of 1.1 W/l/s assumed to be constant volume.	As actual design

Table 12: Mechanical Exhaust parameters - specific

Modelling Parameter	*Requirements*	*Documentation*
Mechanical exhaust systems	• Demonstrate that the energy requirements for mechanical exhaust systems (such as those installed for toilets, kitchens and any other purpose specific systems such as photocopy or equipment/plant room exhausts) are calculated using the following parameters: • Maximum power of the fan; • 50% fan efficiency; and • An operational profile based on the operational profiles. That is, the fan should be on anytime that the HVAC system is on.	Verification Documents: • Design or as-installed (where appropriate) relevant pages from the mechanical specification showing details of mechanical exhaust systems. Energy Report: • Details of how the energy requirements for mechanical exhaust systems are calculated.

Table 13: Mechanical Exhaust parameters - general

8.2 Lighting

Lighting in internal areas

All lighting usage and energy should be calculated either manually (via the lighting energy calculator) or using the computer simulation modelled numbers which must be entered into the lighting energy calculator (or a combination of simulated and manually calculated values may be entered) – these values are automatically transferred into the energy calculator by the excel tool. The relevant lighting operation control schedules (profiles as given in Appendix D) must be selected and applied either in the computer model or in the lighting energy calculator. Where installed as part of the landlord works, lighting controls and daylight sensing can be incorporated in the simulation and will be reflected in the number of points awarded insofar as they reduce the cooling/heating as well as the actual lighting energy loads of the building. For details on lighting schedules to be used when modelling, see Appendix H.

Lighting in external areas

The energy use associated with all lighting in external areas should be calculated and entered into the lighting energy calculator, which automatically transfers it to the energy calculator. The energy consumption calculation should be based on a calculation of the actual number of fittings used and the power ratings of each fitting, together with the consumption profiles given in Appendix D – select 'modelled' under the schedule drop down options to allow the Lighting Energy Calculator to use your calculated energy consumption. If this is not done, the calculator will assume that the lit areas and W/m^2 values are the same for the notional and actual external site area. Where installed as part of the landlord works, lighting controls and daylight sensing can be incorporated in the calculation. For details on lighting schedules to be used when modelling, see Appendix H.

Refer to Appendix B for further detail on the lighting area definitions.

Modelling Parameter	*Requirements*	*Documentation*
Lighting	• Demonstrate that lighting is calculated based on actual fittings. • Demonstrate that the appropriate Lighting Energy Consumption Profile in Appendix D has been used. The lighting profile can be adjusted if sufficient controls are installed. • A. Basic Controls – The Basic Controls option is intended to reflect a standard practice building with simple lighting controls and where a percentage of lighting remains on after hours. The Basic Controls operating hours are based on the Activity Schedules (See Appendix D) for each space / building combination. Where it cannot be shown that more advanced controls are to be installed as required for options B,C & D, then option A must be selected as the default lighting controls schedule. The Notional Building makes use of option A lighting control schedule. In this case, where the Lighting Energy Calculator is used to calculate the actual building lighting energy consumption, the 'Basic Control' schedule must be selected in the calculator. For modelling, the standard lighting profile given in the Activity Schedules (Appendix D) must be used. • B – Local Control – Where it can be justified with design documentation that switching occurs on a space by space basis and external lighting operates on a time clock or photocell, then the Local Controls profile must be used. In this case, where the Lighting Energy Calculator is used to calculate the actual building lighting energy consumption, the 'Local Control' schedule must be selected in the calculator. For modelling, the standard lighting profile given in the Activity Schedules (Appendix D) must be used.	Verification Documents: • Area schedule • Design or as-installed (where appropriate) reflected ceiling plans with base building lighting design • Design or as-installed (where appropriate) relevant pages from electrical specification showing occupancy sensors (if any), time clock (if any), lights and light fittings 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 for the building have been modelled • Details of the lighting control systems and how they have been modelled

Modelling Parameter	*Requirements*	*Documentation*
Lighting	• C. Occupancy Sensing: Where presence detectors are provided at least every 60m² of internal floor area (excluding car parking), the Occupancy Sensing profile may be used. In this case, where the Lighting Energy Calculator is used to calculate the actual building lighting energy consumption, the 'Occupancy Sensing' schedule must be selected in the calculator. For modelling, the standard lighting profile can be adjusted as detailed in Appendix H. • D. Modelled: Where lighting energy consumption is modelled, the results should be input into the Lighting Energy Calculator. For Daylight Dimming, details on the system and the calculation method must be provided. The calculation must use the methodology outlined in Appendix H.	

Table 14: Lighting parameters

8.3 Domestic Hot Water Supply

Domestic water pumping can be ignored. Any other normal or extraordinary energy item that would reasonably be considered significant in an energy model must also be included, and the calculation or simulation methodology must be adequately justified. These items shall include, but not be limited to, groundwater or water recycling treatment plants.

Modelling Parameter	*Requirements*	*Documentation*
Domestic hot water loads	• Domestic hot water loads (to showers and wash hand basins) are to be calculated using the method outlined in Appendix F.	Verification Documents: • Area schedule • Design or as-installed (where appropriate) specification of domestic hot water systems Energy Report: • Details of how the domestic hot water heating energy requirement is calculated in accordance with Appendix F.

Table 15: Domestic Hot Water parameters

8.4 Vertical Transportation

These items are entered separately into the calculator.

Modelling Parameter	*Requirements*	*Documentation*
Lift loads	• Lift loads are to be calculated using the method outlined in Appendix G.	Verification Documents: • Area schedule • Design or as-installed (where appropriate) specification of lift systems Energy Report: • Details of how the lift energy requirement is calculated in accordance with Appendix G.
Escalator and travelator loads	• Escalator and travelator loads are to be calculated using the method outlined in Appendix G.	Verification Documents: • Area schedule • Design or as-installed (where appropriate) specification of escalator and travelator systems Energy Report: • Details of how the escalator and travelator energy requirement is calculated

Table 16: Lifts, Escalator and Travelator parameters

8.5 Indoor Swimming Pools

The energy consumption of swimming pools must be calculated using the parameters set out below. For the purpose of this document, the energy consumption of the sanitising equipment, under water pool lighting and controls systems may be considered negligible and excluded from the pool energy calculation. Also, the energy consumption of the pool hall air conditioning system is excluded from this section as it has already been covered under section 5.4 of this guide.

	Notional (reference) Building	*Actual Building*
Pool pump power	As Actual Building	As per rated motor power of the actual system in the proposed design.
Pool pump run hours	24 hours per day/ 365 days per year	24 hours per day/ 365 days per year
Pool pump energy (KWHrs)	Pump power (KW) x run hours(Hrs)	Pump power (KW) x run hours(Hrs)
Pool Heating system Energy required (KWh heating)	The following parameters must be used for calculating the pool heating energy for the Notional Building. Pool water temperature: 27.0°C Pool heat loss: 148W/m² pool surface area Operating hours: 24hr, 365 day/year	As Actual Building
Pool Heating system efficiency	The swimming pool in the Notional Building is assumed to be heated with a heat pump system with a COP of 3.80	As per actual system proposed (i.e. heat pump, gas boiler, gas boosted heat pump, solar, etc)
Pool heating system energy	Heating system Energy required (KWh) divided by plant COP No adjustment for where the water temperature is set down during night time. No adjustment for pool blankets are assumed for the notional buildings pool.	Heating system Energy required (KWh) divided by plant COP Where the water temperature is set down during night time, the energy requirement to be proportioned accordingly Further adjustment can made to the above run hours for installation of pool blanket. Pool blankets shall reduce the heating requirement to 10% of the design capacity when placed over the pool

	Notional (reference) Building	*Actual Building*
		(Appendix C of AS 3634-1989). The operating times of the pool blanket to be clearly detailed in the design documents. Energy required to be proportioned for the times of the day the blanket shall be used.

Table 17: Swimming Pool parameters

Modelling Parameter	*Requirements*	*Documentation*
Pool pump power	• Demonstrate that the pool pump power is based on the actual buildings' proposed pool pumps.	Verification Documents: • Design or as-installed (where appropriate) specification of the pool filtration and pumping system Energy Report: • Details of how the pool pump power is calculated.
Pool Heating system Energy required (KWh heating)	• Demonstrate that the pool heating requirements for the Notional and Actual Building are based on the parameters set out above.	Verification Documents: • Design or as-installed (where appropriate) drawings indicating the swimming pool layout and the filtration and heating systems serving the swimming pool. Energy Report: • Calculations of the pool heating energy required for the notional and actual buildings

Pool heating system energy	• Demonstrate that the efficiency of the pool heating system for the Notional and Actual Buildings are based on the parameters set out above.	Verification Documents: • Catalogue literature and selection tables from the heating system suppliers giving the performance of the equipment at appropriate operating conditions. Energy Report: • Calculations of the pool heating equipment energy consumption for the notional and actual buildings at the appropriate conditions.

Table 18: Swimming Pool Requirements

9 Guidance for Use of Calculator

Green Star SA - Public & Education Building v1

Energy Calculator

Points Achieved:	6
Ene-0 Conditional Requirement Result:	Achieved

Notes & Instructions:

1. User must enter values into or select options in white cells ONLY
2. Refer to Green Star SA - Public & Education Building v1 Energy Calculator Protocol Guide for detailed information and assistance in using this calculator.

Please select Compliance Route adopted:	Compliance Route 1
If parts or all of the Building is Naturally Ventilated, is thermal comfort criteria met for those spaces? (Thermal comfort requirements need to be met to accept this as an option - refer to the Technical Manual for details)	N/A
Route 2 - ASHRAE *Advanced Energy Design Guide for Small Office Buildings:* 'deemed to satisfy' route has been met?	No (Route 1 used)
Total Building GFA	12 500 m²
Total Area of the building supporting the primary function	10 360 m²
Total Internal Covered Car Parking Area	950 m²
External Area (including external Car Parking)	490 m²

The compliance path for the Energy Conditional Requirement is selected on the main Energy category worksheet.

In the case of naturally ventilated buildings, confirm whether the building thermal comfort criteria has been met (refer to section on naturally ventilated buildings in this protocol for more information).

The areas given in the calculator are linked from the "Building Input" sheet.

ENERGY USE — Go To Lighting Energy Calculator

	Notional Building	Actual Building		
	Electrical use kWh/year	Electrical use kWh/year	Gas use kWh/year	
fuel CO_2 factor	1.20	1.20	0.202	
Heating (nominated area)	50 000	30 000	10 000	modelling data for nom. area (notional & actual buildings)
Cooling & Heat Rejection (nominated area)	350 000	300 000		modelling data for nom. area (notional & actual buildings)
Pumps (nominated area)	40 000	30 000		modelling data for nom. area (notional & actual buildings)
Fans (nominated area)	75 000	50 000		modelling data for nom. area (notional & actual buildings)
Extract and Miscellaneous Fans (nominated area)	50 000	40 000		modelling data for nom. area (notional & actual buildings)
Subtotal HVAC (nominated area)	565 000	450 000	10 000	
Lighting	649 563	339 466		refer to 'Lighting Energy Calculator'
Vertical transportation	500 000	400 000		calculate for Public & Education Building GFA (notional & actual building)
Domestic Hot Water	29 271	100 000	50 000	calculate for Public & Education Building GFA (notional & actual building)
SUB TOTALS (kWh/year)	1 743 834	1 289 466	60 000	

If compliance route 1 is chosen, enter the energy use predictions for both the notional building and the actual building. The first 5 items should be obtained from the thermal simulation program, while other items should all be calculated as defined in this protocol. 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. Gas used in cogeneration systems should not be entered here (it is entered later).

If compliance route 2 or 3 is chosen, the HVAC energy subtotal is automatically entered and is based on an energy benchmark applied to the air conditioning and mechanically ventilated areas.

Lighting loads must be entered via the 'Lighting Energy Calculator', either by entering the values from the actual energy model, or by entering the W/m^2 values per area, using a selected lighting control schedule, or a combination of both. The notional building lighting energy is calculated by the 'Lighting Energy Calculator.' All lighting energy values are automatically brought forward to the Energy Calculator.

Energy Usage for vertical transportation and domestic hot water must be calculated for the actual and the notional building as per this protocol.

ON SITE RENEWABLE ELECTRICITY GENERATION (actual building only)				
	kWh/year	fuel factor $kgCO_2/kWh$	net saving $kgCO_2/year$	net saving $kgCO_2/m^2/year$
Renewable Electricity generated on site including photovoltaics, wind turbines etc.	50 000	0	60 000	5.79

OTHER ON SITE GENERATION (actual building only)				
	kWh/year	fuel factor $kgCO_2/kWh$	net saving $kgCO_2/year$	net saving $kgCO_2/m^2/year$
Onsite Electricity Generation (e.g. electricity from a co-generation system)	50 000			
Type of fuel used	Diesel	0.267		
Amount of fuel used (calorific value in kWh)			60000	5.79

TOTALS		
Energy usage (notional building) - (Spaces supporting primary function)	168	$kWh/m^2/year$
Energy usage (actual building) - (Spaces supporting primary function)	125	$kWh/m^2/year$
Carbon emissions (notional building)	202	$kgCO_2/m^2/year$
Carbon emissions (actual building)	139	$kgCO_2/m^2/year$
PERCENTAGE IMPROVEMENT OVER NOTIONAL BUILDING	31.2%	
Energy Calculator Results:	6	

Any on site renewable electrical energy generated is entered in the next section.

In the case of cogeneration systems, the amount of electricity generated and the amount of fuel consumed should be entered as in the example above. The amount of fuel can be calculated either from the manufacturer's information on consumption or else from the manufacturer's figures for the gross overall efficiency of the generator. Data must be provided to substantiate these figures.

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

10 Naturally Ventilated Buildings

All spaces that are to be air conditioned in the actual building must be modelled as air conditioned in the notional building.

All spaces that are naturally ventilated in the actual building and meet the comfort criteria of IEQ 9 – Thermal comfort for at least one point, must be modelled as air conditioned spaces in the notional building. If the IEQ-9 comfort criteria for one point are not achieved, then the space must be modelled as naturally ventilated in the notional building.

All spaces that are mechanically ventilated in the actual building must be modelled as mechanically ventilated in the notional building

11 Renewable Energy and Cogeneration

11.1 Electrical Energy from on site renewable generation

Any electrical energy generated on site from "renewable" sources (e.g. photovoltaics, wind turbines, etc) is subtracted from the total electrical energy use of the building, whether or not the energy is used on site or exported. Purchase of "green electricity" does not qualify for this section and should not be entered.

11.2 Electrical Energy from on site non-renewable generation (e.g. cogeneration)

The annual fuel used for the generation is entered into the first part of the calculator. The associated electrical energy generated is then subtracted from the total electrical energy consumption of the building. If a conventional generator is proposed to be run using "low carbon" fuel (e.g. biodiesel) the carbon factor for biodiesel can only be used if there is clear evidence that a procurement strategy is in place for the purchase of the fuel or that the equipment has been modified so that it will only be able to operate with the low carbon fuel. In all other cases, conventional fuel must be assumed.

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

Any heat generated from renewable sources (e.g. solar water heating) should be subtracted from the heat energy use required for the building and SHOULD NOT BE ENTERED INTO THE CALCULATOR. This energy is treated as carbon neutral.

If a cogeneration (CHP) system is to be installed, the fuel should be included in the third part of the calculator ("Other On Site Generation," as described above). Any heat obtained from the cogeneration plant is then assumed to be "carbon free". If this heat is to be used on site, then the heat energy which is served from the cogeneration plant should not be included in the heat energy use required for the building and SHOULD NOT BE ENTERED INTO THE CALCULATOR. 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.

12 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[2], 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.

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

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 ;
- 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 Actual building model accurately represents:
  - Glazing on the building – whether the model represents glazing as only a U-value and shading coefficient;
  - The proposed HVAC system;
  - The HVAC controls which are to be used;
  - The performance curves and sizes for plant items;
- Sample performance curves are provided for cooling and heating sources (fans, pumps, chillers, etc.)
- 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 – Public & Education Building v1 rating tool Energy Calculator.

- Gross Floor Area – Refer to the Public & Education Building Technical Manual.
- Nominated Area – Refer to the Public & Education Building Technical Manual.
- Car Parks - Refer to the Public & Education Building Technical Manual.
- Actual or Proposed Building – Refer to the Public & Education Building Technical Manual.
- Notional or Reference Building – Refer to the Public & Education Building Technical Manual.
- Common Public & Education Building Spaces
  - Cellular office - Enclosed office space, commonly of low density.
  - Changing facilities - An area used for changing, containing showers. This activity should be assigned to the shower area and all associated changing areas. For areas which can be used for changing but which do not contain showers, such as a cloak room/locker room, refer to the common room/staff room/lounge category.
  - Circulation area (corridors and stairways) - non public - All public circulation areas where people are walking/sitting. For non public spaces use "Circulation areas (corridors and stairways) - non public"
  - Common room/staff room/lounge - An area for relaxing, taking breaks or meeting in a non work capacity For areas which are occupied predominantly 5 days a week. Where occupancy may be 7 days a week refer to 'Ward common room/staff room/lounge'.
  - Eating/drinking area - An area specifically designed for eating and drinking. For areas where food and drink may be consumed but where this is not the specific function of the area, use "common/staff room" and for areas with transient occupancy, use "tea making".
  - Food preparation area - An area where food is prepared.
  - Hall/lecture theatre/assembly area - An area which can accommodate a large number of seated people.
  - High density IT work space - High density desk based work space with correspondingly dense IT
  - IT equipment - An area dedicated to IT equipment such as a printers, faxes and copiers with transient occupancy (not 24 hrs).
  - Meeting room - An area specifically used for people to have meetings, not for everyday desk working. For everyday desk working areas refer to the appropriate office category.
  - Open plan office - Shared office space commonly of higher density than a cellular office.
  - Plant room - Areas containing the main HVAC equipment for the building eg: boilers/air conditioning plant.

- Public circulation areas - All public circulation areas. For non public circulation spaces use "Circulation areas (corridors and stairways) - non public"
- Reception - The area in a building which is used for entry from the outside or other building storeys.
- Storage area - Areas for un-chilled storage with low transient occupancy.
- Tea Kitchen - Areas used for making hot drinks, often containing a refrigerator with transient occupancy. For larger areas containing seating and a small hot drinks making area refer to "Common room/staff room".
- Toilet - Any toilet areas. If toilets are subsidiary to changing/shower activities refer to "changing facilities"

- Specialised Public & Education Building Spaces
  - Baggage Reclaim area - The area within an airport where baggage is reclaimed from conveyor belts.
  - Cell (police/prison) - A room which accommodates one or more prisoners.
  - Check in area - Area within an airport where travellers check in for their flight, containing check in desks and conveyer belt.
  - Classroom - All teaching areas other than for science or practical classes, for which refer to "Laboratory" or "Workshop - small scale".
  - Consulting room - An area used for medical consultation.
  - Display area - An area where display lighting is used to illuminate items.
  - Dry sports hall - An area where indoor sports can be played.
  - Fitness Studio - An area used for exercising/dance, usually with high person density but with no machines.
  - Fitness suite/gym - An area used for exercise containing machines.
  - Ice rink - An area which contains an ice rink.
  - Laboratory - A facility that provides controlled conditions in which scientific research, experiments, and measurement may be performed.
  - Laundry - An area used only for washing and/or drying clothes using washing machines and/or tumble dryers. This is not for where there is an individual washing machines within another space (eg a food preparation area).
  - Performance area (stage) - For stages with dedicated lighting and equipment in addition to that within the remainder of the space. For stages within other activity areas which do not have specific lighting or additional electrical equipment, do not define these as separate spaces.
  - Sales area – chilled - A storage area containing items which need to be chilled. The area itself can be conditioned.
  - Sales area – general All Sales areas which do not have a large concentration of fridges/freezers or electrical appliances.
  - Security check area - For the security areas of an airport containing equipment such as X-ray machines.
  - Storage area – chilled - A storage area containing items which need to be chilled. The area itself can be conditioned.
  - Storage area - cold room (<0degC) - A storage area kept at below 0degC. Cooling load is assumed to be a process load and therefore not included in the calculation.

- Swimming pool - The area in which a swimming pool is contained. This activity should be used for the whole pool hall.
- Workshop - small scale - An area for sedentary-light practical work. Often containing some machinery.

Areas in the Lighting Energy Calculator:

Internal Covered Car Park Lighting: This refers to all car park lighting that is serving areas internal to the building or below the building structure (e.g. any basement parking areas or ground/above ground parking areas which are part of structured parking or beneath the building's structure). This area is equal to the summation of the 'Internal Covered Vehicle Parking Area' and the 'Sub-basement Vehicle Parking Area' as entered in the 'Building Input' sheet. All lighting that is serving parking areas with opaque 'soft' roof coverings (such as sheet metal & lightweight structure) or translucent covering (such as shade net) must be excluded from the 'Internal Covered Car Park Lighting' area, and must be included in the 'External Lighting' area defined below. Lighting within multi-story car parking buildings separate to the public or education building(s), but within the same site and project scope, must also be included within 'Internal Covered Car Park Lighting'.

External Lighting: This refers to all external lighting that provides light to external areas on the site, including all lighting that is serving external parking areas with opaque 'soft' roof coverings (such as sheet metal & lightweight structure) or translucent covering (such as shade net). The area calculation must include all site area, less building footprints. The same area applies to both the notional and actual building, and thus if the actual site has less external lighting on the site than what is assumed by the calculator for the notional building site, the project is able to attain points in this way. The external lighting area must include external accessible roof areas if they are used regularly by any building occupants or building visitors for any reason (other than maintenance).

APPENDIX C

PUBLIC & EDUCATION BUILDING ACTIVITY BENCHMARKS

The following table provides internal loads (people, lighting and equipment) and ventilation rates for use when calculating the energy consumption of the building. The internal loads have been adopted from the National Calculation Method (NCM) as defined by the Department of Communities and Local Government (DCLG) of the United Kingdom._These figures have been consolidated into the table below for ease of reference. Ventilation rates for the various spaces have been taken from SABS 10400-O:2011.

Space name	People density m²/person	Metabolic rate W/person	Equipment loads W/m²	Ventilation rates: Air Change Rate ACH	Ventilation rates: l/s/person	Lighting W/m²
Cellular office	14.29	120	10.0	2.0	7.5	13.6
Circulation area (corridors and	9.09	140	2.0	2.0	7.5	3.4
Common room/staff room/lounge	9.09	100	5.0	2.0	7.5	10.2
Eating/drinking area	5.00	110	20.0	10.0	7.5	6.8
Food preparation area	9.09	180	40.0	20.0	17.5	17.0
Hall/lecture theatre/assembly area	5.00	140	2.0	10.0	7.5	16.5
High density IT work space	5.00	120	30.0	2.0	7.5	10.2
IT equipment	9.09	140	50.0	2.0	7.5	3.4
Meeting room	5.00	120	5.0	2.0	10.0	17.0
Open plan office	9.09	120	15.0	2.0	7.5	13.6
Plant room	9.09	180	50.0		7.5	6.8
Public circulation areas	5.00	180	5.0	2.0	7.5	6.8
Reception	9.09	140	5.0	2.0	7.5	19.2
Storage area	9.09	140	2.0		7.5	3.4
Tea Kitchen	9.09	140	10.0	10.0	50 l/s /room	6.8
Toilet	9.09	140	5.0	20.0	20 l/s /fixture	6.8
Parking Garage						2.6
Baggage Reclaim area	4.00	180	10.0	10.0	7.5	6.8
Cell (police/prison)	7.69	100	5.0	2.0	5.0	4.6
Changing facilities	7.69	140	5.0	10.0	7.5	6.8
Check in area	4.00	140	15.0	10.0	7.5	17.0
Classroom	1.82	140	5.0	2.0	7.5	10.2
Consulting room	14.29	140	10.0	10.0	7.5	17.0
Display area	9.09	140	2.0	2.0	7.5	33.0
Dry sports hall	1.00	300	2.0		10.0	13.5
Fitness Studio	5.88	300	2.0		10.0	10.2
Fitness suite/gym	5.88	300	15.0		10.0	10.2
Ice rink	5.00	250	2.0		7.5	13.5
Laboratory	9.09	160	10.0	2.0	7.5	17.0
Laundry	9.09	180	50.0	10.0	7.5	10.2
Performance area (stage)	1.00	250	2.0	10.0	7.5	5.5
Sales area - chilled	9.09	140	25.0	2.0	7.5	20.2
Sales area - general	9.09	140	5.0	2.0	7.5	20.2
Security check area	4.00	140	20.0	2.0	7.5	10.2
Storage area - chilled	9.09	140	25.0		7.5	6.8
Storage area - cold room (<0degC)	9.09	140	0.0		7.5	6.8
Swimming pool	5.88	160	2.0		12.0	13.5
Workshop - small scale	14.29	180	5.0		10.0	17.0

APPENDIX D

PUBLIC & EDUCATION BUILDING OPERATIONAL PROFILES

The operational profiles required for modelling various types of spaces in Public & Education Buildings and for various types of buildings have been adopted from the National Calculation Method (NCM). They are available in a separate spreadsheet which can be downloaded from the GBCSA web site at www.gbcsa.org.za. The list below summarises the profiles contained in the spreadsheet.

D.1 BAGGAGE CLAIM
D.1.1 Typical

D.2 CELLULAR OFFICE
D.2.1 Typical
D.2.2 Airport terminals and Bus station/train station/seaport terminal
D.2.3 Casino
D.2.4 Convention Centre and Exhibition Hall
D.2.5 Fire Station/Police station
D.2.6 Libraries/ museums/ and galleries
D.2.7 Restaurant/ public house
D.2.8 Sports centre/ leisure centre - School semesters
D.2.9 Tertiary Education - Tertiary holidays
D.2.10 Tertiary Education - Tertiary semesters
D.2.11 Theatres/ cinemas/ and music halls

D.3 CELL (POLICE/PRISON)
D.3.1 Courts

D.4 CHANGING FACILITIES
D.4.1 Typical
D.4.2 Community/ day centre
D.4.3 Fire Station/Police Station
D.4.4 Primary and secondary schools (Non-residential) - School holidays
D.4.5 Primary and secondary schools (Non-residential) - School semesters
D.4.6 Sports centre/ leisure centre - School semesters
D.4.7 Tertiary Education - Tertiary semesters
D.4.8 Worship

D.5 CHECK IN AREA
D.5.1 Typical
D.6 CIRCULATION AREA
D.6.1 Typical
D.6.2 Airport terminals and Bus station/train station/seaport terminal
D.6.3 Casino
D.6.4 Community/ day centre
D.6.5 Convention Centre and Exhibition Hall
D.6.6 Courts
D.6.7 Fire Station/Police Station
D.6.8 Libraries/ museums/ and galleries
D.6.9 Primary and secondary schools (Non-residential) - School semesters
D.6.10 Restaurant/Public house
D.6.11 Sports centre/ leisure centre - School semesters
D.6.12 Tertiary Education - Tertiary holidays
D.6.13 Tertiary Education - Tertiary semesters
D.6.14 Theatres/ cinemas/ and music halls
D.6.15 Worship

D.7 CLASSROOM

D.7.1 Typical
D.7.2 Tertiary Education - Tertiary holidays
D.7.3 Tertiary Education - Tertiary semesters

D.8 COMMON ROOM/STAFF ROOM/LOUNGE
D.8.1 Typical
D.8.2 Airport terminals and Bus station/train station/seaport terminal
D.8.3 Primary and secondary schools (Residential) - School holidays
D.8.4 Primary and secondary schools (Residential) - School semesters
D.8.5 Tertiary Education - Tertiary holidays
D.8.6 Tertiary Education - Tertiary semesters

D.9 CONSULTING ROOM
D.9.1 Typical

D.10 DISPLAY AREAS
D.10.1 Theatres/ cinemas/ and music halls

D.11 DRY SPORTS HALL
D.11.1 Typical
D.11.2 Community/ day centre
D.11.3 Fire Station/Police Station
D.11.4 Primary and secondary schools (Non-residential) - School holidays
D.11.5 Primary and secondary schools (Non-residential) - School semesters
D.11.6 Sports centre/ leisure centre - School semesters
D.11.7 Tertiary Education - Tertiary holidays
D.11.8 Tertiary Education - Tertiary semesters
D.11.9 Worship

D.12 EATING/DRINKING AREA
D.12.1 Typical
D.12.2 Airport terminals and Bus station/train station/seaport terminal
D.12.3 Casino
D.12.4 Community/ day centre
D.12.5 Convention Centre and Exhibition Hall
D.12.6 Courts
D.12.7 Fire Station/ Police Station
D.12.8 Libraries/ museums/ and galleries
D.12.9 Primary and secondary schools (Residential) - School holidays
D.12.10 Primary and secondary schools (Residential) - School semesters
D.12.11 Primary and secondary schools(Non-Residential)-School semesters
D.12.12 Restaurant/Public House
D.12.13 Sports centre/ leisure centre - School semesters
D.12.14 Tertiary Education - Tertiary holidays
D.12.15 Tertiary Education - Tertiary semesters
D.12.16 Theatres/ cinemas/ and music halls
D.12.17 Worship

D.13 FITNESS STUDIO
D.13.1 Sports centre/ leisure centre - School semesters

D.14 FITNESS SUITE/GYM
D.14.1 Typical
D.14.2 Tertiary Education - Tertiary holidays
D.14.3 Tertiary Education - Tertiary semesters

D.15 FOOD PREPARATION AREA
D.15.1 Typical
D.15.2 Airport terminals and Bus station/train station/seaport terminal
D.15.3 Casino
D.15.4 Community/ day centre
D.15.5 Convention Centre and Exhibition Hall
D.15.6 Fire Station/Police Station
D.15.7 Primary and secondary schools (Residential) - School holidays
D.15.8 Primary and secondary schools (Residential) - School semesters
D.15.9 Restaurant/ public house

D.15.10 Sports centre/ leisure centre - School semesters
D.15.11 Tertiary Education -Tertiary semesters
D.15.12 Theatres/ cinemas/ and music halls
D.15.13 Worship

D.16 HALL/LECTURE THEATRE/ASSEMBLY AREA
D.16.1 Typical
D.16.2 Community/ day centre
D.16.3 Convention Centre and Exhibition Hall
D.16.4 Courts
D.16.5 Libraries/ museums/ and galleries
D.16.6 Primary and secondary schools(Non-residential) - School semesters
D.16.7 Sports centre/ leisure centre - School semesters
D.16.8
D.16.9 Tertiary Education - Tertiary holidays
D.16.10 Tertiary Education - Tertiary semesters
D.16.11 Theatres/ cinemas/ and music halls

D.17 HIGH DENSITY IT WORK SPACE
D.17.1 Typical
D.17.2 Tertiary Education - Tertiary semesters

D.18 ICE RINK
D.18.1 Sports centre/ leisure centre - School semesters

D.19 IT EQUIPMENT
D.19.1 Typical
D.19.2 Community/ day centre
D.19.3 Courts
D.19.4 Libraries/ museums/ and galleries
D.19.5 Primary and secondary schools (Non-residential) - School semesters
D.19.6 Tertiary Education - Tertiary semesters

D.20 LABORATORY
D.20.1 Typical
D.20.2 Libraries/ museums/ and galleries
D.20.3 Primary and secondary schools (Residential) - School semesters
D.20.4 Tertiary Education - Tertiary holiday
D.20.5 Tertiary Education - Tertiary semesters

D.21 LAUNDRY
D.21.1 Typical
D.21.2 Primary and secondary schools (Residential) - School semesters
D.21.3 Sports centre/ leisure centre - School semesters
D.21.4 Tertiary Education - Tertiary semesters
D.21.5 Theatres/ cinemas/ and music halls

D.22 MEETING ROOM
D.22.1 Typical

D.23 OPEN PLAN OFFICE
D.23.1 Typical

D.24 PERFORMANCE AREA (STAGE)
D.24.1 Typical
D.24.2 Restaurant/Public House
D.24.3 Theatres/ cinemas/ and music halls

D.25 PLANT ROOM
D.25.1 Typical
D.25.2 Airport terminals and Bus station/train station/seaport terminal
D.25.3 Casino
D.25.4 Community/ day centre
D.25.5 Convention centre and Exhibition Hall
D.25.6 Courts
D.25.7 Fire Station/Police Station

D.25.8 Libraries/ museums/ and galleries
D.25.9 Primary and secondary schools (Non-residential) - School holidays
D.25.10 Primary and secondary schools (Non-residential) - School semesters
D.25.11 Restaurant/Public House
D.25.12 Sports centre/ leisure centre - School semesters
D.25.13 Tertiary Education - Tertiary semesters
D.25.14 Theatres/ cinemas/ and music halls
D.25.15 Worship

D.26 PUBLIC CIRCULATION AREAS
D.26.1 Typical
D.26.2 Libraries/ museums/ and galleries

D.27 RECEPTION
D.27.1 Typical
D.27.2 Airport terminals and Bus station/train station/seaport terminal
D.27.3 Casino
D.27.4 Community/ day centre
D.27.5 Convention Centre and Exhibition Hall
D.27.6 Courts
D.27.7 Fire Station/Police Station
D.27.8 Libraries/ museums/ and galleries
D.27.9 Primary and secondary schools (Non-residential) - School semesters
D.27.10 Sports centre/ leisure centre - School semesters
D.27.11 Tertiary Education - Tertiary semesters
D.27.12 Theatres/ cinemas/ and music halls
D.27.13 Worship

D.28 SALES AREA-CHILLED
D.28.1 Theatres/ cinemas/ and music halls

D.29 SALES AREA-TYPICAL
D.29.1 Theatres/ cinemas/ and music halls

D.30 SECURITY CHECK AREA
D.30.1 Typical

D.31 STORAGE AREA
D.31.1 Typical
D.31.2 Community/ day centre
D.31.3 Courts
D.31.4 Fire station/Police station
D.31.5 Libraries/ museums/ and galleries
D.31.6 Primary and secondary schools (Non-residential) - School semesters
D.31.7 Restaurant/ public house
D.31.8 Tertiary Education - Tertiary semesters
D.31.9 Worship

D.32 STORAGE AREA-CHILLED
D.32.1 Typical
D.32.2 Community/ day centre
D.32.3 Courts
D.32.4 Libraries/ museums/ and galleries
D.32.5 Primary and secondary schools (Non-residential) - School semesters
D.32.6 Tertiary Education - Tertiary semesters

D.33 STORAGE AREA COLD ROOM (<0DEGC)
D.33.1 Typical
D.33.2 Community/ day centre
D.33.3 Courts
D.33.4 Libraries/ museums/ and galleries
D.33.5 Primary and secondary schools (Non-residential) - School semesters
D.33.6 Tertiary semesters

D.34 SWIMMING POOL
D.34.1 Typical

D.34.2 Convention Centre and Exhibition Hall - School holidays
D.34.3 Convention Centre and Exhibition Hall - School semester
D.34.4 Sports centre/ leisure centre - School holidays
D.34.5 Sports centre/ leisure centre - School semesters
D.34.6 Tertiary Education - Tertiary semesters

D.35 TEA KITCHEN
D.35.1 Tertiary Education - Tertiary semesters

D.36 TOILET
D.36.1 Typical
D.36.2 Airport terminals and Bus station/train station/seaport terminal
D.36.3 Casino
D.36.4 Community/ day centre
D.36.5 Convention Centre and Exhibition Hall
D.36.6 Courts
D.36.7 Fire Station/Police Station
D.36.8 Libraries/ museums/ and galleries
D.36.9 Primary and secondary schools (Non-residential) - School semesters
D.36.10 Restaurant/Public house
D.36.11 Sports centre/ leisure centre - School semesters
D.36.12 Tertiary Education - Tertiary holidays
D.36.13 Tertiary Education - Tertiary semesters
D.36.14 Theatres/ cinemas/ and music halls
D.36.15 Worship

D.37 WORKSHOP-SMALL SCALE
D.37.1 Typical
D.37.2 Community/ day centre
D.37.3 Convention Centre and Exhibition Hall
D.37.4 Primary and secondary schools (Non-residential) - School semesters
D.37.5 Sports centre/ leisure centre - School semesters
D.37.6 Tertiary Education - Tertiary holidays
D.37.7 Tertiary Education - Tertiary semesters
D.37.8 Theatres/ cinemas/ and music halls
D.37.9 Worship

APPENDIX E

ASHRAE DEEMED TO SATISFY SUPPORTING DOCUMENTATION

This appendix reflects the equivalent ASHRAE climate zone for various locations around South Africa. Locations fall into climatic zones according the Heating/Cooling degree-days as well as the moisture content explained below.

Heating degree-days- the average daily temperature below 18^{0}C in a year, taken at hourly intervals using weather information from Meteonorm version 6.1.

Cooling degree-day- the average daily temperature above 10^{0}C in a year, taken at hourly intervals using weather information from Meteonorm version 6.1.

To determine the moisture level A,B or C	
C- Marine	1) Mean temperature of coldest month between 3^{o}C and 18^{o}C
	2) Mean temperature of warmest month must be < 22^{oC}
	3) Four months with mean temperatures above 10^{o}C
	4) Dry season in summer
	5) Month with heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least.
	6) Cold season is April through September.
B- Dry	Not marine and P < 2.0 x (T + 7)
	P = annual precipitation, cm
	T = annual mean temperature, ^{o}C
A-Moist	Locations that are not marine and not dry.

	Zone 1		Zone 2		Zone 3		
Heating Degree Days (HDD18°C)							HDD < 2000
Cooling Degree Days (CDD10°C)	5000 < CDD		3500 < CDD < 5000		2500 < CDD < 3500		CDD < 2500
Moisture Level:	A-Moist	B-Dry	A-Moist	B-Dry	A-Moist	B-Dry	C-Marine
Alexandra					✓		
Alexander Bay						✓	
Aliwal north					✓		
Beaufort West						✓	
Beitbridge		✓					
Benoni					✓		
Bethlehem					✓		
Bloemfontein					✓		
Boksburg					✓		
Botshabelo					✓		
Calvinia					✓		
Cape Town							✓
Cape St Francis							✓
Daveyton					✓		
De Aar					✓		
Dlepmealow					✓		
Durban			✓				
East London					✓		
East Rand					✓		
Ermelo					✓		
Evaton					✓		
George							✓
Germiston					✓		
Ibhayi					✓		
Johannesburg					✓		
Kathlehong					✓		
Kayamnandi					✓		
Kempton Park					✓		
Khayelitsa							✓
Kimberley					✓		
Kwamashu			✓				
Langebaan					✓		
Lekoa					✓		
Mangaung					✓		
Middleburg						✓	
Mmbatho					✓		
Nelspruit			✓				
Ntuzuma					✓		
Pietermaritzburg					✓		
Port Elizabeth					✓		
Pietrsburg						✓	
Pretoria					✓		
Roodepoort					✓		
Sasolburg					✓		
Springbok						✓	
Springs					✓		
Standerton					✓		
Umlazi			✓				
Upington			✓				
Welkom					✓		
West Rand					✓		

APPENDIX F

HOT WATER ENERGY USE

The following table shows the hot water consumption that is to be assumed for each space type when calculating the energy consumption of a hot water system. Note that it is assumed that there is no hot water energy consumption associated with car parks.

Space name	Hot Water Consumption	
Cellular office	0.21	l/m²/day
Circulation area (corridors and	0.00	l/m²/day
Common room/staff room/lounge	0.30	l/m²/day
Eating/drinking area	6.00	l/m²/day
Food preparation area	0.33	l/m²/day
Hall/lecture theatre/assembly area	0.15	l/m²/day
High density IT work space	0.15	l/m²/day
IT equipment	0.00	l/m²/day
Meeting room	0.06	l/m²/day
Open plan office	0.33	l/m²/day
Plant room	0.00	l/m²/day
Public circulation areas	0.06	l/m²/day
Reception	0.03	l/m²/day
Storage area	0.00	l/m²/day
Tea Kitchen	0.00	l/m²/day
Toilet	0.00	l/m²/day
Parking Garage		
Baggage Reclaim area	0.75	l/m²/day
Cell (police/prison)	0.00	l/m²/day
Changing facilities	30.00	l/m²/day
Check in area	0.75	l/m²/day
Classroom	1.50	l/m²/day
Consulting room	0.21	l/m²/day
Display area	0.00	l/m²/day
Dry sports hall	0.00	l/m²/day
Fitness Studio	0.00	l/m²/day
Fitness suite/gym	0.00	l/m²/day
Ice rink	0.06	l/m²/day
Laboratory	0.33	l/m²/day
Laundry	40.00	l/m²/day
Performance area (stage)	0.00	l/m²/day
Sales area - chilled	0.04	l/m²/day
Sales area - general	0.04	l/m²/day
Security check area	0.75	l/m²/day
Storage area - chilled	0.00	l/m²/day
Storage area - cold room (<0degC)	0.00	l/m²/day
Swimming pool	0.00	l/m²/day
Workshop - small scale	0.21	l/m²/day

Table 19: Benchmarks for hot water energy consumption

The calculator currently assesses the efficiency of the hot water system rather than how much hot water is being used, and a fixed estimate of hot water is used independent of the type of fittings.

Protocol for calculating energy use

1. Calculate the **Daily Domestic Hot Water Requirements** by multiplying the hot water supply (L/m²/day) found in the table above by each of the space type areas (m²).

2. Calculate the **Daily Domestic Hot Water Energy Requirements** by determining how much primary energy input is required to heat this amount of water from 20°C to 60°C per day. Ensure distribution and generation efficiencies are included. Where distribution efficiencies are unknown, an efficiency of 40% should be applied to any pump in the system, and piping losses of 20W / linear m of pipe should be applied.

   The Energy required to heat water can be found using the formula
   Energy (in Joules) = $m\ c\ \Delta T / \varepsilon$
   Where m = mass of water in kg (= volume of water in litres)
   c = specific heat capacity of water = 4180 J/kg/K
   ΔT = change in temperature of the water in °C
   ε = overall system efficiency

   The energy (in kWh) can then be obtained by dividing this result by (1 kWh = 3 600 000 joules)

3. Multiply the Daily Domestic Hot Water Energy Requirement by 365 days to calculate the Yearly Hot Water Energy Requirement.

4. Any heat generated from renewable sources (e.g. solar water heating) should not be included in the energy requirement figure identified above. This energy is treated as carbon neutral.

5. The energy requirement in kWh should then be entered into the energy calculator into the electrical and/or gas columns as appropriate depending on the fuel source for the hot water heating system as designed.

Example (yellow section to be filled in by user)

WATER SUPPLIED TO:	HOT WATER REQUIRE-MENTS (L/m²/ day)	TOTAL AREA (m²)	HOT WATER REQUIRE-MENTS (L/day)	DAILY ENERGY REQUIRED (ELECTRIC) kWh/day	DAILY ENERGY REQUIRED (GAS) kWh/day	YEARLY ENERGY REQUIRED (ELECTRIC) kWh/year	YEARLY ENERGY REQUIRED (GAS) kWh/year
Cellular Office	0.21	1000	210	10.8	0	3956	0

Table 20: Example to how to calculate hot water energy consumption - building with electric water heaters and efficiency of 90%

The figures to be entered into the Energy Calculator are 3956 for electric and 0 for gas.

The notional building energy use is calculated by the excel tool as follows
The same volume of hot water is assumed (i.e. 0.21 L/m^2/day) to be heated electrically (efficiency 90% to allow for some distribution losses):

Hot water energy usage in Joules is:
m^3 of water x (1 m^3 = 1000 kg) x specific heat capacity (=4180 J/kg/K) x temp difference (=40°C assuming a cold water temperature of 20°C) x 365 days / 0.9 efficiency factor

Joules are then converted to kWh by dividing by (1 kWh = 3 600 000 joules).

APPENDIX G
VERTICAL TRANSPORTATION ENERGY USE

Vertical Transportation includes lifts (elevators), escalators and travelators.

To calculate actual lift energy use:

1. Determine the lift power ratings (both service and customer lifts) in kW from supplier specifications.
2. The **usage factor is 0.75 and takes into account stopping and starting of the lift.**
3. Calculate the **Yearly Energy Usage.** This must be done by multiplying the lift power rating by the number of lifts, then by the usage factor and finally by 12 hours per day, 365 days a year (4380 hours/year). This is the figure to be entered into the Energy Calculator.

Example (yellow sections are those that are to be filled in by user)

LIFT POWER RATING	NUMBER OF LIFTS	USAGE FACTOR	HOURS IN A YEAR	YEARLY ENERGY USAGE (kWh/year)
25kW (passenger lift – kW rating as per supplier specifications)	2	0.75	4380	164250
30kW (service lift – kW rating as per supplier specifications)	1	0.75	4380	98550
TOTAL YEARLY ENERGY CONSUMPTION (kWh/year)				262800

Table 21: Example of how to calculate lift energy consumption

To calculate notional building lift energy use:
The same number of lifts must be assumed as in the actual building, with the same number of disabled lifts etc. Each lift should be assumed to have a power rating of R = 10 kW. These ratings are based on typical electric traction lifts.

Protocol for calculating escalator and travelator energy use

1. Determine the escalator or travelator power rating from supplier specifications.

2. Determine the **Usage Factor** based on the presence of an escalator or travelator sensor. These sensors detect movement and start the escalator or travelator moving if someone is walking towards it. The usage factor is:
    a. 0.75 if there is sensor; and
    b. 1 with no sensor.

3. Calculate the **Yearly Energy Usage**. This calculation can be done by multiplying the power rating by the number of escalators or travelators, then by the usage factor and finally by 12 hours a day, 365 days a year (4380 hours/year). This number is the figure to be entered into the **Green Star SA – Public & Education Building v1 Energy Calculator**.

Example (yellow sections are those that are to be filled in by user)

ESCALATOR TRAVELATOR POWER RATING	NUMBER OF ESCALATORS	USAGE FACTOR (sensor dependent)	HOURS IN A YEAR	YEARLY ENERGY USAGE (kWh/year)
8kW (without sensor)	4	1	4380	140160
8kW (with sensor)	2	0.75	4380	52560
TOTAL YEARLY ENERGY CONSUMPTION (kWh/year)				192720

Table 22: Example of how to calculate escalator or travelator energy consumption

To calculate notional building escalator/travelator energy use:
Assume that the notional building does not contain escalators or travelators.

APPENDIX H

LIGHTING CONTROL SCHEDULES FOR MODELLING

When modelling the notional building, basic controls are assumed. As such, the lighting schedules shown in the energy modelling Activity Schedules (See Appendix A) must be used for each relevant space. When modelling the actual building, the lighting schedules can be adjusted as follows:

A. Basic Controls – The Basic Controls option is intended to reflect a standard practice building with simple lighting controls and where a percentage of lighting remains on after hours. The Basic Controls operating hours are based on the Activity Schedules (See Appendix D) for each space / building combination. Where it cannot be shown that more advanced controls are to be installed as required for options B,C & D, then the lighting schedules can not be adjusted and must be applied as per the notional building.

B – Local Control – As per 'A' above.

C. Occupancy Sensing: Where presence detectors are provided at least every 60m² of internal floor area, the lighting schedule may be adjusted as shown below. For external lighting and car park lighting, presence detectors are not required for every $60m^2$, but it must be shown that presence detectors have been installed, and at least 70% of the car park lighting and/or external lighting (by installed power not number of fixtures) is linked to presence detectors. The project team should also demonstrate that each floor of the car park is separately controlled and that external lighting is controlled separately to that of the car park.

Where it can be shown that presence detectors are provided as above, the occupancy for each hour of the lighting schedule may be reduced to 82% of the figure shown in the Activity Schedule. An example is shown in the table below.

Lighting schedule BEFORE adjustment for presence detectors

Time	Lighting		
	Week	Sat	Sun
12am - 1am	10%	10%	10%
1am - 2am	10%	10%	10%
2am - 3am	10%	10%	10%
3am - 4am	10%	10%	10%
4am - 5am	10%	10%	10%
5am - 6am	10%	10%	10%
6am - 7am	10%	10%	10%
7am - 8am	100%	10%	10%
8am - 9am	100%	10%	10%
9am - 10am	100%	10%	10%
10am - 11am	100%	10%	10%
11am - 12pm	100%	10%	10%
12pm - 1pm	100%	10%	10%

Lighting schedule AFTER adjustment for presence detectors

Time	Lighting		
	Week	Sat	Sun
12am - 1am	8%	8%	8%
1am - 2am	8%	8%	8%
2am - 3am	8%	8%	8%
3am - 4am	8%	8%	8%
4am - 5am	8%	8%	8%
5am - 6am	8%	8%	8%
6am - 7am	8%	8%	8%
7am - 8am	82%	8%	8%
8am - 9am	82%	8%	8%
9am - 10am	82%	8%	8%
10am - 11am	82%	8%	8%
11am - 12pm	82%	8%	8%
12pm - 1pm	82%	8%	8%

Table 23: Adjustment of lighting schedules for presence detectors

D. Daylight dimming: Due to the complexity of modelling, a reduction in HVAC loads and lighting loads due to daylight dimming or switching should only be included if there will be a substantial reduction compared to the base case (i.e. greater than 2% of total energy consumption).

The calculation methodology for use of daylight dimming or switching should be submitted to the GBCSA via a CIR (credit interpretation request) prior to submission.

APPENDIX-I

Energy modelling report format

It is recommended that the Energy Modelling Report be submitted in the following format (refer to the sections 5 and 6 of this protocol document for details of what should be included in each part). The text *in italics* illustrates where the user should enter details of the project.

General Modelling Parameters

- Project *XYZ*
- Number of Stories *2*
- Location *Johannesburg*
- Simulation Software Used *DesignBuilder v2*
- Weather Data Used *Meteonorm O.R.Tambo/Jan Smuts Airport 1996-2005*
- Space Breakdown

Space	**Supporting Primary Function?**	**Included in simulation?**	**Area (m²)**	**Comments**
Hall/lecture theatre/assembly area	*Yes*	*Yes*	*240*	
Cellular office	*Yes*	*Yes*	*650*	
Circulation area (corridors and stairways) - non public	*Yes*	*Yes*	*900*	
Meeting room	*Yes*	*Yes*	*15*	*extract fan energy calculated manually*
Car Park (external)	*Yes*	*No*	*650*	*lighting energy use calculated manually*
Plant room	*Yes*	*No*	*40*	*lighting and extract vent energy use calculated manually*
TOTAL			*2495*	

[Justification for any areas of the project excluded from the model]

- Central Plant

[Details of any central plant which serves areas other than the modelled area, and how these have been dealt with]

Naturally Ventilated Buildings

[Confirmation that the Natural ventilation comfort criteria have been met or not, and details of modelling to show compliance – either in the energy modelling report or as a separate Natural Ventilation Report – refer Green Star SA Public & Education Building v1 Technical Manual – credit Ene-1]

Building Envelope

- Geometry

[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]

- Fabric

	Notional Building	**Actual Building**
Exterior Wall Construction	*Insulated R=2.2*	*brick, cavity, insulation, block R = 2.5*
Roof	*Insulated R= 2.7*	*tile, membrane, void, insulation R = 2.7*
Floor	*150mm slab with carpet*	*150mm slab with carpet*

- Glazing

	Notional Building	**Actual Building**
Window Type	*SANS 204 minimum standard*	*Double, aluminium frame, solar coating*
Window area (m^2)	*132*	*132*
Average U value including frame and dividers	*7.9*	*2.2*
SHGF	*0.81*	*0.51*
Visual light transmittance	*0.8*	*0.7*

- Shading

[Details of internal and external shading included in simulation]

- Orientation

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

- Infiltration

	Notional Building	**Actual Building**
Infiltration rate	*0 air changes per hour*	*0 air changes per hour*

Internal Loads

	Notional Building							Actual Building						
	Summer Design Temp ℃	Winter Design Temp ℃	People density m² / person	Meta-bolic rate W / person	Equip loads W/m²	Vent rates l/s / person	Lighting W/m²	Summer Design Temp ℃	Winter Design Temp ℃	People density m² / person	Meta-bolic rate W / person	Equip loads W/m²	Vent rates l/s / person	Lighting W/m²
Hall/lecture theatre/assembly area	24.0	21.0	5.0	140	2.0	10.0	16.5	24.0	21.0	5.0	140	2.0	10.0	16.5
Cellular office	24.0	21.0	14.3	120	10.0	10.0	13.6	24.0	21.0	14.3	120	10.0	10.0	13.6
Circulation area (corridors and stairways) - non public	24.0	21.0	9.1	140	2.0	10.0	3.4	24.0	21.0	9.1	140	2.0	10.0	3.4
Meeting room	24.0	21.0	5.0	120	5.0	10.0	17.0	24.0	21.0	5.0	120	5.0	10.0	17.0

[A graphic from the simulation package showing a typical day with the load profiles, to demonstrate that the profiles given in Appendix C have been used]

HVAC Systems

- System design

[Description of the HVAC system, including number and kW rating of chillers, plant efficiency (COP) etc, number and duty of air handling units etc]

- Zoning

[Diagrams of zones used]

- Chilled water, condensing water etc

[Details of results of simulation for each piece of plant showing how these relate to the numbers entered into the calculator]

- Controls

[Details of controls assumed when modelling plant]

- Simulation Energy Usage results

[Details of results of simulation for each piece of plant showing how these relate to the numbers entered into the calculator]

Extract and Miscellaneous Fans

[Details of car park and miscellaneous extract fans energy use]

Lighting

[Details of lighting, car park and external lighting calculations. Where occupancy sensors or other controls are assumed giving full details]

Domestic Hot Water

[Calculation laid out as Appendix F]

Lifts & Escalators

[Calculation laid out as Appendix G]

Renewable Energy & Cogeneration

[Full details of systems proposed, and how annual energy consumption/generation figures have been calculated]

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)]

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]