Design Guidelines for Energy Efficient Buildings in Johannesburg

Joburg

Acknowledgements

The following people contributed to the development of the guide: Enoch Liphoto, Richard Holden, Linda Phalatse, Linda Manyuchi, Jeremy Gibberd and Liteboho Mphutlane.

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It is likely that this document is updated and improved over time. Should you have any suggestions please email suggestions to Linda Manyuchi at LindaM@joburg.org.za.

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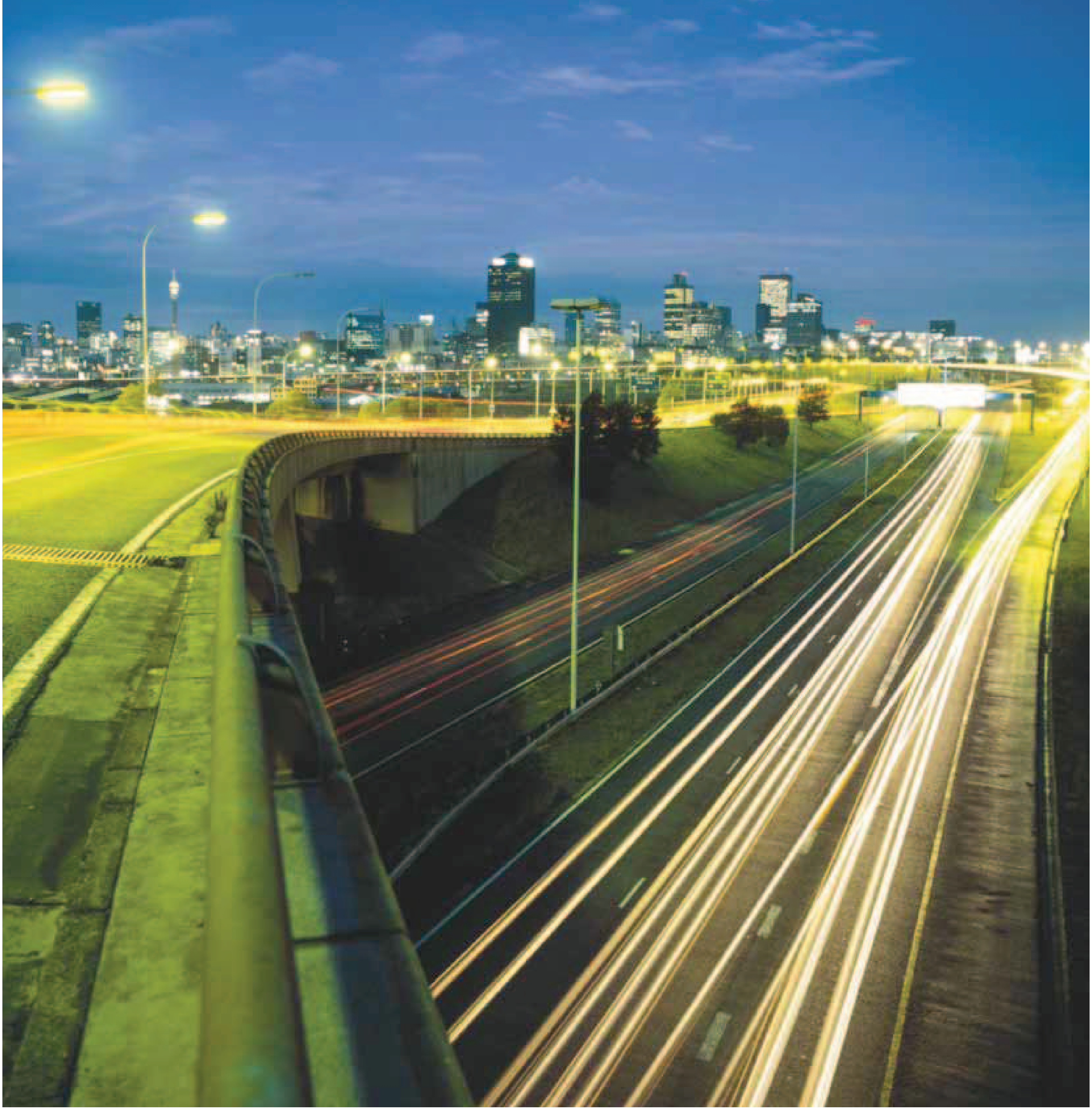


Section 1

Introduction

1 Introduction

This guide has been developed to support the development of energy efficient buildings within the City of Johannesburg. It provides practical guidance on ways of designing buildings that minimize the requirement for energy and has been developed by the City as part of a strategy to reduce energy consumption and address global warming within the municipality.

1.1 Who is the guide aimed at?

The guide is aimed at Architects, Designers, Planners and Developers who wish to develop more energy efficient buildings. It can be used in the following ways:

- Design teams can use the guidelines to develop and check their designs in order to maximise the use of opportunities for energy efficiency.
- Building developers and owners can use the guide as part of a design team's design brief. They can use it to structure discussions that ensure challenging energy efficiency targets are set and achieved in new buildings.
- Planners and urban designers can use the guide as an input into developing more energy efficient settlements and cities.

1.2 What does the guide cover?

The guide has a focus on design for energy efficiency and therefore emphasis strategies that minimize energy consumption through integrated design processes. There is a strong emphasis on passive environmental control, day lighting and the use of renewable energy such as solar power. It does not detail how to make mechanical systems, such as air conditioning and vertical transportation plant, energy efficient.

The document aims to provide guidance that is relevant to both office buildings and residential buildings, and a range of buildings in between. This scope limits the extent to which different buildings types can be dealt with in detail. Design teams should develop building-type and site-specific responses that address and work with the local context.

The guidelines focus on the design of buildings and have been developed for use in the early design stages of a new building. While the guidelines mainly address energy use in building operation they also include aspects where buildings can contribute to energy efficiency in the wider context, through for instance, reducing vehicular use. The scope of the guide is limited to buildings and their immediate surroundings and energy efficiency at a wider urban, or city scale, is not addressed.

1.3 Limitations of the guidelines

The guide provides practical guidelines and rules-of-thumb that have been developed through international and local research. It should be noted that the guidelines do not apply to all conditions and are not a substitute for proper calculations and modeling by the design team.

The guidelines do not address other aspects required in sustainable buildings such as water consumption and waste management.

They also do not replace statutory requirements for buildings. All relevant regulations, standards and bylaws should be consulted and complied with.

1.4 Structure of the guidelines

The guidelines have the following sections:

Section	Content
Why have a guide on energy efficiency in buildings?	Key reasons for addressing energy in buildings
Design processes for energy efficiency:	Actions that can be carried out by the main role-players at different stages of a building's life cycle to ensure that energy efficiency is addressed
Human comfort and minimum environmental standards:	Key environmental conditions required for health and comfort of building occupants
Environmental control strategies in buildings:	Broad strategies that can be used to support energy efficient environmental control of buildings
Site	How the layout of a site can be used to support energy efficiency
Building form and envelope	Building form and building envelope influence energy consumption and this section outlines how strategies such as passive environmental control and day lighting can be used to reduce energy consumption
Internal space	Internal spatial layouts can be configured to support energy efficiencies. This section outlines some the key considerations that should be taken into account
Mechanical systems	Aspects of how mechanical systems in buildings can be made more efficient
Electrical lighting	How energy efficiency can be addressed in electrical lighting systems
Water heating	Outline of additional energy efficient water heating systems including solar water heaters
Appliances and equipment	Guidance on minimising the energy consumption by appliances and equipment in buildings such as computers
Integrated control systems and monitoring:	Control and monitoring systems to support energy efficiency

Section 2

Why have a guide on energy efficiency in buildings?

2 Why have a guide on energy efficiency in buildings?

There are many pressing reasons why all new buildings should be designed to be energy efficient. These include:

- Global warming
- Reducing operating costs
- Compliance with tightening legislation and standards
- Limiting the requirement for additional power
- Market and client demands

2.1 Global warming

Increasing carbon emissions and a reduction in the ability of the natural environment to absorb carbon dioxide is leading to an accumulation of greenhouse gases in the upper atmosphere. These gases trap more heat in the upper atmosphere leading to global warming and temperatures are predicted to increase by 2 - 6°C by the end of the century (IPCC, 2007). Estimates carried out for the City of Joburg indicate that temperatures in the short term may increase between 2 and 3.5°C (Hewitson, Engelbrecht, Tadross, Jack, 2005).

South Africa produces the highest CO2 emissions in Africa and has one of the highest CO2 emissions per GDP in the world (Van Mierlo, 2007), as indicated in the graph below.

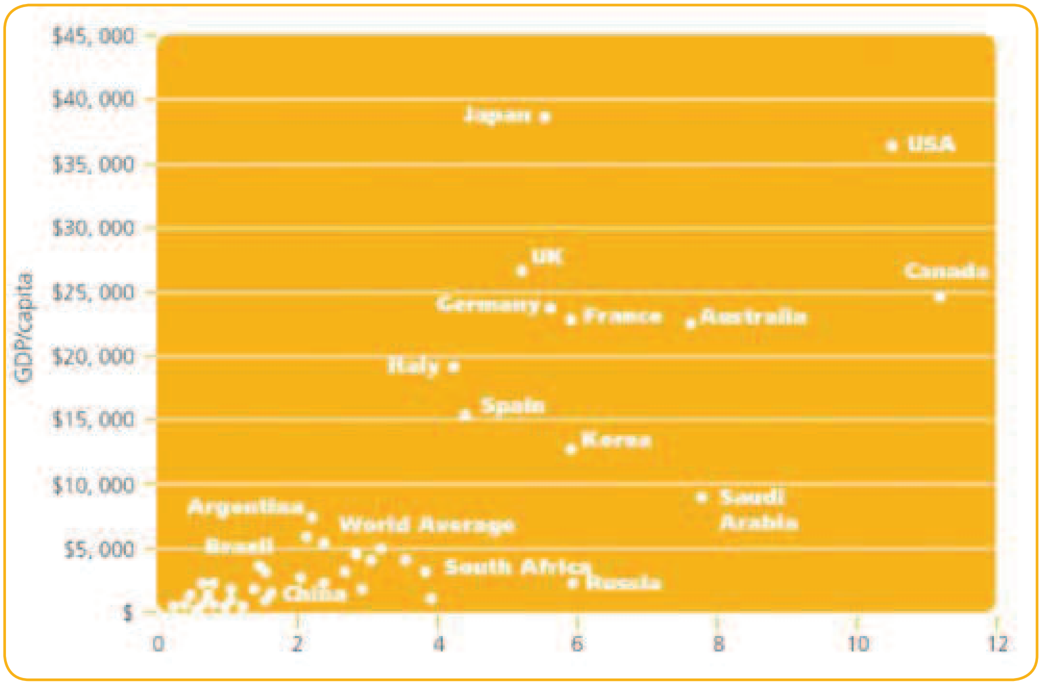


Figure 1. GDP and kW per capita

There is a direct link between buildings, carbon emissions and the ability of the natural environment to absorb carbon dioxide. Globally, 40% of energy use, 17% of fresh water use, 25% of wood harvested and 40% of material use is attributed to the built environment (USGBC 2008). Buildings are also often built on green field sites further reducing the capacity of the natural environment to absorb carbon dioxide.

Energy is consumed throughout the lifecycle of buildings. This includes the construction, operation and demolition of buildings. The approximate proportions of energy consumption at the different lifecycle stages are shown below.

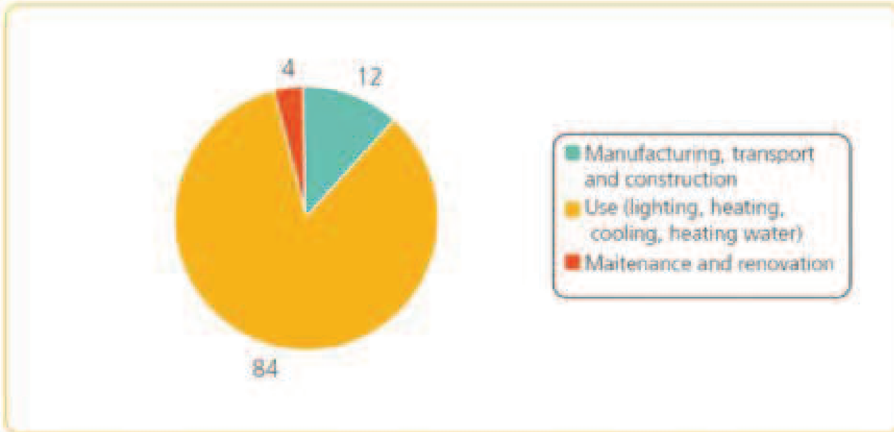


Figure 2. Lifecycle energy use in buildings

Energy in buildings is required to provide lighting, heating and cooling, hot water and to power equipment and appliances. This varies between buildings, however the approximate proportions of energy used in a conventional Johannesburg office and residential building are shown below.

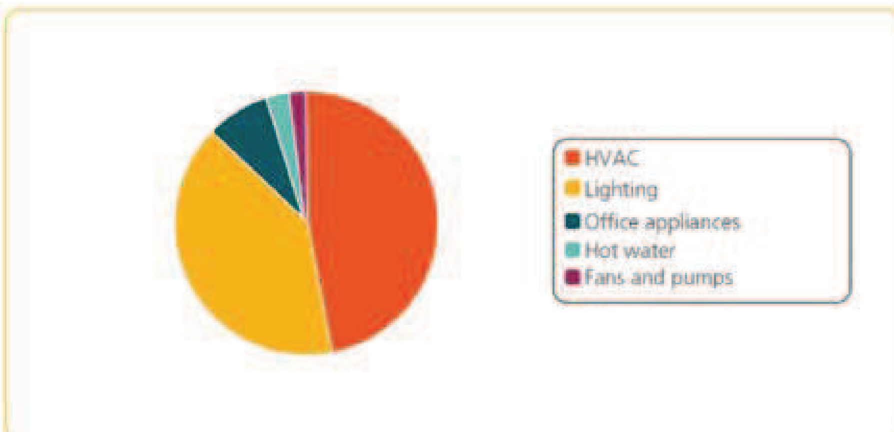


Figure 3. Energy consumption in large air-conditioned office building

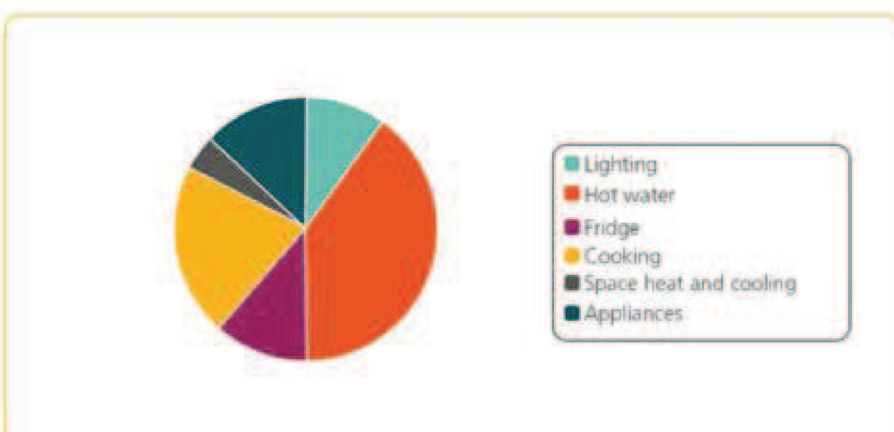


Figure 4. Energy consumption in a medium sized house

2.2 Reduced ongoing costs

More energy efficient buildings benefit their owners and tenants by having lower energy bills. While electricity costs in South Africa have been some of the lowest in the world, costs will increase rapidly and Eskom tariffs are set to double in the next 5 years. Interventions at Megawatt Park, a large office building owned by Eskom, demonstrate how energy costs can be substantially reduced for relatively low capital expenditure. In addition substantial environmental impacts can also be achieved, as indicated below.

Energy efficiency measures	Capital cost	Reduced energy cost per year	Payback period	Environmental impacts
Lighting upgrade Installation of variable speed drives	R4.5 million	R2.2 million	25 months	Reduced $C0_2$, SOx and NOx emissions, 43,000m3 of water saved

Table 1. Energy efficiency measures and impacts in a large commercial building

Simple measures can also be taken to reduce energy consumption in a residential setting. For instance, more efficient lighting, a hot box and a solar water heating substantially reduce energy costs. The capital costs of these technologies can be justified through reduced annual energy costs, as indicated below.

Energy efficiency measure	Capital cost	Reduced energy cost per year	Payback period
Compact fluorescent light bulb (Eskom 2008)	R12 more than tungsten bulb	R18 saving per year	10 months
Hot box (Insulated container used to complete cooking once initial heating of food is complete)	R120	R163 per year	9 months
Solar water heater	R5,000 – R10,000 more than a conventional geyser	R1,000 – R1,750 per year	5 years

Table 2. Energy efficiency measures and impacts in a residential building

2.3 Compliance with tightening legislation and standards

Increasingly, legislation in South Africa will require more energy efficient buildings. The South African Bureau of Standards (SABS) is developing new standards on energy efficiency and municipalities such as the City of Joburg and the City of Tshwane are investigating the development of by-laws and incentives schemes to reduce energy consumption in buildings. Policies and standards supporting energy efficiency in buildings include:

- Energy Efficiency Strategy (Department of Minerals and Energy)
- White Paper on Renewable Energy (Department of Minerals and Energy)
- SANS 204-2, Energy efficiency in buildings with artificial or natural environmental control – Part 2 Application of energy efficiency provisions in buildings with natural environmental control
- SANS 204-3, Energy efficiency in buildings with artificial or natural environmental control – Part 3 Application of energy efficiency provisions in buildings with artificial environmental control
- SANS 204-4, Energy efficiency in buildings with artificial or natural environmental control – Part 4 Application of energy efficiency provisions in Category 1 houses
- SANS 1307, Domestic solar water heaters

2.4 Limiting the requirement for additional power

Eskom has been unable to develop its generating capacity at the same rate at which development has occurred in South Africa. This will lead to load shedding and power cuts until at least 2014. More energy efficient buildings will help reducing the number of power cuts that occur.

Eskom, the Department of Mineral and Energy and Central Energy Fund are also developing a range of incentives to reduce peak power consumption and support energy efficiency. These include subsidies

of up to 100% for energy efficient lighting and solar water heating. More information on these schemes can be obtained from www.eskom.co.za, www.dme.gov.za and www.cef.co.za

2.5 Market and client demands

Clients and the market are demanding more energy efficient buildings. This reflects a concern about the environment and a wish to achieve environmental standards required in schemes such as the Global Reporting Initiative (GRI). The GRI requires reporting on the following indicators that are directly related to energy efficiency.

- EN3 Direct energy consumption broken down by primary energy source
- EN4 Indirect energy consumption broken down by primary energy source
- EN5 Percentage of total energy consumption met by renewable sources
- EN6 Total energy saved due to conservation and efficiency improvements
- EN7 Initiatives to provide energy-efficient products and services
- EN8 Initiatives to reduce indirect energy consumption.
- EN17 Greenhouse gas emissions
- EN18 Emissions of ozone-depleting substances
- EN19 NOx, SOx, and other significant air emissions by weight

A recent study in the USA indicates that properties that achieved the US Energy Star rating sold for 27 per cent more than buildings that had failed to achieve the rating. Occupancy levels in these buildings were also found to be 92 per cent compared the 87 per cent for less energy efficient buildings. (FM World, 2008)

Section 3

Design processes for energy efficiency

3 Design processes for energy efficiency

3.1 The role of design

Energy should be addressed as soon as possible in the design process. Ideally, this is a concern at the outset and informs all aspects of the building including the choice of site, the size of the building and detailed design of the building envelope, systems and interior. An integrated approach during design development stages and contract administration can be used to support energy efficiency and is described below. This helps to ensure that strategic decisions are correct and opportunities are taken to maximise energy efficiency. If early strategic decisions are wrong, the potential energy savings are reduced and the degree of effort required to achieve energy savings are much higher, as indicated in the diagram below.

Stage 1 appraisal & definition	Stage 2 design concept	Stage 3 design development	Stage 4 technical documentation	Stage 5 contract administration & inspection

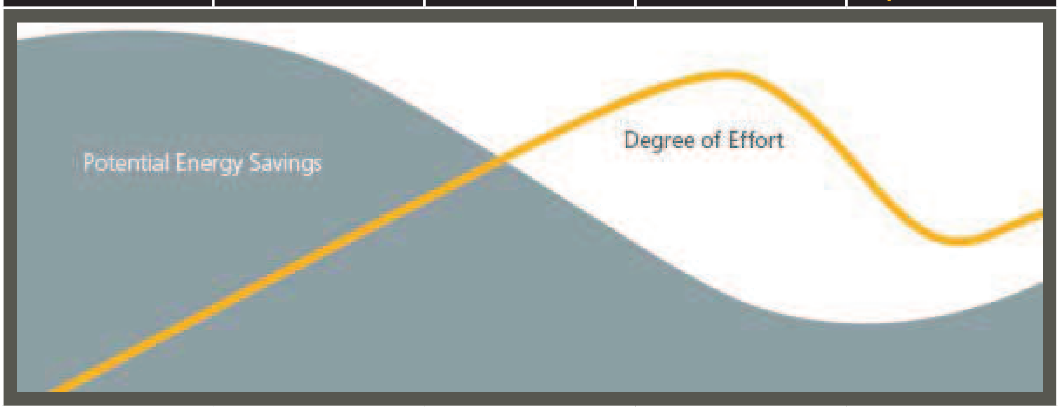


Table 3. Energy savings and the design process

3.2 Integrated design processes

An integrated design process can be used to help ensure that energy efficient buildings are achieved. Aspects of this approach include:

- **Knowing your building type:** The design team ensures that they understand how energy is used in the building type proposed. This includes studies of existing and energy efficient buildings to understand how, and where, energy is used. These studies provide useful targets and approaches that can be built on.
- **Explicit targets:** Early in the design process, challenging energy efficiency targets based on studies above, are set for the building and agreed on by the design team and the client. Checks are made to ensure that targets exceed good practice benchmarks and energy efficiency standards, such as SANS 204.
- **Integrated design:** Concept design development is carried out jointly by the design team to ensure that high performance, integrated solutions are developed.
- **Specialists:** Where appropriate, specialist input is sought and used to inform the design. Examples include the use of passive environmental control and modelling expertise to develop low energy, passive solutions, façade engineers and glass specialists to optimize building envelope designs for energy efficiency and specialist urban designers and landscape architects to develop site layouts and built form that support energy efficiency.
- **Responsive design:** The approach ensures that the design of the building responds to, and works with, features of a site and local climate. Thus the design may respond to topography and existing vegetation to achieve optimum access to natural ventilation and light. This requires a detailed analysis of the site.
- **Modeling and an iterative design process:** Having set explicit and challenging targets, the design team make sure that these are achieved, or exceeded, through calculations and modeling. Different options are explored and modeled to identify the best approach and in an iterative way, high performance integrated solutions are developed.

3.3 Stage one: Appraisal and definition of the project

Activity	By
Check whether a new building is really required. Using, and improving, an existing building avoids demolition waste and energy required for new construction.	Client
Select a design team with low energy building experience and skills. Ideally, ensure that they have worked together and follow and integrated design process (see above).	Client
Provide a brief to the design team which outlines key energy targets and request that this is developed further to ensure that targets are both detailed and challenging.	Client
Undertake background studies on energy consumption patterns of the proposed users of the building and for the building type. Establish key factors that will impact energy consumption within and around the proposed building including work patterns, environmental conditions and transportation patterns of both people and goods. Discuss strategic options for reducing energy consumption including site locations near public transport or residential areas, home working building management techniques such as hot-desking and the sharing of facilities with other local buildings.	Design team and client
Develop detailed energy targets for the building and outline the implications of pursuing these to the client. Implications could include urban site location, reduce building size, more flexible thermal conditions and a requirement for specialist consultants and modelling.	Design team
Undertake feasibility studies and analysis to identify sites and or buildings that will achieve energy targets.	Design team

3.4 Stage two: Design concept

Activity	By
Analyse environmental aspects of the site in order to understand how building design can work with these to reduce energy consumption.	Design team
Develop concept designs that aim to achieve energy targets.	Design team
Check, through modelling and calculations, that the proposed approach will achieve targets. Report on progress.	Design team
Check that targets are being achieved.	Client/independent adviser

3.5 Stage three: Design development

Activity	By
Develop detailed designs that aim to achieve energy targets.	Design team
Check, through modelling and calculations, that the proposed approach will achieve targets. Report on progress.	Design team
Check that targets are being achieved.	Client/independent adviser

3.6 Stage four: Technical documentation

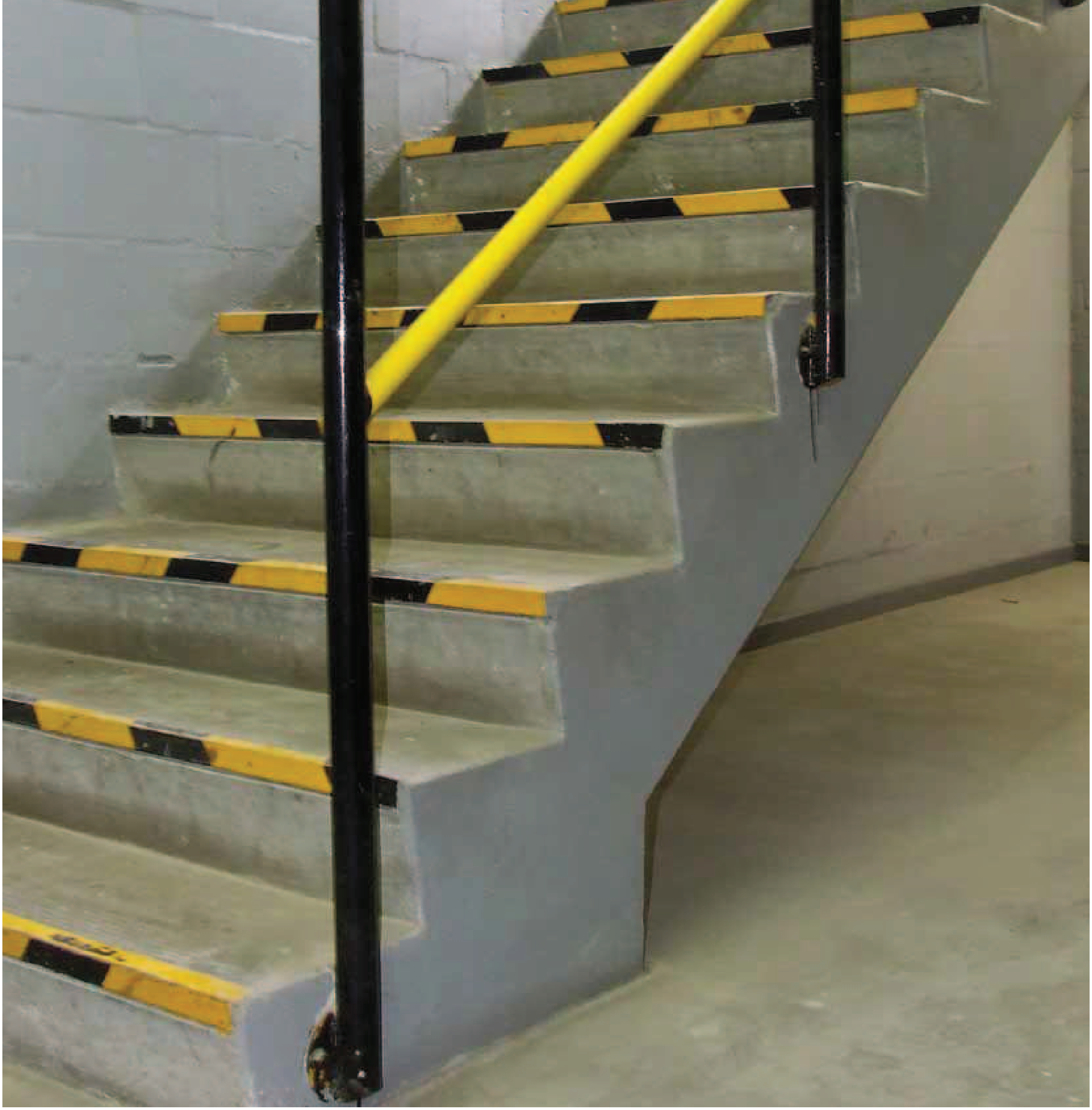
Activity	By
Develop detailed designs that will achieve energy targets. Ensure that tender and contractual documentation requires contractor and relevant suppliers to contribute, as required, in order to achieve energy targets.	Design team
Check, through modelling, calculations and inspections that energy targets are being achieved. Report on progress.	Design team
Confirm that energy targets are being achieved.	Client/independent adviser

3.7 Stage five: Contract administration and inspection

Activity	By
Ensure that the completed building achieves energy targets. Put in place systems that enable close control and monitoring of energy consumption in the building. Issue manuals and technical information that detail the energy targets and explain how the building should be operated to maximise energy efficiency to the building operator or facilities management. Report on progress.	Design team
Provide facilities management training using information developed by design team above to ensure that there is strong capacity and systems to support energy efficient operation of the building.	Design team/Facilities management
Develop induction training for new occupants of the building to ensure that they understand the building's systems and will use these to achieve maximum energy efficiency in the building.	Facilities management/ Human resources
Carry out a Post Occupancy Evaluation to confirm that building, systems, management and occupants are working together to achieve required energy targets. If necessary, take action to address problems and ensure integrated and efficient performance.	Client/independent adviser

3.8 Compliance with SANS 204

Energy efficiency can be demonstrated through compliance with SANS 204, a South African Bureau of Standards (SABS) standard on energy efficiency in buildings. A rational design prepared by a competent person can be used demonstrate that the design will not exceed the maximum energy demand and the maximum annual consumption figures provided in SANS 204-1. Alternatively, compliance with SANS 204-2, SANS 204-3 or SANS 204-4 can be demonstrated.



Section 4

Human comfort and minimum environmental standards

4 Human comfort and minimum environmental standards

There is a strong correlation between environmental conditions including temperature, humidity, daylight and ventilation, and human health and productivity. In achieving energy efficiency, it is important not to provide unhealthy or unsafe environments. Environments should always comply with minimum standards required by legislation such as the Occupational Health and Safety Act. Designers should also understand the key variables that affect health, comfort and productivity in order to understand how these can be used in strategies to develop energy efficient buildings.

4.1 Occupational Health and Safety (OSH) Act and Regulations

The OSH Act provides minimum standards that must be complied with in buildings. The Act is updated, so designers should ensure that they refer to the latest version. The 2007 version has the following requirements that are relevant to buildings and energy:

- At least 0.3 lux is required at floor level in workplaces where there is no natural light or where people habitually work at night to enable employees to evacuate safely.
- Where employees work the majority of their shift in rooms of less than 100m2, the total glazed area of the room shall be three fifths of the square root of the area of the room. Windows sills should not be higher and window heads not lower than one and half metres above floor level. Windows must be glazed in a transparent material.
- Minimum average values of maintained illuminance, measured on the working plan, are set out in the Act. These specify 300lux for general offices, 200lux for classrooms and 75lux for passages and lobbies (at floor level).

4.2 Thermal comfort

Thermal comfort is determined by the following variables:

- **Activity:** Activity is measured in mets, which equates to watts per square meter of body surface. This ranges from from 0.7 met for sleeping to 7.0 met for competitive wrestling.
- **Clothing:** Clothing provides insulation and is measured in clos. Clothing performance range from a measure of 1.5 clo for a heavy business suit to 0.1 clo for a pair of shorts.
- **Air temperature:** Air temperature is usually measured as the average air temperature in the occupied areas. People usually feel comfortable where temperatures are within a range of between 18 to 26oC.
- **Radiant temperature:** The radiant temperature of the surrounding surfaces also has an effect on human comfort. Differing surface temperatures, for instance when the temperature of a large window is much cooler than other surfaces in a room, can lead to discomfort as a result of radiant asymmetry.
- **Air movement:** Air movement affects heat loss from a body and moving air can be used to cool and increase comfort at higher temperatures.
- **Humidity:** Humidity at high temperatures has a negative effect on comfort and continuous levels of high humidity can result in mould and mites in buildings.

These variables can be used to as part of environmental control strategies that achieve occupant comfort in highly energy efficient ways. Some examples are provided below:

- **Clothing:** Encouraging people to wear light, loose-fitting clothing enable people to experience higher temperatures without discomfort. Similarly, encouraging people to wear warm clothes in winter enables them to experience cooler temperatures without discomfort.
- **Air movement:** Using windows and ceiling fans to direct air movement around people creates a cooling effect that enables higher temperatures to be experienced without discomfort.
- **Radiant temperature:** Insulation in a building can increase mean radiant temperatures, enabling lower air temperatures to be experienced without discomfort.

4.3 Daylight

Most people express a strong preference for spaces that are day lit and have views. Research also indicates that daylight supports improved health and productivity. Quality of daylight and access to views should therefore be included as important design considerations.

4.4 Ventilation

There is strong evidence to show that productivity and health of occupants relate to ventilation. Work by Wargocki et al, shows that increasing ventilation rates from 5 to 10l/s/person improved performance of students doing schoolwork by 15% (Wargocki, Wyon, Baik, Clausen, Fanger, 1999). Significant improvements in productivity (5-10%) were also achieved in offices through improved ventilation (Wargocki, Wyon, Matysiak, Irgens, 2005).

4.5 Local control

Control over local environments conditions can help improve user satisfaction and health. A study of office environments showed that symptoms of ill-health reduce, and productivity increases, with perceived individual control over local environments (Wilson, Hedge 1987). Enabling local control over temperature, lighting and ventilation is likely to contribute to occupant satisfaction and an ability to experience greater thermal variation without discomfort.

Section 5

Climate

5 Climate

A good understanding of climate enables designers to develop buildings that respond and work with this to create comfortable, energy efficient, environments. Climatic information for South African can be accessed from www.weathersa.co.za. Key aspects of Johannesburg climate are outlined below. It should be noted that within a city as large as Johannesburg climate will vary. It is therefore important to get climatic data for the site being developed, or as near as possible to this.

5.1 Location

Johannesburg has the following latitude, longitude and altitude:

Latitude: 26° 08’ S
Longitude: 28° 14’ E
Altitude: 1694m above sea level

5.2 Temperature, humidity and rainfall

Temperatures, humidity and rainfall for Johannesburg are outlined in the table below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Maximum monthly temperature (oC)	25.6	25.1	14.7	21.2	18.9	16	16.6	19.3	22.8	23.7	24.1	25.2	21.1
Minimum monthly temperature (oC)	14.7	14.2	13.2	10.4	7.3	4.2	4.3	6.3	9.5	11.3	12.7	13.9	10.17
Average monthly amplitude (K)	10.9	10.9	1.5	10.8	11.6	11.8	12.3	13.0	13.3	12.4	11.4	11.3	10.93
Average monthly relative humidity (%)	64.0	65	64	61.5	53.5	51.5	48.5	46.0	46.0	52.5	59.5	60.5	56.04
Average monthly rainfall mm	126	90	91	52	13	8	4	6	28	73	118	105	59

Table 4. Temperature, humidity and rainfall in Johannesburg

5.3 Solar radiation

Solar radiation levels in South Africa are amongst the highest in the world. Average daily solar radiation varies between 4.5 and 7 kWh/m2. Even in winter, parts of the country receive more than 6.5 kWh/m2 per day (Banks D. and Schaffler J. 2006).

The duration of sunshine is also high. Johannesburg receives bright sunshine for period’s equivalent of between 70% (summer) and 80% (winter) of possible duration. This compares to London (33%), Sidney (49%) and Haifa (73%). These figures indicate that Johannesburg has excellent and reliable solar energy. This free resource can be used in passive environmental control strategies, solar water heaters and photovoltaic systems to improve energy efficiency in buildings.

5.4 Solar charts

The location of the sun in the sky for any given time can be easily ascertained using a solar chart. The solar chart at the end of the document shows how the azimuth (position relative to North) and the altitude (height) of the sun in the sky for a particular day (22 Dec) and time (4.00PM) can be read off the chart (Azimuth 101° in the South West SW, Altitude 35°).

A guide, 'Solar Charts for the Design of Sunlight and Shade in buildings in South Africa', is available from the CSIR that provides more detail on solar calculations. Software and some computer aided design (CAD) packages can also be used for sunlight and shadow projections.

Section 6

Environmental control strategies in buildings

6 Environmental control strategies in buildings

A key function of buildings is to regulate the internal environment to ensure that it is comfortable and healthy for human beings. There are three main approaches to environment control. Each of these has different energy implications and is outlined below:

- **Active environmental control:** This approach is characterized by the use of mechanical heating, ventilation and air conditioning (HVAC) systems to create highly controlled internal environments.
- **Mixed mode:** This approach is characterised by use of both mechanical and passive systems to achieve a balance between controllability of the internal environment and energy efficiency. Buildings and systems are designed in an integrated way to avoid being totally reliant either on mechanical or passive systems. The use of the different systems depend on the circumstances, for instance air conditioning may be used to cool the building during peak summer temperatures, whereas cooling for the rest of the year may be achieved through passive environmental control strategies such as night time cooling and cross ventilation.
- **Passive environmental control:** This approach is characterised by maximum use of ambient resources such as sun, daylight, wind and diurnal temperature ranges to create comfortable internal environments. Buildings are designed to work with these resources and avoid the use of mechanical systems. Internal conditions tend to be more variable, reflecting changing environmental conditions between day and night and winter and summer.

6.1 Choice of environmental control strategy

The choice of environmental control strategy is dependent on factors such as cost, technical capacity, building function, client requirements, climate and the local external environment. The main characteristics of the active and passive control strategies are outlined below.

Aspects	Active environmental control	Passive environmental control
Control and variability of the internal environment	Environments can be more highly controlled and are generally more regulated.	Environments are less controlled and more variable
External environment	Mechanical systems can be overcome conditions in harsh external environments such as that are very noisy or experience extreme temperatures	This approach is less able to accommodate harsh external environments such as those that are very noisy or polluted.
Links to the external environment	Links and openings to the external environment are generally minimised to support energy efficiency.	Links and openings to the external environment are dependent on conditions and are controlled to create comfortable internal environments using ambient conditions.
Occupant involvement	Occupants are not encouraged to get involved in environmental control	Occupants are encouraged through local controls to maintain and control their own comfort.
Technical capacity	Systems can be complex and require high levels of technical competence to design and maintain	Systems can be complex to design, but are generally mechanically simple and easy to maintain

Reliability of energy	Unreliable energy sources can be highly problematic and power cuts can require the building to be evacuated. Large standby / alternative energy sources are required to main operations.	Power cuts can be accommodated and less power from standby generators or alternative power sources is required to keep the building in operation (i.e. to power emergency systems and computers).
Maintenance	Regular maintenance is crucial.	Systems are generally robust and maintenance is simple.
Operational costs	Operational costs are generally higher than passive systems.	Operational costs are generally lower than active systems.
Capital costs	Capital costs of systems are generally higher than passive environmental control.	Capital costs of systems are generally less than active systems (Although building fabric costs may be higher).

The active environmental control approach relies on achieving the optimum integration between building design and efficient mechanical systems to achieve energy efficiencies. As technology changes in this area rapidly and calculations can be complex, suitable expertise should be sought and appropriate modeling should be carried to establish optimum solutions.

In general, this guideline recommends that a passive or mixed mode approach be used in most buildings in Johannesburg because this is more energy efficient, simpler to maintain and more resilient to power outages and shortages. Johannesburg's climate is also relatively mild and constant air conditioning is generally not needed unless specifically demanded by the building's function and internal heat loads.

6.2 Active environmental control strategies

Outlined below are strategies that can be used in buildings with active environmental control to support energy efficiency. Reference is also made to sections of the guide where further information on the strategy can be found.

Strategy	Description	Relevant sections of the guide
Surface area to volume ratio	The surface area of the building in relation to the volume is minimised to reduce heat loss or gain through the building envelope.	8.1
Efficient integrated mechanical systems	The building and proposed mechanical systems are designed to work together in an integrated way to minimise energy consumption.	10
Zoning and controls	Zoning and controls are developed to adapt mechanical systems to changing internal requirements and external conditions.	10.1
Natural or economy cycle	During periods of the year when external air temperatures are comfortable, air is circulated through the building by the HVAC system without being conditioned, reducing energy consumption	10.3

Sub metering	A system of metering is developed to enable detailed monitoring of energy consumption in different areas of the building.	14.1, 14.2
Building management systems	Computers are used to manage different building systems in order to ensure that these work together in an optimal way.	14.8
Envelope design	Glazing design, insulation and air tightness measures are used to avoid uncontrolled heat losses or gains through the building envelope	8

6.3 Selecting active environmental control strategies

In general, all of the above strategies should be used together to maximize energy efficiency in buildings with active environmental control systems. Particularly important considerations in selecting HVAC systems include local capacity to design, commission and maintain systems, the adaptability and flexibility of the systems, features or 'modes' that reduce energy consumption and control and metering mechanisms that enable close control and monitoring of systems.

6.4 Passive environmental control strategies

Outlined below are strategies that can be used in buildings with passive environmental control to support energy efficiency. Reference is also made to sections of the guide where further information on the strategy can be found.

Strategy	Description	Relevant sections of the guide
Solar gain	Sunlight is used to warm thermal mass within the building. This releases heat gradually heating the building.	7.6, 7.11, 8.2
Indirect solar gain	Sunlight is used to warm thermal mass such as a rock bed, which in turn is used to heat a medium such as air to heat the building.	8.3
Nightime cooling	The building is cooled at night by allowing cool night air to flow to flush the building of hot air and cool the building's thermal mass.	8.6
Local controls	Occupants are encouraged to adapt their local environment to create comfort, for instance, by opening windows.	4.5
Cross ventilation	Air flow through the building is used to cool the building and occupants.	8.4
Stack effect systems	Tall vertical spaces coupled with the physical tendency for air to rise when heated are used to ventilate and cool/heat the building.	8.5
Evaporative cooling	The cooling effect resulting from evaporating water is used to cool the building.	7.11
Envelope design	Glazing design, insulation and air tightness measures are used to avoid uncontrolled heat losses or gains through the building envelope.	8

6.5 Selecting passive environmental control strategies

An analysis of Johannesburg's climate indicates that for much of the year conditions in Johannesburg fall within a human comfort range of between 20-80% relative humidity and 20-26 ^{0}C.

Conditions during winter however can be uncomfortably cold and heating is likely to be required. This can be achieved through passive solar heating for most winter months, although there may be days in May, June, July when temperatures drop below 5^{0}C when conventional heating may be required. These conditions are likely to be experienced at night.

Conditions that may lead to discomfort during summer can be addressed through natural ventilation, high mass cooling and shading in buildings. Conventional air conditioning throughout the year is not required unless there are stringent temperature and humidity control requirements or high internal heat loads.

Normally a number of passive environmental control strategies will be designed into a building in order to increase the ability of the building to cope with different weather conditions. For instance, both a cross ventilation and a stack effect system may be used to cool the building. During normal conditions when there is a breeze, the cross ventilation system will be effective. However during hot still conditions when cross ventilation may not be effective, ventilation and cooling can still be achieved through the stack effect system.

Section 7

Site

7 Site

The selection of a site is an important component of an energy efficiency strategy. Buildings located near public transport enable energy expended on transport to be reduced. Similarly, the use of an existing building will avoid the energy required to construct new buildings. Multi-tenanted buildings (such as flats) are also usually more energy efficient to operate compared to single-occupancy buildings (such as houses) because of the densities achieved. Outlined below are considerations that can be used in selecting sites and developing site layouts to support energy efficiency.

7.1 Location

Sites for new buildings should be chosen where transport energy consumption can be minimised. The table below indicates the range in energy consumption for different types transport.

Type of transport	Litres of fuel, or energy equivalent, consumed per person to travel 100 km
Car (single occupant)	9.00
Car (2 occupants)	4.50
Taxi (12 passengers)	1.00
Bus	0.70
Train	0.50
Walking	1.00
Cycling	0.36

Table 5. Energy consumed per kilometre for different types of transportation

From this it is clear that the ideal sites are where occupants can walk or cycle to the building. Other suitable locations include being near public transport nodes such as bus stops and train stations. Locations where people have to use their cars should be avoided.

7.2 Existing buildings

Where possible, existing buildings should be used and upgraded for improved energy efficiency. This avoids the substantial amount of energy required to construct new buildings. It also contributes to efficiencies within city infrastructure as existing systems are used more intensively and additional new service infrastructure (water supplies, sewage etc) is avoided.

7.3 Brownfield sites

Undeveloped green field sites should be avoided and already disturbed sites (brown field sites) should be chosen. This avoids further reductions in the size, and therefore the capacity, of the natural environment to absorb carbon dioxide resulting from man's activities. In addition, new developments require a substantial investment in energy to construct new infrastructure such as roads, power and communication networks and water, sewerage and storm water systems.

7.4 Building orientation

Buildings should be orientated to avoid unwanted heat losses or gains. In general, the long section of buildings should be orientated to +/- 15 degrees North. In addition, the extent of the façade facing north should be maximized and the length of façade facing east and west minimised. This enables good access to sunlight for the north façade, good access to daylight through the north and south façades and reduces unwanted heat gain from early morning and late afternoon sunshine on the east and west façades.

7.5 Access to light

Buildings should be arranged on site to ensure that they have good access to daylight and do not shade close neighbours. Obstructions in front of windows can severely reduce the quality of daylight in spaces. The quality of daylight in a space relates to the visible sky angle measured from the centre of a window on an external wall. The larger this angle the better the daylight quality will be in the space. The no skyline position is the location on the working plan (0.85m above floor in residential and 0.7m above floor level in offices) where the sky can no longer be seen. Space to the interior of this will usually requires supplementary electrical lighting.

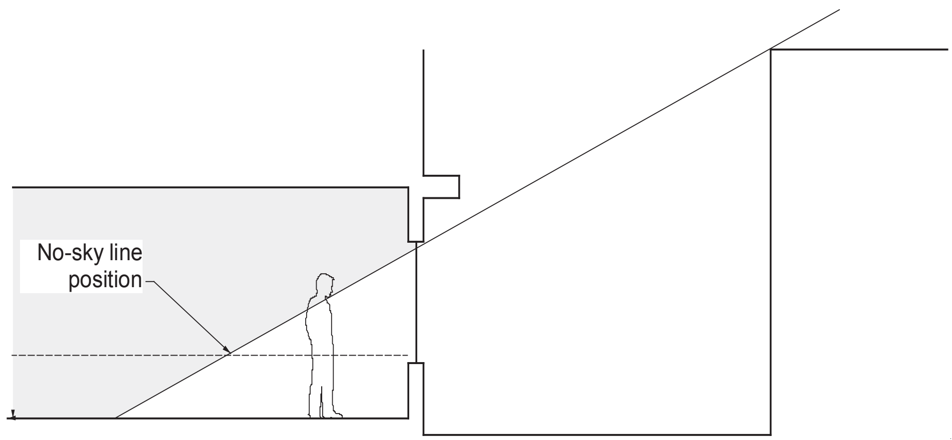


Figure 5. Diagram indicating no-sky position in a building

7.6 Access to sunlight

Buildings should be arranged on site to ensure that spaces and equipment that require high quality sunshine are provided with good access to this. This includes external and internal spaces designed to be heated by the sun and areas with solar water heaters or photovoltaic panels.

7.7 Access to ventilation

The layout of buildings on site and the landscaping strategy should ensure that buildings have good access to breezes where this is required to cool and ventilate buildings. Landscaping can also be used to provide windbreaks to create comfortable protected external spaces and reduce heat losses from buildings in winter.

7.8 Noise

If the site is adjacent to noisy areas such as highways, the site layout should be developed to maximise the distance of buildings to this. In addition, earth berms or non-occupied buildings such as parking garages and electrical substations can be used as a sound buffer. This helps reduce the requirement for high performance glazing and may allow more windows in the building to be openable.

7.9 External hard surface and car parking

Large areas of hard surfaces such as paving and parking can contribute significantly to increased temperatures around building. This is referred to as the urban heat island effect and the retained heat and resultant higher air temperature make it more difficult to keep buildings cool. This can be addressed in the following ways:

- Avoiding large areas of external hard surfaces near buildings
- Shading parking and hard surfaces, ideally using vegetation such as large shade trees
- Using lighter coloured materials for paving and external surfaces to reduce the extent to which these surfaces absorb heat

7.10 Cycling and walking

Cycling can be 30 times more energy efficient (see table 5 on page 30) than using a car. Cycling and walking are also the only readily available forms of transport that use renewable energy and support health and productivity. Cycling and walking can be supported in the following ways:

- Providing dedicated cycle and pedestrian paths around your site
- Developing a driver education campaign and signage to ensure that vehicle drivers are mindful and courteous of cyclist
- Providing secure cycle parking in appropriate locations
- Providing showering and changing facilities in buildings

7.11 Comfortable outside spaces

Comfortable external spaces can be used to create stimulating and contrasting environments for work breaks. Comfortable outside spaces can contribute to energy efficiency by helping condition (cool or warm) air before this is drawn into buildings. They also provide useful additional working, meeting or eating spaces that require very little energy to maintain. Key considerations in developing these spaces are listed below:

- The spaces should be close to buildings.
- Spaces should be sunlit and protected from cold winds in winter to ensure that these are comfortable.
- Spaces should be shaded in summer and away from heat or noise generating areas such as large cars, plant and roads with fast-moving traffic.
- Additional cooling in summer can be provided from evaporative cooling from fountains and water surfaces.

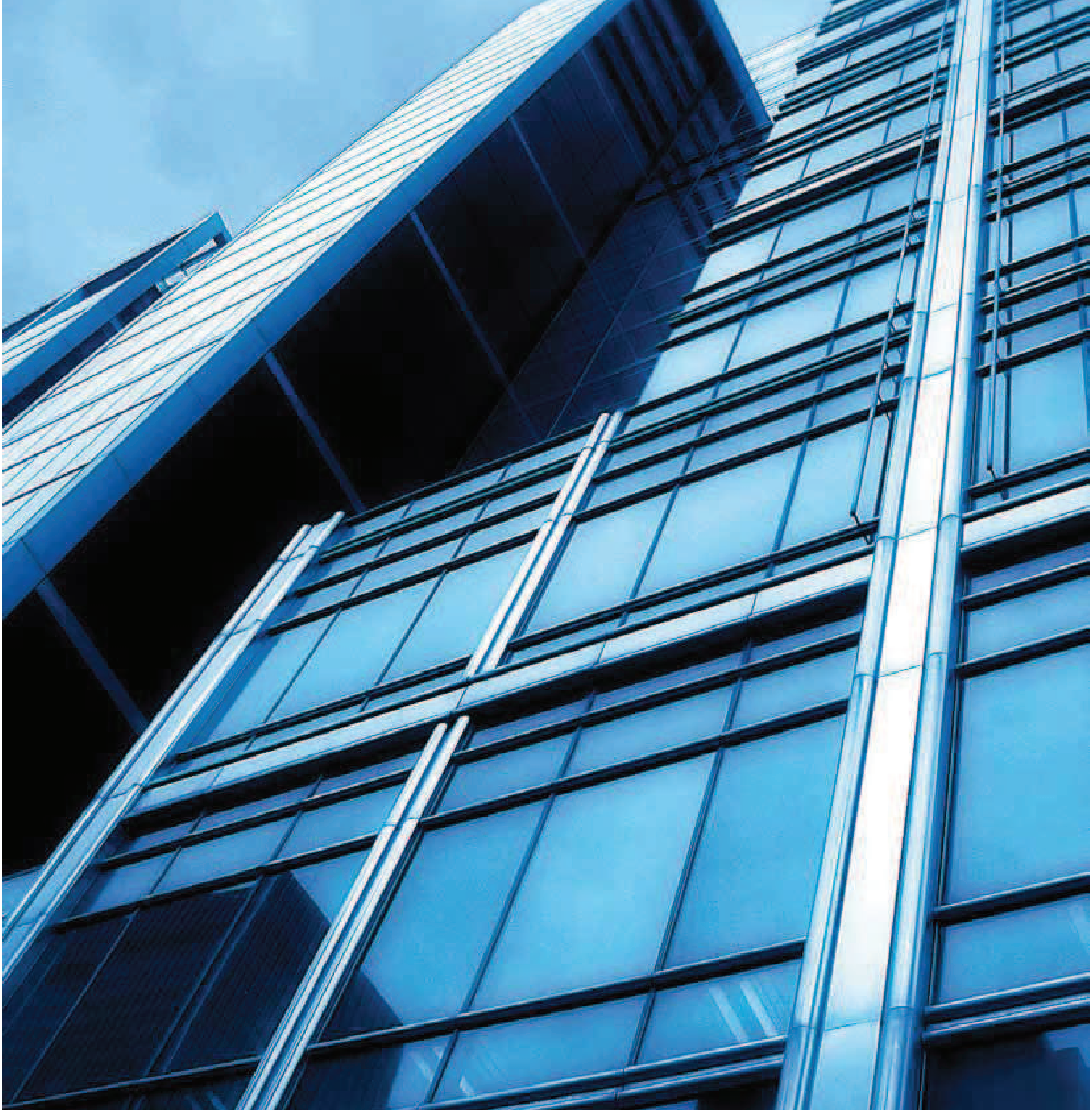
7.12 Access to facilities

Locating facilities such as cafes, restaurants, post boxes, telephones, schools, gyms, banking and retail outlets within or near residential areas or places of work support energy efficiency by enabling people to walk to these facilities rather than use their cars.

7.13 Neighbouring sites

Site layouts should be developed to avoid negatively affecting a neighbouring building's access to sunlight, daylight and ventilation. Ideally, site plans they should be developed in conjunction with neighbouring sites in order to create an integrated master plan that supported energy efficiency. Examples of areas that could be collaboratively explored include:

- Shared car parking space and transportation systems (such as company buses)
- Linked pedestrian and cycle routes
- Integrated building layout and landscaping that developed beneficial microclimates
- Integrated storm and waste water management that enabled moisture to be retained on site and contributed to evaporative cooling



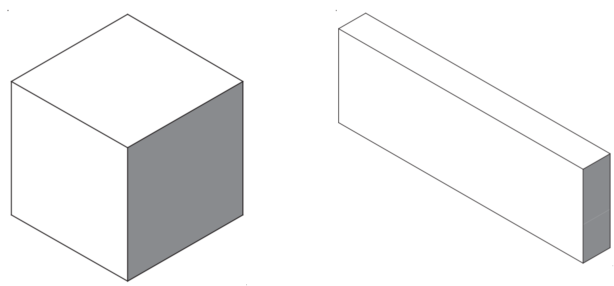
Section 8

Building form and envelope

8 Building form and envelope

8.1 Surface area to volume ratio

In buildings which have active environmentally control it is important to minimise heat gains and losses through the building envelope. One way of reducing this is to minimise the surface area of the building relative to its volume. The surface area to volume ratio is calculated by divided the volume of the building (in m3) by the surface area of the building (in m2). Simple compact buildings achieve the best ratio, as illustrated below.



Volume	27	27
Surface area	54	78
Volume to surface area ratio	0.5	0.34

Figure 6. Diagram showing surface area to volume ratio for different building shapes

8.2 Direct solar gain

Sunlight is a free heat source that can be used to reduce the requirement for heating in buildings on cold days. The simplest way of harnessing this resource is to allow sunlight to enter buildings when heating and warm high thermal mass areas, such as exposed masonry walls or tiled floors. The thermal mass stores this heat and releases it gradually, keeping the building warm. In general, direct solar gain systems should not be used to heat spaces where people where working on computers and where glare may be a problem. In these areas direct solar gain can be used to warm non-working spaces such as circulation and pause areas near working spaces. The following factors should be considered in harnessing solar gain:

- **Location and orientation:** Location and orientation of the building to ensure good solar access at the right times of the year.
- **Building envelope:** Openings, glazing (and possible blinds and curtains) in the building should be designed to direct solar access to the right area and retain heat gathered.
- **Material and finishes:** The location, colour and type of finishes should be selected to provide good thermal storage.

8.3 Indirect solar gain

More complex, but more controllable passive solar heating systems are indirect solar gain systems. These use the sun to warm high thermal mass materials such as rock or water. This heat is then stored and circulated to the building using air or water as a medium. These systems can be complex to design and key considerations include:

- **Location:** Location of the indirect system to ensure that is near the building and has good solar access.
- **Sizing:** The collection area, thermal storage capacity and heat circulating system needs to be sized correctly.

8.4 Cross ventilation

Cross ventilation is an energy efficient way of cooling buildings in areas where there are moderate breezes. Airflow through the building is used to remove heat and bring in fresh air. The following factors should be considered developing buildings with cross ventilation:

- **Landscaping and building layout:** Care should be taken to expose façades with opening windows to breezes and to avoid these being in the 'wind shadow' of other buildings and obstructions.
- **Depth of the buildings:** The depth of the building should not be more than 12-15m.
- **Internal spatial layout:** Air movement should be directed around people and the 'breeze path' between windows on opposite walls be made a direct as possible to ensure that air movement is effective.

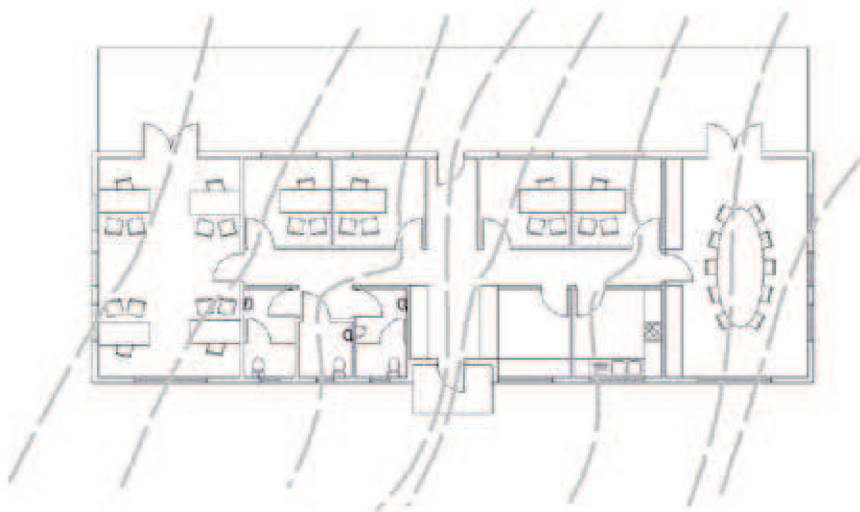


Figure 7. Diagram showing cross ventilation in a building

8.5 Stack effect systems

A stack effect system uses tall vertical spaces and the physical tendency of warm air to rise to ventilate and warm or cool buildings. Rising air within a vertical space, which could be an atrium or solar chimney, is used to draw air into buildings, ventilating it. This air can be drawn from a cool source, cooling the building, or from a warm source, warming the building. The following factors should be considered in developing stack effect systems:

- **The stack effect chimney:** The taller this space is the more powerful the system will be. A minimum of 9m is usually required for effective systems.
- **Location:** The vertical space should be located adjacent to spaces to be cooled or heated.
- **Heat sources:** Stack effect systems can be assisted from heat sources such as the sun, people and equipment. The design and location of the stack effect system should harness these heat sources.
- **Controls:** To control air movement and the extent of heating and cooling.

8.6 Nighttime cooling

Nighttime cooling uses the diurnal range to cool buildings. During the night cooler air is used to flush warm air out and cool the thermal mass of a building. The following factors should be considered in designing for nighttime cooling:

- **Openings:** The design and location of openings should enable good airflow at night through the building. Airflow should be directed around thermal mass in order to remove heat at night.
- **Security:** Care should be taken to avoid compromising security.
- **Thermal mass:** The location of thermal mass within the building where it can act as heat sink during the day and be cooled by night-time ventilation.

8.7 Day lighting

Good day lighting reduces energy consumption by minimising the requirement for artificial lighting. Daylight strategies should consider the following factors:

- **Access to day lighting:** Landscaping and building location to ensure good access to daylight.
- **Depth of the buildings:** The depth of the building should be limited to ensure that internal spaces that cannot be day lit are limited in area. A general rule of thumb is that daylight quality will be reasonable within the space 2h from a window, where h is the height of the head of the window from floor level (see figure 8below).
- **Type of glazing:** Selection of glazing to allow good daylight penetration.
- **Light shelves:** The use of daylight shelves to enable daylight penetration deeper into the building.
- **Internal colour:** The choice of colour and finishes to improve internal reflectance of spaces.

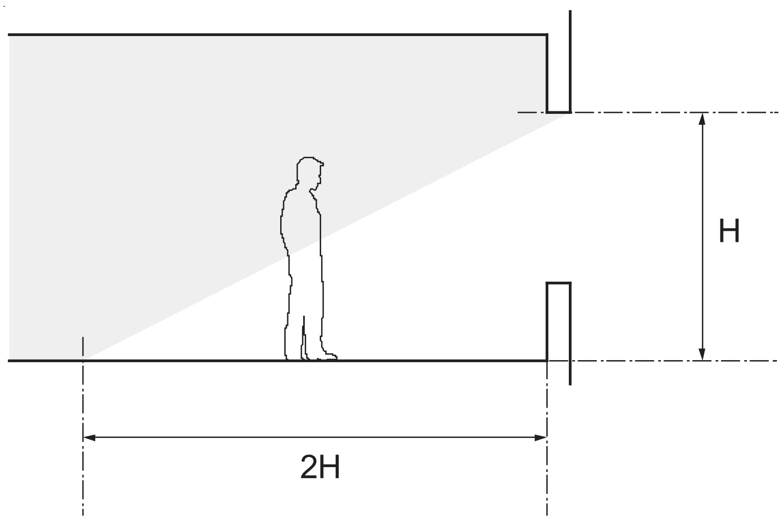


Figure 8. Diagram showing area of high quality daylight

8.8 Shading devices

Shading devices should be used to avoid unwanted heat gains. The design of shading devices are normally based on calculations and modelled to ensure that windows or glazing is shaded from direct sunlight at specific times. In general, horizontal shading elements are appropriate on northern façades and vertical moveable louvers are suitable on east and west façades. On the northern façade shading devices can be designed in accordance with the diagram below.

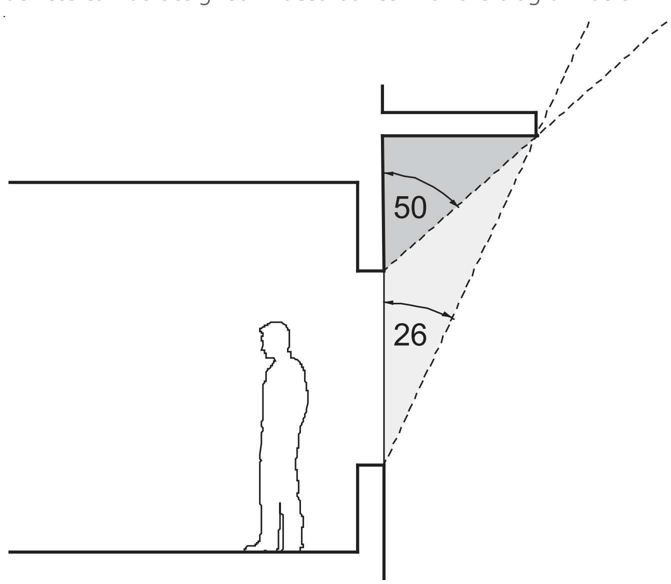


Figure 9. Diagram showing sizing of horizontal shading device on south façade (SANS 204)

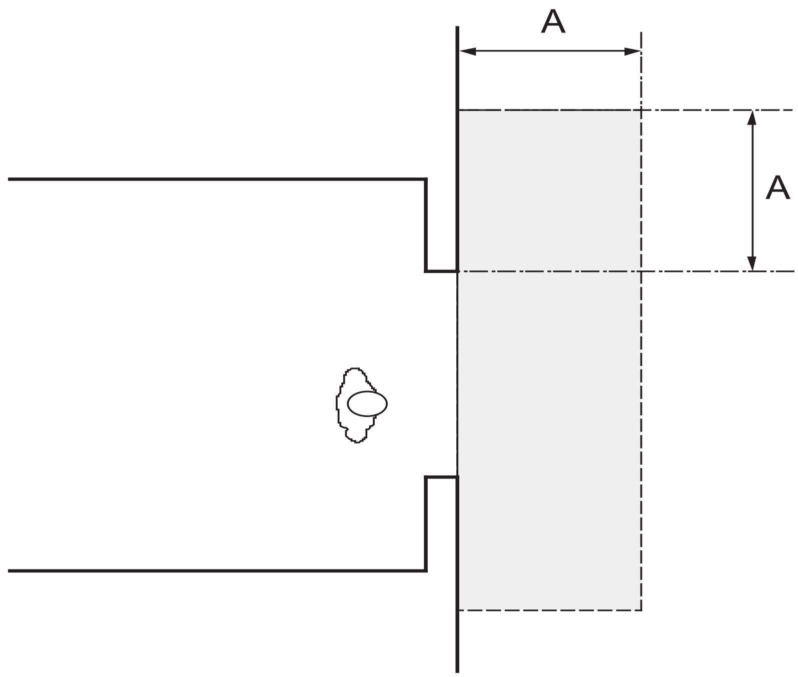


Figure 10. Diagram showing extent to which horizontal shading device should extend beyond the edge of windows (SANS 204)

The section shows the angle of the sun at the equinox (around March 20 and September 23 each year) when the sun is directly over the equator. This angle (26^0) can be used to set out the sill of windows. The angle of the sun at the winter solstice (around June 20) can be used set the head of the window (50^0). The depth of the shading device (A) should be where these angles meet. The shading device should extend beyond the window below by at least length (A) to be effective.

While the above illustrates an approach to designing solar shading on a north façade, it is important for designers to calculate and model solar shading to suit their particular site and building type. For instance, an spaces with computer screens may require solar access to be avoided altogether because of visual and glare problems, whereas a passive solar house may require good solar access during the winter months to heat the house.

8.9 Colour

The colour of building affects the extent to which it absorbs heat from sunlight with darker colours absorbing more heat than lighter colours. Therefore, in general, building envelopes should be light coloured, particularly roofs and east and west façades.

Colour	Value
Slate (dark grey)	0.9
Red, green	0.75
Yellow, buff	0.6
Zinc aluminium—dull	0.55
Galvanised steel—dull	0.55
Light grey	0.45
Off white	0.35
Light cream	0.3

Table 6. Absorbencies of different colours (SANS 204)

8.10 Insulation

Insulation can be used to reduce the heat flow through the building envelope. Detailed guidance on this can be found in SANS 204. In addition, many insulation manufacturers will undertake calculations to assist in determining appropriate envelope build construction, including the type, thickness and location of insulation. There are however some general guidelines:

- Most heat losses and gains are through the roof of buildings; this is therefore the place where insulation will have the most effect.
- In order to maximise the thermal flywheel effect in buildings, insulation should be located on the outside of high thermal mass envelopes and building structures.
- The thermal resistance of building envelopes can be increased easily and at low cost through design. For instance, the incorporation of an air gap within a wall build-up or planting creepers on an external façade use the insulative properties of air to increase thermal resistance of the building envelope.
- Care should be taken to ensure that insulation is as continuous as possible within a building envelope and gaps and thermal bridges should be avoided.
- Minimum insulation levels for different areas of the building envelope are provided.in SANS 204. These should be complied with and exceeded, where appropriate.

8.11 Glazing in façades

The amount, type and location of glazing can have a significant effect on energy consumption used in building for lighting, heating and cooling. The following guidelines can be used to support energy efficiency:

- The area of glazing on a façade should be an optimal balance between daylight quality and heat gains and losses. Glass generally has a much lower R-value than solid walls. Therefore in highly glazed areas it may be difficult and expensive to control heat gains and losses. If areas are going to be highly glazed, high performance glazing should be investigated in order minimise discomfort and energy consumption (see below).
- Where possible, glazing should be avoided on east and west façades to avoid unwanted heat gains. Glazing should also be placed where it provides views and higher up in walls to support good day lighting.

8.12 Windows

Well-designed windows can improve the energy efficiency through enabling good daylight and natural ventilation. Characteristics of windows that can be used to support energy efficiency are outlined below:

- Where windows are being used as part of a cross ventilation strategy, the size and location of opening sections should be designed to ensure that breeze paths through the building are direct and are guided through areas, equipment and people that need ventilation and cooling.
- Naturally ventilated buildings should have an equivalent opening area (of windows or doors) of at least 5% of the floor area.
- Light coloured chamfered reveals help reduce contrast between windows and surrounding walls reducing glare and improving day lighting.
- Windows with opening sections at both high and low level benefit from being able to use the stack effect to create air movement and can be used to vent hot air out of the top of rooms and draw in cooler air in at low levels.
- Window opening controls should be designed to give occupants control over their local environment. This can be done by having regularly spaced windows and providing at least one opening section per 5 m of façade. Window controls should also cater for people with disabilities

8.13 Glass

More sophisticated glazing should be used where high performance is required. The following characteristics of glass can be used to promote energy efficient design.

- **Visible light transmittance:** Glass with high light transmittance supports good daylight within buildings, reducing the requirement for artificial lighting.
- **Solar heat gain coefficient:** This is the proportion of total solar radiation that is transferred through the glass at normal incidence. Glass with lower coefficients reduces the amount of heat gain from the sun.
- **U-values:** Increasing U-values, for instance by using double-glazing, reduces heat losses and gains.

8.14 Doors

In a similar way to windows (see above) external doors can be used to ventilate and cool buildings. Their use on very hot or very cold days however can introduce large volumes of cold or hot air affecting comfort. Air movement through external doors can be reduced in the following ways:

- Revolving doors and lobbies can be used to reduce the amount of air moving in and out of the building.
- Well-fitted insulated doors with perimeter seals can be used.
- Automatic closers can be used to minimise the duration which doors are open.

Section 9

Internal space

9 Internal space

9.1 Functions

Locating functions in a building carefully can enhance energy efficiency by working with environmental conditions within and around the building, rather than against these. An outline of the environmental conditions experienced in different areas of a building, with suggested functions, is given below.

Area of the building	Environmental conditions	Appropriate functions: office	Appropriate functions: residential
East facing	Will receive low angle sunlight and heat gain in the morning	Canteens, kitchens	Kitchens, dining areas, bedrooms
North facing	Will receive varying light throughout and sunshine throughout the day	Work areas, (high thermal mass elements such as stair cases – if passive solar strategy used)	Living, working areas (high thermal mass elements such as stair cases – passive solar strategy used)
West facing	Will receive low angle sunshine and heat gain in the afternoon	WCs, storage, service areas, lift shafts, staircases	Bathrooms, WCs storage areas
South facing	Daylight conditions will be even across the day and relatively little sunshine will be received.	Working areas, circulation, services, meeting areas	Bedrooms, circulation, services
Core of the building	Daylight and natural ventilation are likely to be relatively poor (without roof openings). Temperatures remain fairly steady	Lift shafts, stair cases, circulation, storage	Storage, circulation

9.2 Ventilation

Areas such as WCs and bathrooms that require good ventilation should be located on external walls to maximise the use of natural ventilation. Similarly, spaces with high internal heat gains from people or equipment should be located on or near an external wall in order to enable this heat to extracted to the outside in an energy efficient way, for instance through high level windows or vents.

Where possible, parking should be designed to rely on natural ventilation. In large underground parking areas where natural ventilation cannot be achieved, carbon dioxide detectors can be used to control mechanical ventilation systems to avoid over ventilating space when this is not required.

9.3 Thermal mass

Thermal mass can provide a useful flywheel effect in buildings by storing ‘warmth’ from the solar gain, people and activities. This warmth is released gradually, increasing temperatures in the late afternoon and evening.

Thermal mass can also be used to store 'coolth' from cool nights to reduce temperature increases during the day from solar gain, people and activities by acting as a heat sink and absorbing heat. There are number of factors that should be considered in design systems that include thermal mass. These are outlined below:

- The easiest way to achieve thermal mass is through inclusion of high thermal mass materials such as concrete, stone, ceramic tiles and brick in the construction of the building.
- Thermal mass is most effective if its surface area has maximum exposure to the internal environment and it is located within an insulated building envelope.
- Using ceramic tile or screed floor finish and exposing masonry walls and concrete roof structure is an ideal way to increase the effectiveness of thermal mass in a building. Covering-up thermal mass in buildings through the use of carpets and ceilings should be avoided.
- For good winter performance, thermal mass should be exposed to direct sunlight and is best located behind with unobstructed north-facing glazing.
- Nighttime cooling is most effective when cool night air is directed against thermal mass to absorb heat gained during the day. Design for nighttime cooling should therefore ensure that openings and air movement is directed over thermal mass to ensure that heat gains are effective removed.

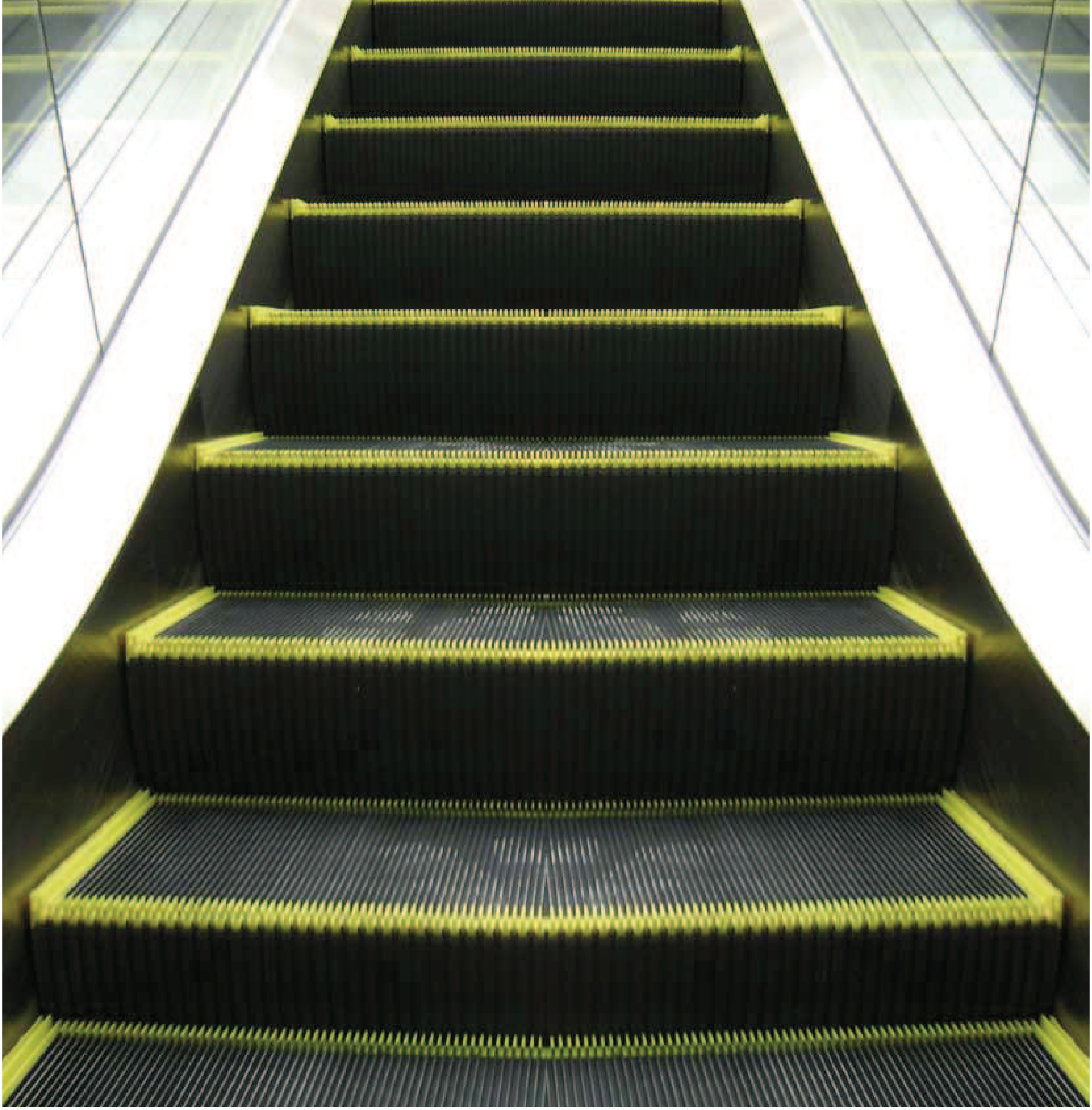
9.4 Internal walls

The location and design of internal wall should be considered carefully in buildings with passive environmental control. In particular the following factors should be considered:

- In buildings where cross ventilation is used, internal walls should not to impede airflow. This can be achieved by designing walls to run parallel to airflows, creating a space above or below walls for air movement and including openings within walls, such as doors with openable lights. In buildings where privacy requirements make normal cross-ventilation strategies difficult, ceiling voids can be used to enable cross ventilation while still ensuring privacy.
- High thermal mass walls, such as concrete and brick walls located around stairs, lifts and bathrooms can contribute to improving the thermal mass of the buildings and can be located and designed to contribute to passive environment control strategies.

9.5 Finishes

Light coloured high thermal mass finishes can help reduce energy consumption by supporting good daylight quality and passive environmental control strategies. Darker coloured floors in areas with direct solar gain are suitable in order to maximise heat absorption.



Section 10

Mechanical systems

10 Mechanical systems

Energy costs in a typical air-conditioned building are usually at least double the energy costs and associated CO_2 emissions of a building with passive environmental control (Carbon Trust 2006). Increased capital and maintenance costs are also likely (Carbon Trust 2006). Therefore mechanical heating and cooling systems should be avoided, where possible. The chart below can be used ascertain whether a mechanical system is required.

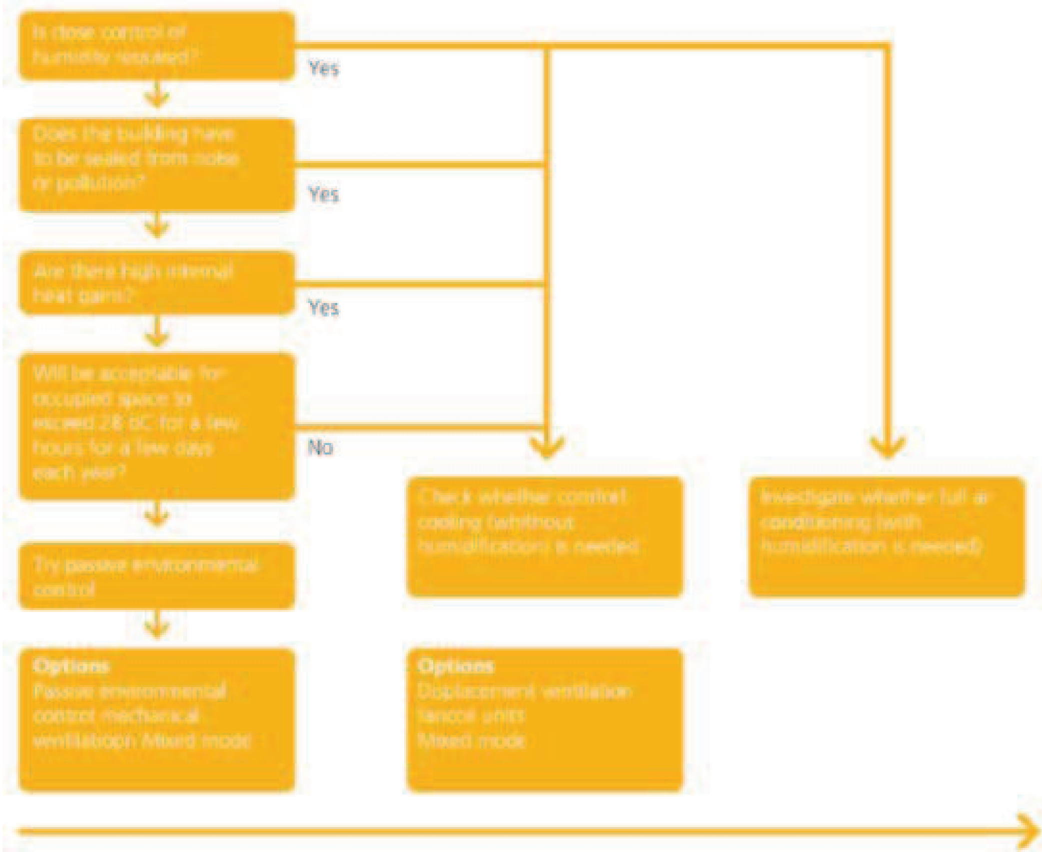


Figure 11. Factors influencing type of environmental control system (Adapted from Carbon Trust)

10.1 Zoning

Zoning a building into different areas depending on ventilation and heating and cooling requirements can enable mechanical systems to be used more efficiently. Thus an area with high ventilation requirements and heat gains such as a kitchen could be zoned and dealt with separately to other areas such as passageways, or storage where ventilation requirements are lower. Zoning also allows heating, cooling and ventilation to different areas of the building to be reduced to match requirements more closely.

Design teams should work closely with building developers and occupants and in order understand how the building will function and relate to the external environment in order to develop zoning and control systems that support energy efficiency.

10.2 Pre-heating and pre-cooling

Heating and cooling systems can be made more efficient by linking these to systems which pre-cool or pre heat air. For example, a heat exchanger can be used to extract heat from exhaust air from a kitchen or gym and use this to warm incoming fresh air.

10.3 Natural or economy cycle

External air temperatures in Johannesburg are comfortable for a large part of the year. Energy efficiencies can be achieved by using this air directly to ventilate buildings without conditioning it. This is sometimes referred to a 'natural' or 'economy' cycle and can be used to achieve substantial energy savings.

10.4 Mechanical ventilation

Mechanical ventilation should be avoided where possible through the use of passive ventilation strategies. There are however situations where mechanical ventilation cannot be avoided. This includes spaces such as internal kitchens, underground parking, toilets and server and print rooms. In order to maximise the energy efficiency of mechanical ventilation in these areas the following factors should be considered:

- Spaces should be located as near as possible to an external wall in order to minimise the distance air has to be extracted.
- Ducting design and fan specification should be carried out to minimise energy consumption.
- Controls such as movement sensors, CO2 monitors and timers should be used to ensure that spaces are not over-ventilated when not in use.

10.5 Exhaust fans

Exhaust fans can result in uncontrolled air movement in and out of the building when not in use. SANS 204 therefore requires exhaust fans in conditioned spaces to be fitted with a sealing device such as a self-closing damper to prevent this.

10.6 Vertical transportation

In large buildings the use of lifts and escalators may be unavoidable, however in smaller buildings people should be encouraged to use stairs or ramps to move between different levels. This reduces energy consumption in buildings and has the added advantage of providing exercise. The easiest way of encouraging people to use stairs is to locate them and design them so that they are easier to use then lifts or escalators.

Section 11

Electrical lighting

11 Electrical lighting

Electrical lighting systems vary widely and it is important to select the most appropriate system for your application. In particular the following issues should be considered:

- **Light level requirements:** Required light levels for different areas are outlined in SANS 10400 and should be followed.
- **Safety:** Requirements for emergency egress and compliance with the Occupation Health and Safety Act should be ensured.
- **Energy efficiency:** Energy efficient lighting systems should be selected. Good indicators of energy efficiency are luminous efficacy and energy requirements per m2 (see below).
- **Colour rendering:** The extent to which colours are rendered effectively can be important, particularly in museum, art gallery and retail environments.
- **Maintenance:** The cost of replacing lamps can be considerable, particularly in difficult-to-access locations such as atria or auditorium roofs. The lifespan of lamps may therefore is an important factor.

11.1 Lamp selection

The selection of lamp has a major influence on energy efficiency. A good indicator of energy efficiency in lamp selection is the luminous efficacy in lumens per Watt. This information for different lamp types are provided below. The use of tungsten and halogen lamps, the least energy efficient lamps, should be minimised.

Type	Overall luminous Efficacy (lm/w)	Life span (Hours)	Applications	Notes
Tungsten	7 - 24	700-1000	General lighting	Least efficient lamp
Halogen	12 - 36	2,000 - 4,000	General lighting, accent lighting	Bulb burns very hot, care should be taken about locations
Compact Fluorescent	45 - 90	Up to 10,000	General lighting	Very efficient, readily available
Fluorescent (tubular)	50 - 100	10,000 - 20,000	General lighting	Very efficient, readily available
White LED	30 - 60 (200)	30,000 - 80,000 (100,000)	General lighting, Accent lighting	Rapidly changing technology (figures in brackets are predicted performance in next few years)
Metal halide	60 - 125	6,000 - 10,000	Retail, sports facilities, arenas, convention halls	Good colour rendering
Mercury Vapor	20 - 63	1600 - 6000	Outdoor lighting	Produces blue green light, poor colour rendering
High Pressure Sodium	60 - 140	18,000 - 24,000	Outdoor, industrial lighting	Produces yellow light, poor colour rendering
Low Pressure Sodium	90 - 180	Approximately 16,000	Security lighting	Very poor colour rendering

Table 7. Lamp efficiencies

11.2 Zoning and circuits

The design lighting systems should ensure that lighting is only used on when required. It should also ensure that only the specific area where lighting is needed is lit. The situation therefore of having a whole floor lit to accommodate one person working late should be avoided.

11.3 Lighting maintenance

The accumulation of dust and dirt on light fittings and lamps can reduce their effectiveness by up to 40%. The design of lighting should therefore ensure that light fittings and lamps can be easily accessed and cleaned.

11.4 Lighting controls

Lighting should be switched off when not needed. This can be done manually or automatically. The following factors should be considered when designing lighting controls:

- **Location:** Light switches should be located in prominent positions on routes out of rooms and passageways, and as you exit the building, as a whole.
- **Zoning:** Lighting should be zoned into logical areas that can be switched on and off individually. Generally lighting zones should not be restricted to the size of the room in closed plan environments and to less than 100m2 in open plan environments.
- **Daylight sensors:** daylight sensors can be used to dim or turn-off lighting when there is adequate daylight.
- **Nighttime switching:** External lighting should be linked to daylight sensors or timers to ensure that this is on only when needed.
- **Movement sensors:** Movement sensors can be used to automatically switch off lighting in spaces that are not being used.
- **Timers:** Timers can be used to ensure lighting is on for specified time only. For instance, external lights can be designed to switch on between 6.00 and 10.00 PM when external spaces are used and then switched off for the rest of the night.

11.5 Energy consumption

Energy consumption in lighting should be evaluated against best practice benchmarks. A benchmark that can be used are the power density and maximum average annual energy consumption figures outlined below from SANS 204.

Class of occupancy or building	Occupancy	Population	Recommended good practice maximum values	
			Power watts per m²	Energy kilowatts-hours per annum per m²
A1	Entertainment & Public assembly	Number seats or 1 person/m²	10	25
A2	Theatrical & indoor sport	Number seats or 1 person/m²	10	25
A3	Places of instruction	1 person / 5 m²	10	25
A4	Worship	Number seats or 1 person/m²	10	10
A5	Outdoor sport is viewed	Number seats or 1 person/m²	10	15

B1	High risk commercial	1 person / 15 m²	24	60
B2	Moderate risk commercial	1 person / 15 m²	20	50
B3	Low risk commercial	1 person / 15 m²	15	37.5
C1	Exhibition Halls	1 person / 10 m²	15	22.5
C2	Museums	1 person / 20 m²	5	12.5
D1	High risk industrial	1 person / 15 m²	20	50
D2	Moderate risk industrial	1 person / 15 m²	20	50
D3	Low risk industrial	1 person / 15 m²	15	37.5
D4	Plant rooms		5	5
E1	Places of detention	2 person / bedroom	15	37.5
E2	Hospitals	1 person / 10 m²	10	87.6
E3	Other institutional residences	1 person / 10 m²	10	25
F1	Large shops	1 person / 10 m²	24	105.12
F2	Small shops	1 person / 10 m²	20	87.6
F3	Wholesaler's store	1 person / 20 m²	15	65.7
G1	Offices	1 person / 15 m²	17	42.5
H1	Hotels	2 person / bedroom	10	43.8
H2	Dormitories	1 person / 5 m²	5	12.5
H3	Domestic residences	2 person / bedroom	5	5
H4	Dwelling houses	4 person / house	5	5
J1	High risk storage	1 person / 50 m²	17	42.5
J2	Moderate risk storage	1 person / 50 m²	15	37.5
J3	Low risk storage	1 person / 50 m²	7	17.5
J4	Parking areas covered	1 person / 50 m²	5	21.9

Table 8. Recommended light levels, power and energy for the classes of buildings

Section 12

Water heating

12 Water heating

Electrical geysers use up to 40% of a home's energy consumption (Eskom 2006). Therefore reducing the consumption of hot water and using solar energy to heat water and can be make a significant contribution to energy efficiency.

12.1 Solar water heating

A highly energy efficient way of heating water is through solar water heaters. A 150L solar water heater will replace about 4.5kWh/day of electricity, which saves 2 tonnes of carbon emissions per year (Eskom 2006)

Solar water heaters should comply with the requirements of SANS 1307 and be installed in accordance with SANS 10106. Solar water heaters can be used in all areas of South Africa to provide hot water throughout the year. The design and sizing of the system should be carried out in conjunction with a solar water heater supplier, however the following issues are common to most solar water heaters:

- Solar collectors should face true north, if possible. Deviations of 45^{o} East and West can usually can be accommodated.
- The pitch (angle from horizontal) of the solar collector should normally be latitude of the location plus 10^{o}, so collectors in Johannesburg would be angled at 36^{o}.
- Solar collectors should be positioned where surrounding buildings or trees will not shade them. Small obstacles such as TV aerials do not have much effect.
- Solar collectors are most effective when they are clean. As these tend to get dusty ensure that they are located where they can be cleaned regularly.
- When full of water, solar heating systems will have a considerable weight and sufficient structure should be provided to take this.

12.2 Pipe runs

The distance between hot water storage or generation and use should be as short as possible in order to minimise heat losses from hot water pipes. This also helps reduce water consumption, as large amounts of cold water are not drawn off before hot water reaches taps.

12.3 Insulation

Hot water pipes and storage units should be insulated to minimise heat losses. Levels of insulation should be provided in line with SANS 204 and are outlined below.

Internal diameter of pipe	Minimum R-value
Internal piper diameter 40mm and less	0.625
Internal piper diameter exceeding 40mm, but not exceeding 80mm	1.00
Internal piper diameter exceeding 80mm	1.50
Hot water cylinder or storage	2.00

Table 9. Minimum R-values for pipe insulation

12.4 Hot water temperatures

The temperature of hot water should be suitable for its use. Normal washing can be done with water at 55^{0}C. Setting the thermostat at the right temperature can improve energy efficiency. For instance, lowering the temperature of an electrical geyser from 70^{0}C to 60^{0}C can reduce the energy consumption by about 5% (Eskom 2006).

12.5 Hot water consumption

Hot water consumption should be minimised by specifying water efficient delivery devices. For instance, showers should be specified in preference to baths. Guidelines targets for hot water consumption in different water delivery devices are provided below.

Water delivery device	Maximum flow/water consumption
Showers	6-7 litres/min
Clothes washing machines	50 litres per wash of 5 kg cottons.
Dishwashing	18 litres per load
Hand basins taps	2 litres/min

Table 10. Maximum flow and water consumption in water delivery devices

12.6 Hot water energy targets

The design of hot water systems should be checked against benchmarks to ensure that they are energy efficient. Annual domestic hot water heating power densities required by SANS 204 are provided below.

Occupancy	Heating power density (W/m2)
Residential	9.61
Hotels & guest houses	4.65
Hospital	20.00
Office	0.23
Retail	0.14

Table 11. Annual domestic hot water heating power density

Section 13

Appliances and equipment

13 Appliances and equipment

Appliances and equipment used in buildings should be as energy efficient as possible. As technology in this area changes rapidly it is worth investigating the latest energy consumption features and comparing different models in order to identify the most efficient.

13.1 Ratings and controls

There are rating systems for energy efficiency in appliances and equipment such as 'energy star'. These ratings and features such as standby modes can be used to help identify the most energy efficient equipment.

13.2 Domestic appliances and equipment

An indication of the average energy consumption for domestic appliances is provided below. The high levels of energy consumption for swimming pool pumps and air conditioners should be noted in order to avoid these if possible.

Appliance	Average kWh p/a
Swimming pool pump	2020
Air conditioner (room)	1070
Colour television (on)	197
Computer	130
Coffee maker	100
Stereo/radio	75
Hair dryer	50
Ceiling fan	50
Iron	50
Video machine	40
Telephone	36
Answer machine	36
Colour television (off)	33
Vacuum cleaner	25

Table 12. Energy consumption in domestic appliances

13.3 Office equipment

Increasingly office equipment has energy ratings and includes energy saving features. The following issues should also be considered in selecting equipment.

- **Monitors:** Consider using flat screen monitors that emit less heat, use less energy and space than conventional monitors.
- **Computers:** Consider using laptops instead of conventional desktops. These use about 10% of the energy of desk tops and can also promote energy efficiency through reduced travel by enabling remote or home working.
- **Photocopiers and printers:** Seven day timers can be used to ensure that these are switched off at night or on weekends when they are not being used. They should also be positioned in areas with good natural ventilation and airflow to avoid air conditioning costs and the build up of fumes.

Section 14

Integrated control systems and monitoring

14 Integrated control systems and monitoring

In order to maximize energy efficiency in buildings adequate controls and monitoring and metering systems need to be in place. These enable users of buildings to only use electrical systems or parts of electrical systems when they are needed. It also enables users to track energy consumption and develop targets and strategies to reduce this over time.

14.1 Meters

Electricity meters should be located where they can be easily read. Energy consumption information should be shared with building users through notice boards and intranet sites in order to ensure that they are aware of levels of consumption and are able to take responsibility for reducing this.

14.2 Sub-metering

Where systems, such as mechanical heating and cooling, consume over a third of the buildings energy consumption it can be beneficial to sub-meter and monitor these systems. Sub metering and monitoring have been found to save at least 5% of yearly energy costs (Carbon Trust 2006).

14.3 Switching and controls

The switches and controls for electrical equipment and lighting should be made easy to use and located in areas that are easily accessible to the person responsible for using these. A simple instruction manual and training should be provided in order to ensure that people who manage building understand how and where energy consumption is consumed and how this can be minimised through management.

14.4 Thermostats

Most air-conditioned areas do not need to be cooler than 24°C and a temperature of 19 °C set for heating to be initiated. This can be used to develop 'dead band' setting of 19-24°C where no mechanical heating and cooling takes place (Carbon Trust 2006). This type of setting can help increase energy efficiency without significant impacts on comfort. Thermostats on electrical geysers used for producing water for washing should normally be set at 55°C.

14.5 Daylight sensors

Daylight sensors can be used to reduce energy consumption by electrical lighting. This requires that electrical lighting within areas that normally receives good daylight are zoned so that lighting can easily be switched off or dimmed when there is adequate daylight. This can be done manually through well-located switches and building user awareness training or automatically through daylight sensors. All external lighting should be linked to daylight sensors to ensure that this is switched off during the daytime.

14.6 Movement sensors

Movement sensors can be used to ensure lighting is switched off when spaces are not being used and can be used in a wide range of applications including office areas, meeting rooms, toilets, car parking, storage areas and external routes around a building. Movement sensors can also be used to switch on mechanical extract fans in spaces such as bathrooms while they are occupied only.

14.7 Timers

Timers can be used to switch off electrical equipment when it is not used and can be applied to many different situations to reduce energy consumption. Some examples are provided below:

- Office equipment such as photocopiers and printers can be put on a seven-day timer, which switches off equipment at night and on weekends when not in use.
- Electrical geysers can be linked to timers, which switch geysers off and on when hot water is required.
- Feature and architectural lighting: Timers can be used to switch lighting on when necessary, for instance in the early evening, and then off for the rest of the night.
- Timers can be used to use electricity only at off-peak times (such as at night). Dishwashers, washing machines and pool pumps could be switched on and off in this way.

14.8 Building management systems

In complex buildings that consume large amounts of energy it is worth having a building management systems that enable electrical systems to be closely controlled and monitored.

Section 15

Useful checklists and information

15.1 Office design checklist

	Aspect	Design process and features	Self assessment
1	Targets	Does the brief require that challenging and specific energy targets are set and achieved? Is there a monitoring and evaluation process in place for this?	
2	Occupants	Is energy efficient occupant behavior being encouraged? Is a building user manual and an appropriate dress code in place?	
3	Location	Is the site 400m from a public transport node? Are there incentives for people to use public transport rather than cars?	
4	Existing building/ Brownfield sites	Has an existing building or brown field site been used? Is this within a municipal boundary?	
5	Orientation	Are buildings orientated within 150 of North?	
6	Site layout	Does the site layout avoid working spaces being located deeper than the 'no skyline position' in buildings?	
7	External hard landscaping	Has external hard landscaping been minimized? Where this does occur, is this shaded and of a light colour?	
8	Cycling	Are there local cycling routes? Has secure cycle storage and showering facilities been provided?	
9	Facilities	Are facilities such as a grocery retail, post office and banking within walking distance to reduce car usage?	
10	Parking	Is parking naturally ventilated and day lit?	
11	Glazing	Has glazing on the East and West façades been minimized? Where this does exist, is there appropriate solar control?	
12	Internal spatial layout	Have all toilets and kitchens been located on a perimeter wall where they can be easily ventilated?	
13	Daylight	Are all workstations located within 2h of an external window (where h is the head of the window)?	
14	Air conditioning	Is comfort achieved in occupied spaces without air conditioning?	
15	Solar gain	Has solar gain been used to warm the building in winter?	
16	Leakage	Are leakage rates through the building envelope lower than that required by SANS 204?	

17	Insulation	Are insulation levels at least at the levels required by SANS 204?	
18	Cross ventilation	Is the width of the building depth less than 20m and are there direct routes less than 25m in length for natural airflow across the building?	
19	Windows	Have windows been designed and located to promote comfortable natural ventilation?	
20	Lighting	Is the energy intensity of office electrical lighting below 15W/m2?	
21	Daylight sensors	Has lighting been linked to daylight sensors where appropriate?	
22	Movement sensors	Have movement sensors been linked lighting and other mechanical systems where appropriate?	
23	External lighting	Are all external lights on daylight switches?	
24	Computers	Are laptops and energy efficient monitors used?	
25	Timers	Are photocopiers and printers on seven-day timers?	
26	Water heating	Is cold water or solar heated water used for all washing requirements in the building?	
27	Local controls	Have local controls been provided to enable user to have control over the local environment?	
28	Electricity meters	Are these located where they can be easily monitored or linked to a BMS?	
29	Sub metering	Is sub metering used to ensure that detailed monitoring can be carried out?	

15.2 Residential design checklist

	Aspect	Design process and features	Self assessment
1	Targets	Does the brief require that energy targets exceed SANS 204 and that monitoring and evaluation processes are in place to ensure this?	
2	Location	Is the site 400m from a public transport node?	
3	Existing building/ Brownfield sites	Has an existing building or brown field site been used? Is this within a municipal boundary?	
4	Orientation	Are buildings orientated within 150 of North?	
5	Site layout	Does the site layout avoid working spaces being located deeper than the 'no skyline position' in buildings?	
6	External hard landscaping	Has external had landscaping been minimized? Where this does exist is this shaded and of a light colour?	
7	Cycling	Are cycle routes provided within 1km of housing?	
8	Facilities	Are education, recreation, retail facilities and work opportunities available within walking distance to reduce car usage?	
9	Glazing	Has glazing on the East and West façades been minimized? Where this does exist, is there appropriate solar control?	
10	Internal spatial layout	Have all toilets and kitchens been located on a perimeter wall where they can be easily ventilated?	
11	Daylight	Are all habitable rooms within 2h of an external window (where h is the head of the window)?	
12	Air conditioning	Is comfort achieved in occupied spaces without air conditioning?	
13	Solar gain	Has solar gain been used to warm the building in winter?	
14	Leakage	Are leakage rates through the building envelope lower that that required by SANS 202?	
15	Insulation	Are insulation levels at least at the levels required by SANS 204?	
16	Cross ventilation	Is the width of the building depth less than 20m and are there direct routes less than 25m in length for natural airflow across the building?	
17	Windows	Have windows been designed and located to promote comfortable natural ventilation?	
18	Lighting	Have energy efficient lighting such as CFLs been used?	
19	Movement sensors	Have movement sensors been linked lighting, such as security lighting?	
20	External lighting	Are all external lights on daylight switches?	

21	Appliances	Have energy efficient appliances been specified?	
22	Water heating	Is solar heated water used for all washing requirements?	
23	Pipe runs	Have pipe runs between water heating and usage areas been minimized?	
24	Insulation	Are insulation levels in line with SANS 204?	
25	Water efficient fittings	Have water efficient showerheads and taps been used? Have baths been avoided, where possible?	
26	Swimming pools	Have swimming pools and Jacuzzis been avoided?	
27	Electricity meters	Are these located where it can be easily monitored?	

15.3 Benchmarks

15.3.1 Artificial lighting

SANS 204 provides the following recommended good practice maximum values for lighting in different spaces within buildings. Designers should therefore ensure that lighting levels do not exceed those outlined below, but at the same time, do not go below the minimum requirements of the Occupational Health and Safety Act. Therefore, for instance, lighting levels in an office would be expected to be somewhere between 300 and 500 lux, depending on the specific requirements of the activities in that office.

Class of Building	Occupancy	Maximum values lux
A1	Entertainment & Public assembly	50
A2	Theatrical & indoor sport	50
A3	Places of instruction	100
A4	Worship	100
A5	Outdoor sport is viewed	100
B1	High risk commercial	700
B2	Moderate risk commercial	500
B3	Low risk commercial	300
C1	Exhibition Halls	300
C2	Museums	100
D1	High risk industrial	700
D2	Moderate risk industrial	500
D3	Low risk industrial	300
D4	Plant rooms	100
E1	Places of detention	300
E2	Hospitals	200
E3	Other institutional residences	200
F1	Large shops	700
F2	Small shops	500
F3	Wholesaler's store	300
G1	Offices	500
H1	Hotels	200
H2	Dormitories	100
H3	Domestic residences	100
H4	Dwelling houses	100
J1	High risk storage	500
J2	Moderate risk storage	300
J3	Low risk storage	150
J4	Parking areas covered	100

Table 14. Maximum lux values for different building types (SANS 204)

15.3.2 Maximum energy demand

SANS 204 provides the following recommended maximum energy demand levels for different building occupancy types.

Occupancy or building	Description	Maximum energy demand VA/m^2
A1	Entertainment and public assembly	85
A2	Theatrical and indoor sport	85
A3	Places of instruction	80
A4	Worship	80
F1	Large shop (including shopping malls)	90
G1	Offices	80
H1	Hotel	90
The maximum demand shall be based on the sum of 12 consecutive monthly maximum demand values per area, divided by twelve.		

Table 15 Maximum energy demand per building classification (SANS 204)

15.3.3 Maximum energy consumption in buildings with artificial environmental control

SANS 204 provides the following recommended maximum energy consumption levels for buildings with artificial environmental control.

Occupancy or building	Description	Maximum energy consumption kWh/m^{2}pa
A1	Entertainment and public assembly	420
A2	Theatrical and indoor sport	420
A3	Places of instruction	420
A4	Worship	120
F1	Large shop (including shopping malls)	240
G1	Offices	200
H1	Hotel	650
The annual consumption per m^2 shall be based on the sum of 12 months monthly consumption of consecutive months. Non electrical consumption, such as fossil fuels shall be accounted for on a thermal equivalence basis, i.e. convert MJ to KWH		

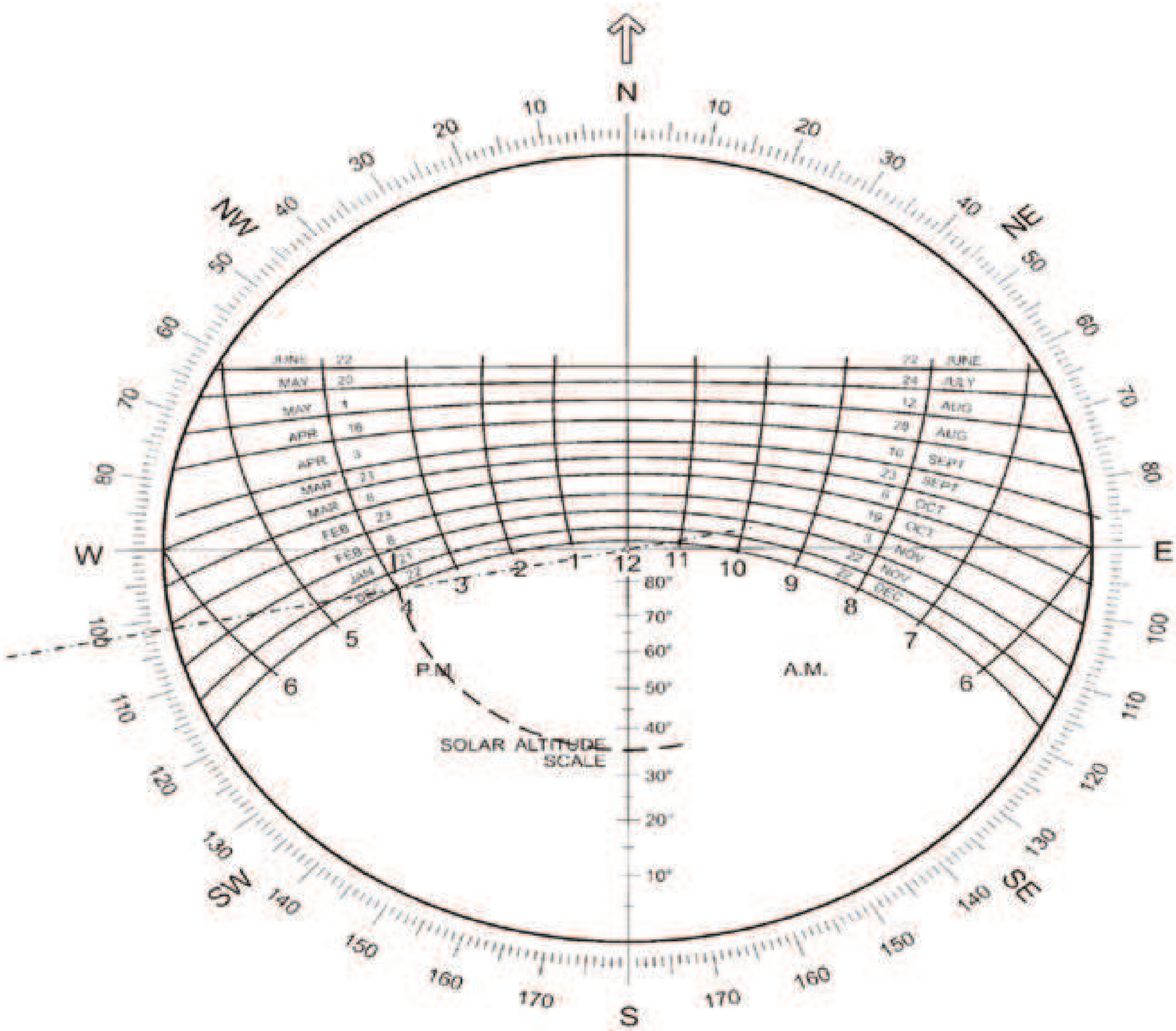
Table 16. Maximum annual consumption per building classification for cold interior climate for artificially ventilated buildings (SANS 204)

15.3.4 Notional energy usage intensity requirements for buildings with natural environmental control requirements for buildings

Occupancy or building	Notional energy usage intensity requirements (kwh/m2.A)
Office	171
Retail	152
Clinic	211
School	209
Residential	210
Category 1 House	298

Table 17.Notional energy usage intensity requirements (kWh/m2.a) for naturally ventilated buildings (SANS 204)

15.4 Solar chart for latitude 260^0 south



Latitude 26° south

15.5 Acronyms

CAD	Computer Aided Design
DME	Department of Minerals and Energy
GRI	Global Reporting Initiative
IEQ	Indoor Environmental Quality
SANS	South African National Standard
SABS	South African Bureau of Standards
WC	Water Closet (toilet)

15.6 Definitions

Air conditioning: A system or unit installed in a building to control the temperature and humidity of the air by heating or cooling. Systems may range from a simple package unit installed in the wall of a dwelling, through to a complex integrated system made up of a number of distinct subsystem and components, as found in plant rooms or on the roofs of buildings.

Envelope: The external elements of the building, that is walls, windows, roofs and so on.

Embodied energy: The total energy used to create, use and dispose of a product including all the processes involved in harvesting, production, transportation, construction, use and disposal or re-use. This can represent a significant portion of the total energy used during the lifecycle of a building.

Glazing: Windows, glazed doors or other transparent and translucent elements including their frames (such as glass bricks, glazed doors, etc) located in the building fabric.

Greenhouse gases: Gases that affect the temperature of the earth's surface. They include water vapour, tropospheric ozone, chlorofluorocarbons, carbon dioxide, methane and nitrous oxides. The last three gases are of particular concern because they take a long time to remove from the atmosphere.

Rational assessment: Assessment by a competent person of the adequacy of the performance of a solution in relation to requirements by a process of reasoning, calculation and consideration of accepted engineering principles, based on a combination of deductions from available information, research and data, appropriate testing and service experience

Rational design: Any design by a competent person involving a process of reasoning and calculation and may include any such design based on the use of a code of practice or other relevant technical document

Illumination power density: The total amount of that which will be consumed by the lighting systems in a space and it includes the lamps, ballast, current regulators and control devices. The total is arrived at by adding the energy used and then dividing it by the floor area of the room.

Infiltration: Uncontrolled air leakage at a relatively low flow rate due to an imperfectly sealed building. It is affected by the quality of sealing of specific openings such as windows and doors and less obvious openings such as exhaust fans, range hoods, light fittings and chimneys.

Insulation: Material that resists heat flow. Insulation of the building envelope helps keep heat in during the winter and out during summer to improve comfort and save energy. A well insulated and well designed home or building will provide year-round comfort, cutting cooling and heating costs and reducing greenhouse emissions. Resistance to heat flow is achieved by the use of either bulk insulation or reflective insulation, which work in different ways. Insulation of the building envelope helps keep heat in during the winter, but allows heat out during summer to improve comfort and save energy.

Light source efficacy: The energy efficiency of a lighting device. The effectiveness of the lighting device is measured by the amount of lux (illumination measured as lumens per unit area) on the task divided by the electrical power that will be used by the lamp (in watts). In regards to the interpretation of the values, the higher the rating, the more efficient the light source.

Lumens (lm): The units for luminous flux (the light emitted from the light source or luminaire). In regards to the numbering system, the higher the lumen value the brighter the light. The lumen value is obtainable from the manufacturer and may be described as the "lm" value in lighting product literature.

Outdoor air economy cycle: An outdoor air economy cycle is a mode of an air-conditioning system that, when the outside air properties are favourable, increase the quantity of outside air used to condition the space. It is often referred to as "free cooling" and occurs when the climate is suitable such as the autumn and spring or in the early morning in the summer in temperate climates.

Passive design: A design that does not require mechanical heating or cooling for example buildings that are designed to take advantage of natural energy flows to maintain thermal comfort.

R-Value: The measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e. the thermal resistance (m2.K/W) of a component calculated by dividing its thickness by its thermal conductivity.

Shading coefficient: A measure of the solar gain performance of windows. It is the ratio of the solar energy transmitted and convected by the window to the solar energy transmitted and convected by clear 3 mm glass.

Solar access: The amount of useful sunshine reaching the habitable areas of a building.

Solar Heat Gain Coefficient (SHGC): A measure of the amount of solar radiation (heat) passing through the entire window, including the frame. SHGC is expressed as a number between 0 and 1.0. The lower the SHGC the better.

Thermal mass: A term to describe the ability of building materials to store heat . Building materials that are heavy weight store a lot of heat so are said to have high thermal mass. Materials that are lightweight do not store much heat and have a low thermal mass.

Thermal resistance: The resistance to heat transfer across a material. Thermal resistance is measured as an R-Value. The higher the R-Value, the better the ability of the material to resist heat flow.

Total R-Value: The sum of the R-Values of the individual component layers in a composite element including the air space and associated surface resistances, as per an Internationally recognized test or calculation method.

Total U-Value: The thermal transmittance (W/m2.K) of the composite element including the air space and associated surface transmittance.

U-value: Used to measure the rate of heat transfer through a building element, the length larger than its thickness (for example, a wall). Expressed in W/m2.K. U-values the other surface. Lower values indicate higher resistance to heat flow.

Ventilation opening: An opening in the external wall, floor or roof of a building designed to allow air movement into or out of the building by natural means including a permanent opening, an openable part of a window, a door or other device which can be held open.

Visible transmittance (VT) : The amount of visible light that comes through a window. Visible transmittance is expressed as a number between 0 and 1.0. The higher the number, the more light is transmitted and the better the VT.

Watt (W): The determined metric or SI (international system of measuring units) value for energy loads and is used to rate electrical motors, appliances, lights etc. and in expressing energy loads and energy consumption.

15.7 Useful links

www.cef.co.za	Central Energy Fund
www. dme.gov.za	Department of Minerals and Energy
www.eskom.co.za	Eskom
www.joburg.co.za	City of Joburg
www.sabs.gov.za	South African Bureau of Standards
www.weathersa.co.za	South African Weather Service

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ANNEXURE “A”

Policy for the Promotion of Energy Efficiency in Land Use Development

Version: E   Date: 1.02.2009

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POLICY FOR THE PROMOTION OF ENERGY EFFICIENCY IN LAND USE DEVELOPMENT

Table of Contents

POLICY FOR THE PROMOTION OF ENERGY EFFICIENCY IN LAND USE DEVELOPMENT

1 Introduction

This Policy has been developed to support more energy efficient development within the City of Johannesburg. It describes why energy use in cities and buildings is important and provides policy guidelines that can be used to ensure that development and land use become more energy efficient over time.

The policy should be read in conjunction with the **Criteria and Benchmarks for Energy Efficient Development** and the associated manual**.** This provides quantified criteria and benchmarks that can be used to guide and assess energy performance of different development and land use proposals.

1.1 Reinforcing current sustainability frameworks

The Policy aims to reinforce the sustainability objectives set out in the City of Johannesburg's Strategic Plans. In particular, it reinforces the following strategic objectives set out in the Draft Spatial Development Framework 2008-09:

- Determine priority areas for short-medium term investment and allocation of future development rights;
- Re-direct the respective capital investment programmes of the City's service providers to address the short-term hotspots and strategic priority areas;
- Limit future development rights in infrastructure hotspots within the City until backlogs have been addressed;
- Identify priority investment areas for public and private sectors, specifically in respect of municipal infrastructure;
- Introduce development conditions that are congruent with global best-practice standards relating to resource efficiency (energy, water, fuel);
- Introduce development obligations relating to the full spectrum of Inclusionary Housing (i.e. subsidized housing, bonded, rental / social
- housing) in identified priority areas;
- Apply a package of incentives to promote and facilitate development that subscribes to the socio-economic and spatial imperatives of the City;
- Establish monitoring and evaluation mechanisms to review the status of the infrastructure hotspots and the limitations placed on these areas.

1.2 Using the policy, criteria and benchmarks

The Policy is intended for use by City of Johannesburg officials and aims to enable them to develop a cohesive approach on energy efficiency in land use planning and management. It provides arguments, criteria and benchmarks that can be used to structure engagement with developers and other role players to ensure that energy efficiency is addressed effectively.

The policy and criteria can also be used as an input to city planning and development frameworks such as the Spatial Development Framework (SDF) by providing quantifiable measures that can be used to test different options and define optimum solutions.

2 The need for more energy efficient cities

There are many compelling reasons why cities should become more energy efficient. Key issues include global warming, increasing energy costs and social inequity. These are outlined in more detail below.

2.1 Global warming

Even though cities are a small proportion of the earth's surface, they accommodate 50% of the world's population, consume 75% of the world's energy and produce 80% of world's greenhouse gas emissions (Clinton Climate Initiative 2008). The accumulation of greenhouse gases in the upper atmosphere is leading to global warming and temperatures are predicted to increase by 2 - 6^{O}C by the end of the century (International Panel on Climate Change 2007).

Local estimates for the City of Johannesburg indicate that temperatures may increase between 2 and 3.5°C in the short term (Hewitson, Engelbrecht, Tadross, Jack, 2005). Global warming and increasing temperatures lead to reductions in agricultural yield, erratic and extreme weather events, rising sea levels and species extinctions.

Within Africa, South Africa produces the highest CO2 emissions and has one of the highest CO2 emissions per GDP in the world. In 2002, carbon emissions per capita in South Africa were 8.4tonnes/capita - higher than Western European averages of 7.9tonnes/capita (SEA 2006).

Developing more energy efficient cities will help reduce global warming. As over 50% of South Africa's population now live in cities, investment in more energy efficient cities can be used to make a substantial impact in reducing carbon emissions.

2.2 Energy

Eskom has been unable to develop its generating capacity at the same rate at which development has occurred in South Africa. This will lead to load shedding and power cuts until at least 2014. The cost of electricity is also set to double in the short term.

Predictions suggest that global oil production will peak in 2011 and, if demand continues unabated, will be depleted by 2030 (Davenport 2008). The cost of fuel is forecast to increase rapidly and oil may exceed $200/barrel (resulting in the cost of a litre of diesel being around R12/litre) in the short term. (Davie 2008).

More energy cities and built environments cushion the impact of increased energy costs on companies and households. Cities and buildings that reduce their reliance on non-renewable energy sources are also more resilient and able to weather the impact of high prices and depleting resources.

2.3 Social equity

Energy inefficient cities tend to reinforce social inequality. In South Africa apartheid planning and land costs have meant that many poorer communities live at the periphery of cities, some distance away from economic opportunities and social services. These locations result in significant travel costs which can be ill afforded by many poorer households living in South African cities.

Cities designed to enable people to access work and services locally, free time and resources that can be spent on improved education, health and housing. This not only helps reduce inequity but also contributes, at a macro level, to social cohesion and economic competitivity.

3 Energy consumption in the built environment

In South African metropolitan areas most energy is consumed by transport (56%), followed by industry and manufacturing (14%), residential (13%) and commercial (3%) (SEA 2006). Patterns of carbon emissions are however different and although coal fired electricity only accounts for 32% of energy consumption within cities this is responsible for 66% of carbon dioxide emissions, followed by petrol and diesel use (18%) and coal use (10%) (SEA 2006).

South African buildings, which rely heavily on electricity, therefore make a substantial contribution to carbon emissions. The International Energy Agency calculates that the public and commercial sector contributes 14 % to total carbon emissions in South Africa, with most this from buildings. Buildings not only contribute to carbon emissions as a result of consuming energy in operations, they also affect the amount of energy consumed in transportation and services. This is illustrated in the diagram below.

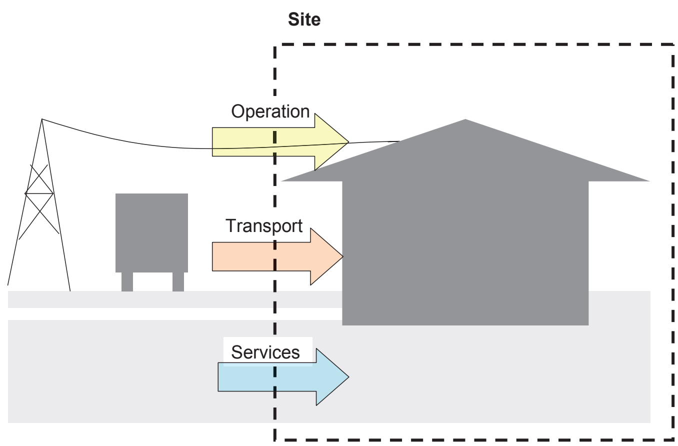

Figure 1. Energy consumption in and around buildings in South African cities

3.1 Building operation

Buildings consume energy in lighting, heating, cooling and ventilating buildings. Energy is also consumed running equipment and vertical transportation such as lifts. Many large buildings in the City of Johannesburg are deep plan and have large internal spaces that require constant artificial lighting. Others incur substantial heat gains through glazed facades and from internal heating loads and require substantial mechanical plant to maintain comfort.

Research indicates that there is a strong relationship between built form and energy consumption. Deep plan buildings generally require more energy to light and ventilate relative to narrow plan buildings (Steemers 2003). Similarly, significant energy savings can be accrued by increasing densities and apartment buildings can have up to a 50% reduction in heat losses through the building envelopes per unit relative to freestanding houses (Steemers 2003).

Buildings and urban form can be designed to work with topography, landscaping and climate and provide comfortable and productive environments that require little energy to operate. Aspects include built form and orientation that maximise natural day lighting and beneficial shading and solar access. It includes landscaping and building envelope design that work with local microclimates to promote cooling and ventilation by directing breezes and airflow along streets and through buildings.

3.2 Transportation

Energy is expended moving people and goods around cities. This includes energy consumed by commuter buses and trains getting people to and from work and energy expended in delivering products used in buildings such as food, paper and equipment.

City planning can be used to reduce transport energy by promoting more compact development and locating work, education, retail, leisure and public transport closer to residential areas in order to minimise the requirement for car travel. Dense cities with good public transport systems such as Hong Kong, for instance, use 10% of the transport energy used by sprawling American cities such as Houston (Newman and Kenworthy 1989).

3.3 Services

Energy is also consumed to provide services required in buildings. Energy and extensive infrastructure is required to pump, treat and distribute potable water to buildings. Similarly extensive infrastructure is required to remove sewage and treat this. Buildings also generate large amounts of solid waste which require energy for collection and disposal.

Grey water systems and water efficient devices can be used to reduce potable water consumption in buildings by up to 30%. Johannesburg has an annual rainfall of 600mm, which, combined with suitable roofs and tanks could enable many buildings to be effectively self-sufficient for water. This would reduce energy and infrastructure requirements used in mains potable water systems.

Levels of energy consumption and greenhouse gas emissions used in the provision of services such as waste collection, water, and electricity vary between South African municipalities, with the City of Johannesburg producing 103kg of CO_2 per capita, compared with eThekweni’s figure of 76kg and Cape Town’s figure of 98kg (SEA 2006). The variation suggests that improvements are possible and that it may be useful for municipalities to share best practices in this area.

4 Policy

4.1 Introduction

This section provides an outline policy for new developments to ensure these support energy efficiency. More detailed information is provided in the **Criteria and Benchmarks for Energy Efficient Development Document** and the associated manual**.**

4.2 Energy consumption

New developments within the City of Johannesburg should be energy efficient. In particular, energy consumption levels should not exceed good practice benchmarks and should align with guidance as set out in SANS 204.

4.3 Maximum energy demand

To reduce the requirement for additional generation capacity new developments within the City of Johannesburg should minimise peak energy demand and align with guidance set out in SANS 204. Strategies that can be used to reduce peak demand include thermal storage and onsite renewable energy generation.

4.4 Renewable energy sources

New developments within the City of Johannesburg should make use of renewable energy to reduce carbon emissions and mains power requirements. Strategies followed could include photovoltaic panels, solar thermal systems and wind power.

4.5 Urban heat island

To reduce the urban heat island and increased inner city temperatures, new developments within the City of Johannesburg should avoid using materials with high absorptance values for roofs and external hard surfaces. Lighter coloured materials and materials with low absorptance values should be used and large areas of external parking should be shaded.

4.6 Orientation

Optimum orientation should be sought for all new buildings developed in the City of Johannesburg in order to minimise heating and cooling energy requirements. Town planning schemes and site layouts should ensure that buildings can be correctly orientated.

4.7 Building form

New developments should support energy efficiency by ensuring that buildings can be naturally lit and ventilated. This should be achieved through avoiding deep plan buildings and careful design of the building envelope.

4.8 Ventilation

Natural ventilation should be used, or possible in all new buildings developed within the City of Johannesburg. This can be achieved through passive environmental control strategies such as use of the stack effect and cross ventilation. Minimum opening areas in the building envelope as defined by good practice guidance and SANS 204 must be complied with.

4.9 Daylight

Day lighting should be used in all new buildings to minimise the requirement for artificial lighting. Deep building plans and careful building envelope design should be used to ensure even and glare-free day lighting within buildings.

4.10 External lighting power density

Over-lighting external spaces and facades should be avoided and controls should be in place to ensure external lighting is switched off when not needed.

4.11 Water heating

Solar water heating is a highly efficient and renewable means of heating water. All new development requiring hot water should use solar water heaters rather than conventional electrical geysers. Where solar water heating is not possible because of over shading or building heights other energy efficient means of heating water such as heat pumps should be used.

4.12 Public transport

Public transport is far more energy efficient than conventional car use. New development should therefore be located close to public transport nodes and provide easy and safe access to this.

4.13 Urban Development boundary

New developments should not be created near or outside the urban development boundaries of the City of Johannesburg. This helps to avoid urban sprawl and ensure that existing service and transport infrastructure is used efficiently.

4.14 High priority areas

New developments should be encouraged in areas identified for development in the City's Spatial Development Framework (SDF). Developments in these areas should carefully consider the development objectives of the local area and seek to support these.

4.15 Density

Increased urban densities help to reduce transportation requirements. New developments should therefore achieve at least the minimum development densities stipulated by the City of Johannesburg.

4.16 Parking

To encourage use of public transport and discourage car use, new development should limit car parking provision to the minimum requirements set by the City of Johannesburg. Instead, developers should encourage walking, cycling and use of public transportation.

4.17 Pedestrians

New developments should support pedestrian movement through provision of comfortable and safe routes around sites and to the main entrances of buildings on sites.

4.18 Local facilities

In order to minimise the requirement for car trips, new developments should be located near facilities such as banks, post offices, shops and restaurants that are used by occupants on a regular basis. If these facilities are not located close to the development, these facilities should be included in the development.

4.19 Cycling

Cycling should be supported in new developments. This should be done through the provision of dedicated cycle lanes and paths around, and on sites. Secure and convenient parking, showers and lockers should also be provided.

4.20 Recycling

To reduce landfill and related transportation impacts new developments should support recycling. This should be done through the provision of adequately sized and conveniently located recycling areas. In addition, agreements should be entered into with local recyclers to ensure systems are maintained and effective.

4.21 Run off

Increased storm water runoff from sites should be avoided to reduce the infrastructure and energy requirements of urban storm water management systems. Runoff from roofs and hard surfaces should be harvested, or allowed to replenish groundwater. Mechanisms used could include rain water harvesting systems, retention ponds and sustainable urban drainage systems (SUDS) features such as swales.

4.22 Rain water harvesting

To reduce the energy and infrastructural requirements for mains potable water supplies, new developments should harvest rainwater. Rainwater can be used to flush toilets and for irrigation reducing the amount of mains potable water required. Large rain water tanks also have the advantage of provided a back-up supply for fire fighting and in case of mains water supply interruptions.

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ANNEXURE “B”

Manual on the Criteria for the Promotion of Energy Efficiency in Land Use Development

Date: 14.12.2008

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It is likely that this document will be updated and improved over time. Should you have any suggestions please email these to Richard Holden at RichardH@joburg.org.za

Disclaimer
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MANUAL ON THE CRITERIA FOR THE PROMOTION OF ENERGY EFFICIENCY IN LAND USE DEVELOPMENT

Table of Contents

1 Introduction

This manual is designed to accompany the **Criteria for Promotion of Energy Efficiency in Land Use Development** and provides greater detail on the criteria listed in this document. Criteria descriptions in the manual have the following format:

- **Objective:** This sets out the objective of the criteria
- **Rationale:** This explains the need, or basis, for the criteria
- **Criteria:** This outlines the criteria. X represents a variable which depends on the building type.
- **Protocol:** This outlines how performance should be measured in ascertaining whether a criterion has been achieved.
- **Additional information:** This provides additional information that can be referred to for more detail.

2 Energy consumption

Objective

- To minimise mains energy consumption in new developments

Rationale

Annual energy consumption in kWhrs/m2pa represents the amount of energy used per m2 of a building over a year. This is an effective measure of energy consumption that enables comparisons between, and across building types and is used in SANS 204 on Energy Efficiency in Buildings.

Criteria

- Annual mains electricity consumption will be less than X kWhrs/m2.pa.

Protocol

To ascertain compliance, calculation should be carried out to establish annual energy consumption per m2 for the development. Calculations should be carried out in accordance with SANS 204.

Additional information

SANS 204 Energy Efficiency in Buildings

3 Maximum energy demand

Objective

- To minimise peak energy demand

Rationale

Minimising peak energy demand will help reduce the requirement for additional electricity generation capacity by reducing peaks and spreading demand more evenly over a 24hour period.

Criteria

- Maximum energy demand will be less than X VA/m2.

Protocol

To ascertain compliance, calculation should be carried out to establish peak energy demand per m2 for the development. Calculations should be carried out in accordance with SANS 204.

Additional information

SANS 204 Energy Efficiency in Buildings

4 Energy sources

Objective

- To maximise onsite energy generation from renewable sources

Rationale
In general, buildings in South African are highly reliant on electricity generated in coal fired power stations. This process results in very high levels of CO2 emissions. Using cleaner sources of energy such as natural gas can substantially reduce carbon emissions. Gas can be easily obtained in bottled form and in a number areas of Johannesburg piped supplies can be provided.

Criteria
- Cleaner energy sources of energy are used where possible, for instance gas is used for cooking.

Protocol
Developments should demonstrate how they are using cleaner energy supplies, such as gas, for functions such as cooking, where this can be readily used.

Additional information
City of Johannesburg, www.joburg.org.za/content/view/36/66/
Egoli gas, www.egoligas.co.za/

5 Renewable energy sources

Objective
- To maximise onsite energy generation from renewable sources

Rationale
Most electricity in South Africa is generated in coal fired power stations. This process consumes large amounts of water, incurs transmission losses and leads to very high levels of CO2 emission per kW generated. Generating electricity onsite using photovoltaic panels or wind power consumes no water, has very low transmission losses and does not produce any CO2 emissions.

Criteria
- 10% of annual energy consumption energy will be sourced from renewable sources.

Protocol
To establish compliance total renewable production should be calculated as a % of total energy consumption

$$\text{\% Renewable energy consumption} = \frac{\text{Total renewable energy produced (kWhrs/year)}}{\text{Total energy consumption (kWhrs/year)}} \times 100$$

Additional information
Sustainable Energy of Southern Africa, www.sessa.org.za

6 Urban heat island

Objective
- To minimise urban temperature increases as a result of the urban heat island effect.

Rationale
Cities have been shown to be significantly warmer than the surrounding countryside. This is called the urban heat island effect and is a result of heat being absorbed in cities and not readily dissipated. Key contributors to this effect are large dark coloured external car parking areas and roofs which absorb and retain heat from the sun. Higher temperatures result in increased cooling loads and therefore greater energy consumption. Avoiding large dark roofs and car parking areas helps to keep cities cooler and therefore reduces energy requirements for cooling.

Criteria
- Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.

Protocol

To establish compliance ensure that materials used for roofs and car parking have an absorptance value of less than 0.5. Absorptance values of common colours are provided below.

Colour	Value
Slate (dark grey)	0.9
Red, green	0.75
Yellow, buff	0.6
Zinc aluminium—dull	0.55
Galvanised steel—dull	0.55
Light grey	0.45
Off white	0.35
Light cream	0.3

Additional information
SANS 204 Energy Efficiency in Buildings

7 Orientation

Objective

- To ensure that building orientation supports reduced heating and cooling and lighting loads.

Rationale
Correctly orientated buildings can reduce energy consumption for heating, cooling and lighting by up to 30%. In particular, large west facing facades, particularly those with glazing, can result in high levels of unwanted heat gain being experienced in buildings. These can often only be dealt with through mechanical cooling, resulting in increased energy consumption and accentuated peak energy demands.

Criteria

- Buildings are orientated within 15 degrees of North

Protocol
To establish compliance site development plans should indicate building outlines showing their orientation relative to North. Where there is deviation from North, the angle(s) of deviation should be provided.

Additional information
SANS 204 Energy Efficiency in Buildings

8 Building form

Objective

- To ensure that building forms support natural ventilation and lighting.

Rationale
Research indicates that there is a strong relationship between built form and energy consumption. In particular, deep plan buildings have been shown to generally require more energy to light and ventilate as indicated in the figure below.

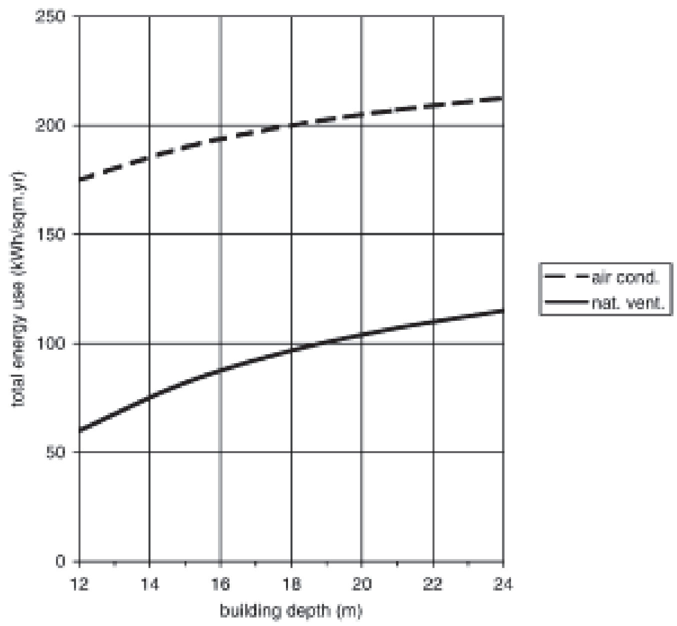

Figure 1: Building depth to total energy use (Steemers 2003)

Criteria

- Building depth does not exceed 15 m

Protocol

To establish compliance, floor plans of all buildings in the development should be provided showing key floor plate dimensions.

Additional information

SANS 204 Energy Efficiency in Building

9 Ventilation

Objective

- To ensure that buildings can be naturally ventilated.

Rationale

In most buildings natural ventilation can be used to meet legislated ventilation requirements. Natural ventilation has a range of benefits. Ventilation achieved through cross ventilation or the stack effect requires little or no energy and is therefore very energy efficient. Controls for opening windows can be located near occupied spaces and designed to provide users with high levels of control over their thermal environments. Natural ventilation consists of 100% fresh air without a recirculated component. Increasing levels of fresh air supply have been shown to improve productivity and health.

Criteria

- Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.

Protocol

To ascertain compliance a schedule of opening areas and associated floor areas for all buildings should be provided, with the relevant percentages indicated.

Additional information

SANS 10400

10 Daylight

Objective

- To maximise the use of natural daylight in buildings

Rationale
Buildings with narrow floor plates and well designed building envelopes can make use of natural light to light interiors for most of the day. This avoids the need for artificial lighting and associated energy consumption and heat gains.

Criteria
- All occupied areas within dwellings have an average daylight factor of at least 2.5%.

Protocol
Compliance can be established through modelling. Alternatively, indicative compliance can be established by using the rule of thumb that states that good day lighting will be achieved on a working plane that is within 2H of a window, where H is the height of the head of the window adjacent to working surfaces.

Additional information

11 External lighting power density

Objective
- To minimise energy consumption in external lighting

Rationale
Many sites have extensive external lighting that is switched on throughout the night. Careful design can be used to reduce the amount of lighting required on site. External lighting can also be linked to controls such as timers and movement sensors to reduce the duration that lighting is on. These strategies enable significant energy savings to be achieved.

Criteria
- External lighting power requirements do not exceed XW per m2 of internal area and are linked to daylight sensors, motion sensors or timers.

Protocol
To establish compliance the number of the number of lights should be multiplied by their wattage to achieve an overall wattage for external lighting. This should be divided by the internal area of the building to get a XW per m2, which can be compared to the benchmark.

Additional information

12 Water heating

Objective
- To maximise the use of solar power or energy efficient methods for heating water.

Rationale
It is estimated that electrical geysers are responsible for 40% of energy consumed in conventional South African households. South Africa has some of the best quality sunlight in the world and for most of the year water can be easily and efficiently heated using solar power. Solar water heaters therefore not only significantly reduce energy consumption, they also use renewable energy and therefore have no carbon emissions.

Criteria
- All water heating requirements will be met through solar water heating.

Protocol
To establish compliance water heating requirements should be met using solar power.

Additional information
Sustainable Energy of Southern Africa, www.sessa.org.za

13 Public transport

Objective

- To maximise the use of public transport

Rationale

Public transport is much more energy efficient than using private cars. As indicated below, using a train can be 18 times more efficient than using a car.

Type of transport	Litres of fuel, *or energy equivalent*, consumed per person to travel 100 km
Car (single occupant)	9.00
Car (2 occupants)	4.50
Taxi (12 passengers)	1.00
Bus	0.70
Train	0.50
Walking	1.00
Cycling	0.36

Table 1. Energy consumed per kilometre for different types of transportation

Criteria

- All dwellings area located within 1km of a public transport node

Protocol

To establish compliance distances from a train station, bus stop and regularly used taxi stops to the main entrance of buildings should be measured and indicated on site plans. Distances measured should follow actual routes walked and should not be 'ás the crow flies'.

Additional information

14 Urban Development boundary

Objective

- To avoid development outside or near the periphery of urban areas

Rationale

The urban centres are generally have good public transport, economic opportunities and services such as education and health. Towards the periphery of cities these services are less available forcing people to travel further to access these. New development at the urban periphery also uses up valuable agricultural land and natural vegetation and requires new water, sewage and transport infrastructure, all of which requires additional energy to develop and maintain.

Criteria

- The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).
-

Protocol

To establish compliance the site should be located on a map indicating its relationship to the urban development boundary.

Additional information

City of Johannesburg Spatial Development Framework, www.joburg.org.za/content/view/502/129/

15 High priority areas

Objective

- To support the development of high priority areas as identified by the City of Johannesburg

Rationale
Through the policy and planning instruments the City of Johannesburg may identify areas that would benefit from development. This may be done to use existing or newly developed infrastructure and public transport more efficiently or to create local employment and beneficial relationships between related land uses. Supporting these initiatives can reduce energy consumption by ensuring that infrastructure is used efficiently and energy transportation reduced.

Criteria
- The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).

Protocol
To establish compliance new developments should be located on plans which indicate their relationship to high priority areas as identified by the City of Johannesburg.

Additional information
City of Johannesburg Spatial Development Framework, www.joburg.org.za/content/view/502/129/

16 Density

Objective
- To maximise optimise urban densities

Rationale

There is a clear relationship between urban density and energy consumed in transportation. Dense cities such as Hong Kong use 15 times less transport energy compared to sprawling cities such as Houston in the USA. This relationship is indicated in the graph below.

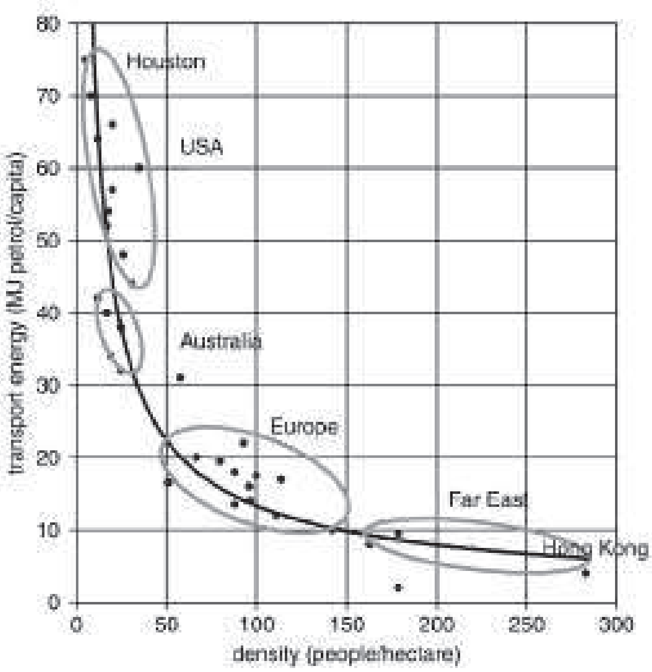

Figure 2: Energy consumption and urban density (Baker and Steemers 2000)

Criteria
- The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).

Protocol

To establish compliance densities of new developments should be indicated in relation to densities as outlined in relevant City of Johannesburg policy and planning instruments.

Additional information
City of Johannesburg Spatial Development Framework, www.joburg.org.za/content/view/502/129/

17 Parking

Objective

- To discourage the use of private vehicles

Rationale
Private vehicle use is far less energy efficient than public transport or walking and cycling. Cars also take up large amounts of space in parking areas which often have to be artificially lit and mechanically ventilated. Avoiding or reducing private car use and its associated impacts can result in significant energy savings.

Criteria

- Parking provision does not exceed City's requirements by more than 10%..

Protocol
To establish compliance new developments should indicate parking provision in relation to the City of Johannesburg requirements.

Additional information
City of Joburg, www,joburg.org.za

18 Pedestrians

Objective

- To encourage walking

Rationale
Walking is the second most energy efficient form of transport after cycling. Encouraging walking not only helps to reduce energy consumption and pollution it also has health and social benefits such as increased social cohesion.

Criteria

- Dedicated pedestrian routes from public highways and public transport to the main entrances of all buildings with safe road crossing points are provided.

Protocol
To establish compliance new developments should indicate pedestrian routes from surrounding areas and public transport nodes to main entrances of buildings. Routes must comply with SANS 1024 and be physically separated from roads. Safe crossing points must be provided wherever routes cross roads.

Additional information
SANS 10246

19 Local facilities

Objective

- To encourage the development of local facilities

Rationale
Many car journeys are generated by people undertaking daily tasks such as shopping for food, going to the bank or post office, dropping children off at school and going to a restaurant for lunch. These trips and the energy consumed by them can be avoided by enabling people to walk to regularly used facilities.

Criteria

- Access to the following facilities are provided within 400m: playground/park, crèche, primary school and within 2km of the site: bank/bank ATM, post office, convenience store/supermarket and secondary school.

Protocol

To establish compliance the above facilities (ie primary school, post office etc) should be located on a plan with distances to the development indicated. Distances should be measured along actual routes used and not 'as the crow flies'.

Additional information

20 Cycling

Objective

- To encourage cycling

Rationale

Cycling is the most energy efficient form of transport and is up to 18 times more energy efficient than using a car. Bicycles also use less space to park and have been shown to support health and productivity.

Criteria

- Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.

Protocol

To establish compliance cycle routes should be indicated on plans showing how a cyclist can safely access buildings from local public highways. Routes should be indicated showing how these comply with good practice design standards.

Additional information

21 Recycling

Objective

- To encourage recycling

Rationale

Currently most solid waste in South Africa ends up in landfill sites. This takes up valuable land and requires energy to transport and compact waste. Recycling reduces landfill requirements. It alsohas the added advantage of reducing energy consumption in the development of new products as recycled content materials generally consume far less energy in production compared to products made from virgin materials (where large amounts of energy is usually required to to mine, process and transport materials).

Criteria

- A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.

Protocol

To establish compliance the total internal area of developments should be calculated and indicated. The total area of recycling areas should also be calculated and indicated. The recycling area should then be divided by the total internal area to establish the percentage area.

Additional information

Pikitup, www.pikitup.co.za
City of Joburg, www.joburg.org.za/content/view/725/66/

22 Run off

Objective

- To minimise increased runoff

Rationale

Urban areas, with large areas of impermeable surfaces can generate very large volumes of runoff after rainstorms. This requires large storm water infrastructure to manage and treat. Reducing

Criteria

- The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.

Protocol

To establish compliance the current volume of runoff generated by the site should be calculated. The predicted volume of runoff from the new proposed development should also be calculated. These two figures should then be compared.

Additional information

Sustainable Urban Drainage Systems, www.ciria.org/suds/index.html

23 Rain water harvesting

Objective

- To maximise rainwater harvesting

Rationale

Most of Johannesburg's water supply has to be pumped large distances, from areas such as the Katse dam in Lesotho. Extensive infrastructure is also required to treat and distribute water to buildings. This system requires energy to maintain, it also experience high levels of leakage resulting large volumes of water being wasted. Harvesting rainwater on site reduces the requirement for mains potable water with its associated energy requirements. It also provides a useful back-up supply for fire fighting and in case of mains water supply interruptions.

Criteria

- Onsite rainwater harvesting capacity equivalent to XL/m2 is provided and linked to toilets / irrigation system / other large water consumption area.

Protocol

To establish compliance total internal area should be calculated. Total volume of rainwater tanks should also be calculated. The volume of rainwater tanks should then divided by the total internal area to provide a L/m2 figure which can be compared to the criteria.

Additional information

Department of Water Affairs, www.dwaf.gov.za
Rand water, www.randwater.co.za

24 Definitions

Air conditioning: A system or unit installed in a building to control the temperature and humidity of the air by heating or cooling. Systems may range from a simple package unit installed in the wall of a dwelling, through to a complex integrated system made up of a number of distinct subsystem and components, as found in plant rooms or on the roofs of buildings

Envelope: The external elements of the building, that is walls, windows, roofs and so on.

Embodied energy: The total energy used to create, use and dispose of a product including all the processes involved in harvesting, production, transportation, construction, use and disposal or re-use. This can represent a significant portion of the total energy used during the lifecycle of a building.

Glazing: Windows, glazed doors or other transparent and translucent elements including their frames (such as glass bricks, glazed doors, etc) located in the building fabric.

Greenhouse gases: Gases that affect the temperature of the earth's surface. They include water vapour, tropospheric ozone, chlorofluorocarbons, carbon dioxide, methane and nitrous oxides. The last three gases are of particular concern because they take a long time to remove from the atmosphere.

Illumination power density: The total amount of that which will be consumed by the lighting systems in a space and it includes the lamps, ballast, current regulators and control devices. The total is arrived at by adding the energy used and then dividing it by the floor area of the room.

Light source efficacy: The energy efficiency of a lighting device. The effectiveness of the lighting device is measured by the amount of lux (illumination measured as lumens per unit area) on the task divided by the electrical power that will be used by the lamp (in watts). In regards to the interpretation of the values, the higher the rating, the more efficient the light source

Lumens (lm): The units for luminous flux (the light emitted from the light source or luminaire). In regards to the numbering system, the higher the lumen value the brighter the light. The lumen value is obtainable from the manufacturer and may be described as the "lm" value in lighting product literature.

Outdoor air economy cycle: An outdoor air economy cycle is a mode of an air-conditioning system that, when the outside air properties are favourable, increase the quantity of outside air used to condition the space. It is often referred to as "free cooling" and occurs when the climate is suitable such as the autumn and spring or in the early morning in the summer in temperate climates.

Passive design: a design that does not require mechanical heating or cooling for example buildings that are designed to take advantage of natural energy flows to maintain thermal comfort.

R-Value: The measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e. the thermal resistance ($m^2.K/W$) of a component calculated by dividing its thickness by its thermal conductivity.

Shading coefficient: A measure of the solar gain performance of windows. It is the ratio of the solar energy transmitted and convected by the window to the solar energy transmitted and convected by clear 3 mm glass.

Solar access: the amount of useful sunshine reaching the habitable areas of a building.

Solar Heat Gain Coefficient (SHGC): a measure of the amount of solar radiation (heat) passing through the entire window, including the frame. SHGC is expressed as a number between 0 and 1.0. The lower the SHGC the better.

Thermal mass: a term to describe the ability of building materials to store heat . Building materials that are heavy weight store a lot of heat so are said to have high thermal mass. Materials that are lightweight do not store much heat and have a low thermal mass.

Thermal resistance: The resistance to heat transfer across a material. Thermal resistance is measured as an R-Value. The higher the R-Value the better the ability of the material to resist heat flow.

Ventilation opening: An opening in the external wall, floor or roof of a building designed to allow air movement into or out of the building by natural means including a permanent opening, an openable part of a window, a door or other device which can be held open.

Watt (W) : The determined metric or SI (international system of measuring units) value for energy loads and is used to rate electrical motors, appliances, lights etc. and in expressing energy loads and energy consumption.

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ANNEXURE “C”

Criteria for the Promotion of Energy Efficiency in Land Use Development

Version: F

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It is likely that this document will be updated and improved over time. Should you have any suggestions please email these to Richard Holden at RichardH@joburg.org.za

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CRITERIA FOR THE PROMOTION OF ENERGY EFFICIENCY IN LAND USE DEVELOPMENT

Table of Contents

1 Introduction

The criteria for promotion of energy efficiency in land use development have been designed to support more energy efficient built environments within the City of Johannesburg. The document provides quantified criteria and benchmarks that can be used to guide and assess energy performance of different development and land use proposals.

1.1 Existing policy and legislation

This document aims to reinforce sustainability objectives set out in the City of Johannesburg's Strategic Plans. In particular, it aims to reinforce the following strategic objectives set out in the Draft Spatial Development Framework 2008-09:

- Determine priority areas for short-medium term investment and allocation of future development rights;
- Re-direct the respective capital investment programmes of the City's service providers to address the short-term hotspots and strategic priority areas;
- Limit future development rights in infrastructure hotspots within the City until backlogs have been addressed;
- Identify priority investment areas for public and private sectors, specifically in respect of municipal infrastructure;
- Introduce development conditions that are congruent with global best-practice standards relating to resource efficiency (energy, water, fuel);
- Introduce development obligations relating to the full spectrum of Inclusionary Housing (i.e. subsidized housing, bonded, rental / social
- housing) in identified priority areas;
- Apply a package of incentives to promote and facilitate development that subscribes to the socio-economic and spatial imperatives of the City;
- Establish monitoring and evaluation mechanisms to review the status of the infrastructure hotspots and the limitations placed on these areas.

1.2 Energy use in cities

Energy is used South African metropolitan areas in the following ways: transport (56%), industry and manufacturing (14%), residential (13%) and commercial (3%) (SEA 2006). Patterns of carbon emissions are however different and although coal fired electricity only accounts for 32% of energy consumption within cities, this is responsible for 66% of carbon dioxide emissions, followed by petrol and diesel use (18%) and coal use (10%) (SEA 2006).

South African buildings, which rely heavily on electricity, therefore make a substantial contribution to carbon emissions. The International Energy Agency calculates that the public and commercial sector contributes 14 % to total carbon emissions in South Africa, with most this from buildings.

Buildings not only contribute to carbon emissions as a result of consuming energy in operations, they also affect the amount of energy consumed in transportation and services. These aspects are described below:

- **Building operation:** Buildings consume energy in lighting, heating, cooling and ventilation. Energy is also consumed running equipment and vertical transportation such as lifts.
- **Transportation:** Energy is expended moving people and goods around cities. This includes energy consumed by commuter buses and trains getting people to and from work and energy expended in delivering products used in buildings such as food, paper and equipment. Energy is also required to remove solid waste from building for recycling or disposal in landfill sites.
- **Services:** Energy is consumed in servicing buildings. For instance, delivering potable water to buildings and the removing and treating sewage requires energy.

These aspects represent the main areas that can be readily addressed in order to make buildings and cities more energy efficient. Energy is also consumed in other areas related to the built environment. For instance, energy is required to produce materials and products and construct buildings (the embodied energy of buildings). It is also required to administrate and manage municipal infrastructure and transportation as well as provide services related to new and existing buildings such as building control and electricity and water supplies. These aspects however have a relatively low impact and are difficult to measure and influence. This document therefore only provides criteria in relation to the key areas described above. These areas are also shown in the diagram below.

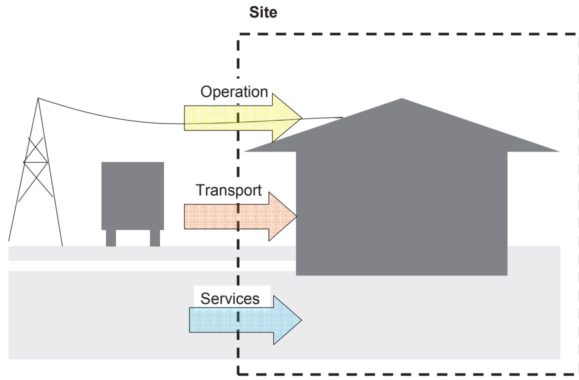

Figure 1. Energy consumption in and around buildings in South African cities

1.3 Criteria and benchmarks

Criteria and benchmarks selected and developed in this document are designed to achieve a balance between ease of use and effectiveness. A literature review and case studies were used to establish good practice benchmarks and design criteria. Performance benchmarks were drawn from guidance developed from the South African Bureau of Standards (SABS) and the Chartered Institute of Building Service Engineers (CIBSE). In particular, the document refers to SANS 204 (SANS) on energy efficiency in buildings, developed by the South African Bureau of Standards.

Criteria were also developed that relate to policies of City of Johannesburg. In particular, reference is made to the Town Planning Scheme and the Spatial Development Framework (SDF).

1.4 Using the criteria and benchmarks

The criteria for promotion of energy efficiency in land is intended for use by City of Johannesburg officials and aims to enable them to develop a cohesive approach on energy efficiency in relation to new developments. It provides arguments, criteria and benchmarks that can be used to structure engagement with developers and other role players to ensure that energy efficiency is addressed effectively.

The criteria can also be used as an input to city planning and development frameworks such as the Spatial Development Framework (SDF) by providing quantifiable measures that can be used to test different options and define optimum solutions.

1.5 Structure of the document

The criteria for promotion of energy efficiency in land use are structured in the following way.

Criteria have been developed for different types of land use such as **low density residential** and **high density residential.** This is reflected in the *title* at the top of the page.

Following this is the *Assumed Occupancy* and the *Assumed Occupation*. The *Assumed Occupancy* provides the assumed density ie 2 persons per bedroom and the *Assumed Occupation* provides assumed hours of occupation ie 24 hours a day, 7 days a week.

Detailed criteria are then found under main headings of *Building Operation, Transport and Services*. A column on the right, titled '*Achieved?*' provides a space where achievement of criteria can be noted.

2 Low density residential

	Assumed occupancy	2 persons per bedroom
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 40 kWhrs/m2.pa	
O2	**Maximum energy demand**	Maximum energy demand will be less than 50 VA/m2.	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	All dwellings area located within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of all buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: playground/park, crèche, primary school and within 2km of the site: bank/bank ATM, post office, convenience store/supermarket and secondary school.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

3 High density residential

	Assumed occupancy	2 persons per bedroom
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 40 kWhrs/m2.pa.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 50 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	80% of occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 0.5W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. If this is not possible because of the height of the building energy efficient heat pumps should be used.	

T Transportation

T1	**Public transport**	All dwellings are located within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: playground/park, crèche, primary school and within 2km of the site: bank/bank ATM, post office, convenience store/supermarket and secondary school.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water	

		harvesting, onsite retention and filtering systems are used to achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

4 Low cost and government subsidy housing projects

	Assumed occupancy	2 persons per bedroom
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 40 kWhrs/m2.pa.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 50 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 2W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	All dwellings are located within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities is provided within 400m: playground/park, crèche, primary school and within 2km of the site: Bank/bank ATM, post office, convenience store/supermarket and secondary school.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to	

		achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

5 Retail including restaurants

	Assumed occupancy	1 person per 10m2
	Assumed occupation	12/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 240 kWhrs/m2.pa (SANS).	
O2	**Maximum energy demand**	Maximum energy demand will be less than 90 VA/m^2 (SANS).	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North (n/a for spaces over 750m2).	
O7	**Building form**	Building depth does not exceed 15 m (n/a for spaces over 750m2).	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area. (n/a for spaces over 750m2).	
09	**Daylight**	50% of occupied areas within building have an average daylight factor of at least 2.5% (n/a for spaces over 750m2).	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. Where this is not possible, energy efficient heat pumps are used.	

T Transportation

T1	**Public transport**	All retail units are within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities is provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water	

		harvesting, onsite retention and filtering systems are used to achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 5L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

6 Offices

	Assumed occupancy	1 person per 10m2
	Assumed occupation	12/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 200 kWhrs/m2.pa (SANS).	
O2	**Maximum energy demand**	Maximum energy demand will be less than 80 VA/m^2 (SANS).	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	80% of occupied areas within building have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. Where this is not possible, energy efficient heat pumps are used.	

T Transportation

T1	**Public transport**	All office buildings are within 1000m of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

7 Service Stations

	Assumed occupancy	1 person per 10m2
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 900kWhrs/m2.pa.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 120 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North (n/a if restricted site).	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	100% of occupied areas within building have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 5W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. Where this is not possible energy efficient heat pumps area used.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to	

		achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

8 Leisure and entertainment

	Assumed occupancy	1 person per m2
	Assumed occupation	18/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 420 kWhrs/m2.pa (SANS).	
O2	**Maximum energy demand**	Maximum energy demand will be less than 85 VA/m^2 (SANS).	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North (n/a if restricted site)	
O7	**Building form**	n/a	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	50% of occupied space (non-performance) within building have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 2W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. Where this is not possible energy efficient heat pumps are used.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of buildings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to	

		achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 5L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

9 Tourist, hospitality (hotels, guest houses etc)

	Assumed occupancy	2 persons per bedroom
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	For large hotels with catering annual mains electricity consumption is less than 650 kWhrs.pa per m2 (SANS). For smaller hotels, non-catering hotels and guest houses this will not exceed 340 kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 90 VA/m^2 (SANS).	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	80% of occupied space has an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 2W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating. Where this is not possible this will be done through energy efficient heat pumps.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water	

		harvesting, onsite retention and filtering systems are used to achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

10 Civic, Institutional and educational

Primary school

	Assumed occupancy	1 person per 5m2
	Assumed occupation	12/5

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 420 (SANS) 120 (CIBSE) kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 80 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail. All accommodation of learners is provided within 2km.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to	

		achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

11 Community and recreation centres

Community centre 500m2

	Assumed occupancy	1 person per 5m2
	Assumed occupation	12/5

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 420 (SANS) 140 (CIBSE) kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 80 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 2W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail. All accommodation of learners is provided within 2km.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water	

		harvesting, onsite retention and filtering systems are used to achieve this.	
S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

12 Medical, particularly hospitals

	Assumed occupancy	1 person per 10m2
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 650 kWhrs.pa per m2. (SANS).	
O2	**Maximum energy demand**	Maximum energy demand will be less than 90 VA/m^2 (SANS).	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 2W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating or where this is not possible through energy efficient heat pumps.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

13 Warehousing

	Assumed occupancy	1 persons per 20m2
	Assumed occupation	12/5

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 40 kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 40 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m (n/a where building is larger than 750m2).	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 5L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

14 Light industrial

	Assumed occupancy	1 persons per 20m2
	Assumed occupation	12/5

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 120 kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 80 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.(n/a where building is larger than 750m2).	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 5L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

15 Heavy industrial

	Assumed occupancy	2 persons per bedroom
	Assumed occupation	24/7

O Building Operation

	Title	Criteria	Achieved?
O1	**Energy consumption**	Annual mains electricity consumption will be less than 240 kWhrs.pa per m2.	
O2	**Maximum energy demand**	Maximum energy demand will be less than 90 VA/m^2	
O3	**Renewable energy Sources**	10% of annual energy consumption energy (O1) will be sourced from renewable sources.	
O4	**Energy sources**	Cleaner energy sources are used where possible, for instance gas is used for cooking.	
O5	**Urban heat island**	Large external surfaces such as car parking and roofing are constructed of a material with an absorptance value of under 0.5 or a minimum of 60% of the hard surface area is shaded.	
O6	**Orientation**	Buildings are orientated within 15 degrees of North.	
O7	**Building form**	Building depth does not exceed 15 m.	
08	**Ventilation**	Occupied spaces have openings with a minimum area of at least 5% of the internal floor area.	
09	**Daylight**	All occupied areas within dwellings have an average daylight factor of at least 2.5%.	
O10	**External lighting power density**	External lighting power requirements do not exceed 1W per m2 of internal area and are linked to daylight sensors, motion sensors or timers.	
O11	**Water heating**	All water heating requirements will be met through solar water heating.	

T Transportation

T1	**Public transport**	The development is within 1km of a public transport node.	
T2	**Urban development boundary**	The development is located at least 4km inside the City's Urban Development Boundary (Map 15 and 16, SDF 2008).	
T3	**High priority areas**	The site is located within a Priority Densification Area or a Marginalised Area (Map 39, SDF 2008).	
T4	**Density**	Density is in line with City's spatial development requirements for the area.	
T5	**Parking**	Parking provision does not exceed City's requirements by more than 10%.	
T6	**Pedestrian**	Dedicated pedestrian routes from public highways and public transport to the main entrances of the dwellings with safe road crossing points are provided.	
T7	**Local facilities**	Access to the following facilities are provided within 400m: crèche, bank/bank ATM, post office, restaurant/food retail.	
T8	**Cycling**	Cycle routes are clearly designated on roads and provision is made for safe passage at road crossings and junctions and storage.	

S Services

S1	**Recycling area**	A designated, covered recycling area is provided on site. This has an area equivalent to at least 1% of the building internal floor area.	
S2	**Runoff**	The amount of runoff from site is not increased and quality of runoff water quality is not adversely affected. Rain water harvesting, onsite retention and filtering systems are used to achieve this.	

S3	**Rainwater harvesting**	Onsite rainwater harvesting capacity equivalent to 10L/m2 is provided and linked to toilets / irrigation system / other large water consumption area.	

16 References

1. SEA 2006, *State of Energy in South African Cities*. SEA. Cape Town.
2. South African Bureau of Standards. 2007. *SANS 204 Energy Efficiency in Buildings*