Sustainable Green infrastructure development is also known as eco-design, environmentally considerate and sustainable building principles. The aim is to create living and working environments that are comfortable, attractive and with minimum environmental impacts that may negatively impacting on the natural environment or human health whilst incorporating energy and resource efficient usage.

1. PILLARS OF SUSTAINABLE AND GREEN BUILDING DESIGN PRINCIPLES AND STANDARDS

TOUCH THE EARTH LIGHTLY PRINCIPLES

1. The type of development will determine the level of permanence and should if necessary, be easily removed from the landscape with minimum impact or permanent damage to the site category of development. Life cycle expectancy will determine level of permanence.

2. The site selection and foundation conditions need to enhance the application of touch the earth lightly principles.

GREEN BUILDING PRINCIPLES

1. Passive design principles should allow for maximum use of natural renewable resources like light and ventilation, etc. to reduce energy requirements.

2. Passive as well as energy efficient designs should be applied holistically to all the development components, including the support services. (Apply SANS, XA and X)

NATURAL & CULTURAL RESOURCE OPTIMIZATION PRINCIPLES

1. Designs must follow an iterative process that is strongly underpinned by a thorough analysis and understanding of all natural, biophysical, socio-economic and heritage attributes as well as the legal requirements of the site.

2. Designs should not compete with or detract...
### APPLY ALL APPLICABLE SANS CODES IN DESIGNS - SANS 204and 106 XA , X AND ALL REFERRED SANS CODES

#### 2. GUIDING PRINCIPLES

- **Local appropriateness**
- **Conservation of the natural environment and natural resources**
- **Conservation of the historical site attributes**

| 3. Renewable materials, textures and colours should be utilized wherever possible to ensure structures blend into the natural landscape. Sustainable materials to utilized, recycled materials where possible. | 3. The promotion of usage of re-useable, recyclable and non hazardous materials in designs and construction, recyclable materials to be utilized as far as possible where applicable. | from the historical and cultural values of the site and the immediate surrounding areas. This should not preclude cultural elements from being incorporated into designs. |
| 4. The infrastructure should blend in with the natural landscape and should in effect “flow” through and over structures where possible. | 4. Designs should be cost effective in terms of the life cycle of the Development. | 3. Designs should promote the visitors sense of wilderness experience. Improve contact with natural surroundings (Building designs) |
| 5. Consider peripheral development as far as possible - to reduce services, etc. - depending on external factors. | 5. Designs should incorporate material specifications that will sustain the infrastructure throughout its life expectancy for sound maintenance purposes. | 4. New values – incorporated and cautious in terms of master planning, |
| 6. Zoning will determine the scale, type of development. | 6. Designs should incorporate all latest innovative technologies, energy and water conservation. | 6. Themes and local appropriateness |
| 7. Themes and local appropriateness | 7. Market requirements incorporated – from latest tourism plans, updated and considered as part of designs and themes. | |
• Resource efficiency
• Lifecycle approach
• Zero Waste approach
• Use of renewable and recyclable resources
• Sustainable procurement
• Local production for local use
• Human health and wellbeing
• Monitoring and evaluation
• Positive legacy

It is essential that these guiding principles are implemented in the planning, design, operation, maintenance and eventual demolition and removal of developments and are not seen as ‘add-ons’ but rather as an integral part of the design and construction process with the ultimate goal being the promotion of a more sustainable lifestyle, minimizing impact on the environment and resources.

**Local appropriateness**

All developments should address the social, environmental, economic and cultural context within which they are situated.

**Conservation of the natural environment**

Green building implies an environmentally sensitive approach to the design and construction of the built environment, and an approach which aims to conserve the natural resources and ecosystems which sustain life on planet earth.

Environmental and historical conservation measures outlined in Environmental Impact Assessments (EIAs) and related processes must be enforced and used to inform the overall design. Develop Environmental Management Plans (EMPs), Operational Management Plans...
(OMPs) and Landscape Plans to guide the construction and operation of buildings to reduce negative impacts.

**Resource efficiency**

Energy and water efficient technologies, management systems and behaviour, must be promoted in all aspects of planning, construction, operation, and maintenance of buildings.

**Lifecycle approach**

Decisions about the design of a building and the specification of the materials from which it is made must take the entire lifecycle of these products into consideration in order to select the best overall option.

A lifecycle approach also aims to reduce ‘embodied’ energy and water. This is the energy or water that was used in the process of manufacturing and transporting the materials all along the production and retail chain, before being used in the building. Materials which are less processed and manufactured closer to the construction site are more sustainable as these have lower embodied energy.

**Zero Waste**

Green building should aim to achieve zero waste in the construction and operation of the built environment. This requires the application of the zero waste approach during the planning and design phases. The zero waste approach emulates nature where discarded resources are re-used elsewhere, so that all resources (including physical materials, water, energy, and money) are constantly cycled and put to use in the system. Applying zero waste means designing products and processes to avoid creating waste during their lifecycle; reducing the volume and toxicity of waste and materials, and conserving and recovering all resources for composting, re-use and recycling rather than burning or burying them in a landfill. Zero waste aims to eliminate any
solid, liquid or gaseous wastes that harm people or ecosystems.

**Use of renewable resources**

Resources and materials that can be constantly renewed through natural and biological processes are preferable to resources from non-renewable sources that cannot be replaced when consumed, such as mined materials and fossil fuels. However, designers must also avoid specifying materials harvested from threatened species and ecosystems, for example many species of tropical hardwoods. Make use of certification systems to verify that materials are sourced from sustainably managed areas.

Promote the use of renewable energies in the manufacturing of building products and in generating the energy used in buildings.

Utilizing thatch as a renewable resource for example.

**Sustainable procurement**

The goods and services procured in the planning, operation, management and maintenance of buildings must be sustainable. This includes involving appropriate expertise and specifying products that have a minimal negative effect on the environment through the course of their lifecycle. When procuring products also analyse the impact of their packaging and negotiate for these to be delivered in sustainable alternatives. Procure local products and services as a mechanism for local job creation.

**Local production for local use**

Products and materials sourced and manufactured in the vicinity of a development reduce the energy embodied in transporting materials for long distances to the site. Furthermore, using local materials boosts the local economy, and promotes job security for people living in the area.
Monitoring and evaluation

It is essential to gather information on the impact of green building interventions to raise awareness and share learning. Monitoring systems should be designed from the outset so that these are an integral part of the construction and operation process.

Positive legacy

Managers should ensure that both the short and the long-term impacts of decisions and actions lead to sustainability. Interventions should also help to raise public awareness and encourage behavioural change.

IMPLEMENTATION GUIDELINES

This section provides practical guidelines for the implementation of green buildings. Each section provides an overview and specific recommendations that should be implemented

Site selection

Greenfield, Greyfield and Brownfield redevelopment

Greenfield site - Natural totally nin previously disturbed sites

A Greyfield site is ‘any site previously developed with at least 50% of the surface area covered with impervious material.’

Greyfield redevelopment of disused sites, such as old factories and commercial buildings, helps to avert urban sprawl rather than clearing new areas in natural environments. Developers benefit by having fewer development restrictions. Redeveloping a degraded area can improve
its environmental performance, if the area is designed with environmentally sustainable gardens and buildings.

A Brownfield site is a ‘property, the expansion, redevelopment, or re-use of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

Brownfield redevelopment can offer opportunities for purchasing prime land cheaply, however, the cost of site rehabilitation needs to be taken into account. Redevelopment of severely degraded land can be a difficult process, as it is likely that cleanup operations have to be carried out before building can begin and the full extent of contamination may not be known upfront. There is no regulatory body dealing with Brownfield sites, and standard procedures for cleanup operations have not yet been established.

**Recommendations for site selection**

**UTILIZE THE KNP SITE SELECTION CRITERIA DOCUMENT**

The redevelopment of a Grey- or Brownfield site is generally favoured above the development of a Greenfield site.

Appropriate rehabilitation needs to be done on degraded sites to reduce any negative environmental and health impacts.

Appropriate Environmental Impact Assessments (EIAs) need to be done.

The influence that topography and soil conditions of a particular site have in relation to implementing sustainable interventions should be taken into account when selecting a site. A minimum of 3 alternative sites need to be considered.

Access to amenities, existing services and transport routes should be taken into account when selecting a site.
Design phase

Efficient site planning

Careful site planning can ensure that the proposed buildings placed on site will have minimal negative effects on the environment, while maximising its efficiency.

The first step of site planning should be to analyse how a site relates to the surrounding neighbourhood and broader context. Find out what development and design guidelines are already in place, including recommended building densities for the area. Good site planning optimises natural features and open spaces while achieving the requirements of the building, to enhance biodiversity. If possible, ensure that the site contributes to the development of green corridors. Placing the building in a certain position on site can enhance the natural functioning of a larger ecological network and contribute to creating a more inhabitable urban environment. Avoid placing buildings where they will have a negative impact on significant natural features and existing flora and fauna, mature trees, animal habitats and wildlife paths.

Analyse how to make the best use of the microclimate, topography, streetscape and views while responding to dynamic elements like wind, water flows through the site and potential threats like fire. Buildings should be positioned to make maximum use of natural resources for lighting and ventilation. Avoid placing buildings in a way that will jeopardise the ability of surrounding sites to access views and light.

Efficient building design

The floor plan of any building should be designed to avoid wasted space, which also wastes
materials, however, one must be careful not to compromise the ‘liveability’ of the building by creating unpleasant spaces. Generous common areas make for more habitable buildings.

The rooms that are used most, such as living rooms and kitchens, should be on the northern side of the building, so that they are naturally light and warm. Rooms such as bathrooms and storerooms should be placed so that they screen unwanted western sun or placed to prevent heat loss from south-facing walls.

A compact plan exposes less wall area to the outside, reducing the heat lost from the building. Compact houses are attached rather than separate, and double or multi-storey, rather than single storey.

If possible, the people using or living in a building should have a say in the way it is designed.

Passive solar design

Passive solar design uses building orientation, solar energy, natural convection and the inherent properties of materials to naturally heat and cool a building. Passive solar design operates on the principle that as sunlight enters a building it can be reflected, absorbed or transmitted, depending on the properties of the building materials used. A passive solar design building can achieve greater energy efficiency and save money in heating and cooling operational costs. By using natural light and ventilation instead of air conditioning, the running costs of the building can be reduced while also creating a more comfortable and healthy indoor environment. The following are aspects of passive solar design. Refer also to the section on energy efficiency, which contributes to passive solar design.

Orientation and shading

All new buildings should be elongated along an east-west axis, with large windows on the north side of the building. This means that during winter months the
north side of the building will receive the greatest amount of sunlight, during the morning and early afternoon, thus warming the interior and allowing the building to be naturally ventilated and lit.

However, to prevent overheating in summer months windows should be shaded. Window awnings or roof overhangs must extend far enough to block incoming radiation from summer sun, which is high in the sky, while still allowing the lower winter sun to penetrate the windows.

Deciduous trees and vegetated trellises can also be used to shade windows in summer.

Buildings should also be orientated to accommodate the wind. It should prevent strong winds entering, but allow gentle breezes to naturally ventilate the building. It should also be positioned so as not to create wind tunnels.

Energy efficient building materials
REFER TO KNP GREEN BUILDING STANDARDS AND SPECIFICATIONS

All building materials transmit energy in different ways. Some are good conductors of heat (corrugated iron), some prevent heat passing through and are good insulators (cardboard, wood and glass fibre) and some can store heat well (clay brick, concrete, stone and water).

These properties of materials are used in different ways in the walls, roof, ceiling and floor of a house to keep a building warm in winter and cool in summer. To make the best possible choices about energy efficient building materials, you need to understand their properties, on their own, and how they should be used in combination. For example, a roofing material with high reflective properties will contribute to a cooler interior. However, the same roofing material might also be a good conductor of heat, in which case it should be used with a ceiling material which is a good insulator (see heat sinks below).

Investigate the embodied energy of materials during their extraction and manufacture, and
how they will contribute to using energy when the building is used and maintained. In general, to reduce the amount of embodied energy in a building and save on costs, specify materials that have had little processing; don’t require extra finishes; and are made as close to the building site as possible to cut down on transport. Use materials with high embodied energy when their properties such as strength or longevity are critical. For example, use fired bricks for weatherproofing on the outside of a building and unfired clay bricks for internal walls. Cement blocks are hollow so less resources such as sand, stone and cement are used and the hollow area can be filled with soil-crete (cement stabilised soil) to increase its thermal efficiency.

Specify second-hand materials which save natural resources including energy. Include provisions for re-using or recycling demolition waste in tender documentation for the building contractor.

Design the building to minimise the natural weathering and degradation of the building, for example:
- Cover the entrance area
- Specify drip edging
- Provide adequate roof overhangs
- Slope backfill to divert surface water away from the building

**Ceilings and insulation**

Insulation in the ceiling and walls assists in keeping a home warmer in winter and cooler in summer

Low income houses with ceilings and insulation burn 26% less coal than un-insulated homes in winter. This translates into less money being spent on energy for heating, less air pollution and lower incidence of respiratory disease

**Heat sinks**
Certain building materials, including concrete, masonry and water, have a high ‘thermal mass’, which means that they can store heat. A basic principle of passive solar design is to make use of these materials to absorb and store heat during the day, thereby keeping the building interior cooler. At night when the outside temperatures drop this heat is released, warming up the interior of the building. This helps to offset the dramatic day time temperature

Walls and floors constructed from concrete for these purposes are termed ‘thermal mass’ walls and floors. Certain rules apply to making use of thermal mass:

Thermal mass materials should not exceed 15 cm in thickness

• For every square meter of north facing glass, use 680 kg of masonry or concrete, or 150 litres of water for thermal mass

• Ideally, thermal mass materials should be evenly spread throughout work and living spaces and not concentrated in isolated areas

• Thermal mass floors should be left uncarpeted if possible, or fitted with rugs instead of wall-to-wall carpets which would insulate the floor from absorbing heat. Modern concrete and stone finishes are attractive and often don’t need carpeting to be aesthetically pleasing

• The colour of thermal mass walls and floors is not important unless one is trying to increase the heat gained from direct sunlight
Thermal mass can also be achieved by building co-joined homes, which work well in South Africa where large differences between day and night temperatures are experienced.

Natural and traditional building materials and methods
Before industrialisation, people built with natural materials that were available in the area. Examples of traditional building materials include, amongst others:

- **Abiotic**: Earth material such as stone, rock, gravel, sand and clay
- **Biotic**: Wood, bamboo, reeds, or animal-based organic stabilisers such as cow dung

Unique building methods and forms developed over time that were suited to the culture and context in which people lived. Many of these natural building methods are being revived and adapted to current use because they create healthier environments, use less fossil fuel to make, and transport is often much cheaper.

Examples of natural building methods include, amongst others:
- Straw-bale construction
- Cob, adobe and mud brick construction
- Rammed earth construction
- Stone construction
- Thatched roof

Sundried or cement stabilised earth bricks are an alternative to conventional clay or cement bricks. They save energy because they are not fired and also result in houses that have excellent thermal mass. You cannot use topsoil, which is rich in decomposing organic material, for making earth bricks.

*Design according to standard sizes of construction materials*

Many construction materials such as plywood, tiles, wooden beams and particleboards are produced in standard sizes. Cutting of such materials to fit designs results in producing waste in the form of off-cuts. By designing buildings so as to minimise cutting of standard-sized products, a dramatic reduction in waste volumes and cost can be achieved.
Recommendations for the design phase

• Do a cost-benefit analysis of the long-term implications of the different design options being considered, which take the operating and maintenance costs into account

• Support the local economy through using local contractors, building materials, fittings and furniture

• Establish a knowledgeable team who will support the process of implementing a green building

• Do effective site planning to ensure that the development impacts positively on the existing natural and urban context, taking broader planning and design guidelines into account. Consider natural features including the microclimate, wind, topography, soil conditions, and established features such as trees. Consider densities; block design and streetscape character from an urban design perspective

• Position buildings to gain maximum benefit from light and views, while reducing noise and pollution. Create human-scale and vibrant urban spaces, using appropriate setbacks and greening

• Design the floor plan of a building to maximise functionality and take into account the microclimate of the site

• Invest in passive solar design and structural interventions that make use of sunlight and natural convection to heat, cool, light and ventilate buildings

• Ensure that buildings are elongated along an east-west axis, with large windows on the northern side of the building, where appropriate
• Ensure that roof overhangs are constructed to block incoming radiation from summer sun, which is high in the sky, while still allowing the lower winter sun to penetrate the windows

• Use appropriate building materials in the right combination taking into consideration their unique thermal qualities so that the building can be cool in the summer and warm in winter

• Use building materials that are natural, less processed and require no additional finishes as this reduces the amount of embodied energy in a building and saves on costs

• Incorporate design features that minimise the natural weathering and degradation of the building

• Use natural and traditional building materials and methods

• Design according to standard sizes of construction materials to reduce wastage

• Consider the implementation of a roof garden, and other integrated planting, where appropriate

Construction phase

Soil conservation - IMPORTANT

Conserve topsoil
Topsoil is the most important component of soil, as it is this portion which is rich in organic materials and seed stock. The presence of good topsoil is a prerequisite for the growth of healthy, strong vegetation.

It can take 50 to 1000 years to form one centimetre of topsoil.

In order to limit the loss of topsoil during construction, every construction site should have
a soil erosion control plan in place. Topsoil loss occurs when plants have been removed in order to build and the soil is washed away by rain, or blown away by wind. This reduces the productive capacity of the land and can also impact negatively on rivers or lakes in the area, through the build-up of sediments in these water systems. Erosion control measures include temporary and permanent planting, fencing, mulching and earth dikes.

If construction includes excavating or grading, the topsoil should be saved for later use by removing and stockpiling it. A minimum of 10 cm of topsoil depth should be removed over the entire site. Topsoil must be kept separate from overburden. Materials should be stacked in the order in which they were removed, in order to facilitate easy replacement. After construction is finished the topsoil should be replaced and re-vegetated, to ensure that it is not washed away by rain. Re-vegetation can be achieved through seeding or planting of seedlings.

Topsoil stockpiles must be stabilised to ensure that they are not blown away. This can be achieved through temporary planting, fencing and mulching. If temporary planting is to be used, seeds should be sown within 30 days of the stockpile formations. Straw bales can be used, but care must be taken to ensure that alien plants are not transplanted via the straw.

**Reduce soil compaction**

Heavy earth moving machinery and other vehicles are primary causes of soil compaction on a construction site. If soil becomes too compacted, water is unable to penetrate the surface, causing faster run-off during rains and eventual erosion and difficulty in establishing plants.

In order to prevent soil compaction wooden planks or mulching can be placed in areas where vehicles are most often used.

**Recycle construction and demolition waste**

During the demolition of buildings large amounts of waste are created in the form of bricks,
doors, window frames and other items which can be re-used in a new development. Re-use of these items offers developers an opportunity to cut down on both materials and waste disposal costs. Recycled concrete bricks are available from many major brick suppliers, and are effective substitutes for more conventional types of brick.

It is envisaged that over time, a demolition plan will have to be submitted prior to the demolition of a building to ensure that all the re-useable materials and rubble is incorporated in the new building or sold on to demolition companies to avoid waste going to landfills. Include requirements for careful demolition for recycling purposes in the tender documentation.

Use sustainable materials and products

The design team should specify sustainable materials where the lifecycle impacts on human health and environment have been considered. However, contractors can also contribute by sourcing materials from suppliers that make an effort to be more sustainable.

Investigate the environmental performance of bulk material manufacturers and suppliers and choose those that follow best practice in terms of pollution control, rehabilitation of mining operations etc.

Another concern in the construction industry is the over-harvesting and extinction of species, such as hardwoods. Timber products used in construction and decorating must be sourced from sustainable forest plantations, or from alien vegetation clearance projects. Developers must ensure that protected and endangered tree species are not exploited for building materials.

One of the ways to do this is through the Forest Stewardship Council (FSC) which is a voluntary, market driven, certification and trademark system that allows customers to choose products that promote responsible management of the world’s forests. Suppliers and purchasers can check that their specified product is FSC certified in several ways. In all cases the invoice of the supplier should clearly state that FSC certified timber was supplied. The chain of custody certificate number should be included on all product invoices, although the product may
not physically carry the FSC trademark. To verify the FSC certificate number, review the FSC certificates list or the certificates database. If you do not find the certificate number please contact the International FSC Centre via their website www.fsc.org.

Buy local

A lot of fossil fuels are consumed when building products are transported over long distances, especially if the product is a heavy material such as brick or steel. Use local materials from the closest possible supplier to reduce carbon emissions associated with transportion.

Recommendations for the construction phase

• Ensure that every construction site has a soil erosion control plan in place in order to limit the loss of topsoil during construction

• If excavation or grading occurs during construction, ensure that topsoil is removed and stockpiled in order to guarantee that it is protected and replaced

• Avoid unnecessary soil compaction on a construction site as it has negative environmental impacts on the soil and vegetation

• Re-use and recycle demolition and construction waste to reduce the waste to landfill and strive for Zero Waste

• All wood products which are used in the construction of buildings should be sourced from sustainable forest plantations, or from local alien vegetation clearance projects, with certification from the Forest Stewardship Council (FSC)

• Source bulk and non-renewable materials from suppliers that implement best practice in reducing the impacts of resource extraction, mining and manufacturing.
• Source materials and products locally where possible

Sustainable resource management

Energy efficiency

Reducing the energy consumption of a building not only saves the environment, but will also save on the running costs of the building. By designing energy efficient or renewable energy options into a building, the demand for electricity during peak consumption times is reduced, delaying the need to build new power stations.

Below are some ways to reduce energy consumption.

Insulation
Perhaps the most important component of energy efficiency in any building is insulation. Properly insulated ceilings and walls mean that indoor spaces are less vulnerable to temperature fluctuations, remaining cooler in summer and warmer in winter than non-insulated spaces, often eliminating the need for air conditioning during much of the day. Furthermore, if air conditioning or heating is needed during peak hours or extremes of temperature, the conditioned air will remain at a comfortable temperature substantially longer in an insulated space, thus saving on a building’s energy bill.

Ceilings
The installation of a ceiling is the most cost effective energy efficiency measure as most heat is gained or lost through the roof, especially if it is constructed from a conducting material like corrugated iron. This is particularly important to consider in low-cost housing developments.

Although eliminating ceilings may be cost-effective, in the long-term it creates an unnecessary energy burden on the occupant.
Air ventilation
Locate and size windows to prevent draughts while making the best use of prevailing winds and the natural convection of air to ventilate the building. Eliminate or minimise the need for air conditioning by making use of passive solar design techniques (see section 3.2.4).

Where air conditioning cannot be avoided, it is important that a qualified professional accurately determines the size of the air conditioner required, as oversized air conditioners are inefficient and energy intensive. A smaller air conditioner can often be installed in buildings that have adequate thermal insulation, thus saving on electricity costs. If a large space needs air conditioning, a central unit which services a number of rooms or floors is more energy efficient than using many single room units. However, individual preferences in thermal comfort levels must also be considered. These systems must be checked regularly to ensure that the ducts are not leaky, as this reduces the energy efficiency of the unit. Only air conditioners with a seasonal energy efficiency ratio (ratio of the seasonal energy output to the seasonal energy input) of 10 or more should be used.

A properly sized and energy efficient air conditioner can reduce electricity bills by between 20 and 40%.

Tight construction
It is important to ensure that a building is constructed so that it is tightly sealed. This means that doors and windows must be properly fitted and sealed, and there should be no cracks in the construction that allow unwanted airflows in and out of the building. In windy situations consider building an entrance hall with two doorways to prevent draughts.

Electricity
Using energy efficient electrical installations is one of the cheapest and easiest ways to reduce energy costs and thus improve the economic and environmental performance of existing developments. Newer equipment is often more energy efficient than old equipment.

Choose appliances such as energy efficient geysers, stoves, and zero-CFC based refrigerators.
Although these may initially be more expensive, in the long-term they reduce electrical costs and environmental impacts.

3.4.1.6 Lighting
The use of natural daylight instead of artificial lighting is obviously the most sustainable and efficient way of saving energy. Ensure that living and work spaces have an acceptable level of illumination without using artificial lighting during the day time by designing windows and skylights that are orientated to maximise the natural light without glare or overheating.

Reflective and angled ceilings will also bring more light deeper into a building.
Artificial lighting should be designed to create brighter areas where tasks are being performed and more ambient light should be designed for elsewhere. Controls such as dimmers and motion sensors reduce energy consumption, while ensuring that there is light when it's needed.

Energy efficient light bulbs can substantially reduce energy costs.
Compact fluorescent light bulbs (CFLs) use less than one quarter of the energy required to power a conventional light bulb for the same amount of time, and last 10 times longer. Each CFL will save between 500 kg and 1 ton of carbon dioxide (CO2) emissions in its lifetime.

Using efficient lighting is another method by which large energy savings can be achieved.
Fluorescent lights are the most energy efficient option in large communal spaces, such as office buildings, and produce a more natural coloured light than ordinary incandescent lighting. Modern fluorescent lights which use electronic ballast are not prone to the annoying flicker and hum of older fluorescents, and can provide a well-lit and comfortable working space.

Street lights are a significant component of bulk service costs, and impact on the quality of the development. Centralized high-mast lighting is more expensive per erf to install and operate than other options. The most efficient street lighting options are CFL or LED streetlights attached to the electricity reticulation poles, which can be powered by grid electricity or solar
photovoltaic (PV) panels.

**PV panels**

Solar photovoltaic (PV) panels generate electricity from sunshine. A panel could produce around 70 Watts at 12 volts for roughly 6 or 7 hours per day (about 0.4kWh/day). A complete off-grid system includes a battery to store PV-generated electricity for night time use, and a regulator to protect the battery from over-charging or over-discharging. These components should all be matched to one another. PV panels may be connected in series or parallel for larger systems, depending on the electricity requirements. Connecting PV systems to the national or local grid though two-way metering has not yet been widely implemented in Cape Town or South Africa, but is certainly being considered for the future.

**Water heating**

Solar water heaters are, simply, roof-mounted water panels that operate by heating water in black pipes using the power of the sun. Other more complex systems using vacuum tubes, for example, are also available. Solar water heaters are usually fitted with electricity back up.

Solar water heaters can save 20% - 40% of normal electricity use, and pay for themselves in 3 to 5 years. Financing a solar water heater through a bond translates into immediate monthly cost savings for a householder.

Geyser blankets and pipe insulation can be made from any heat resistant insulating material that is wrapped around the geyser and hot water pipes. Modern geyser cylinders are unlikely to need a geyser blanket, but any geyser or piping that feels warm to the touch is losing heat and needs insulation. A vertical geyser is significantly more energy efficient than a horizontal geyser.

Installing geyser blankets and insulating all hot water pipes, can save 5 - 10% of the energy used to heat water.

Geyser timers are devices which are installed on household geysers and operate by switching the geyser on and off at specified times, thus providing hot water only when it is needed. All solar water heaters with electricity back-up should be fitted with a timer in order to ensure
best use of the sun’s power.

A geyser timer can save up to 30% on monthly electricity bills, paying for itself within a year.

Recommendations for energy efficiency

• Install properly insulated ceilings
• Place and size windows to make optimal use of natural light, winter heating and ventilation without creating draughts, or gaining too much heat in summer or losing heat in winter
• Avoid the use of air conditioning, or at least ensure that the correct size is installed and that use of the unit is minimised
• Use air conditioners with a seasonal energy efficiency ratio of 10 or more (ratio of the seasonal energy output to the seasonal energy input)
• Ensure that the building is constructed so as to be tightly sealed, to prevent unwanted air flows. Doors and windows must be appropriately sized and fitted with seals
• Energy efficient electrical installations should be used
• Ensure that artificial lighting is designed so that light is focused where necessary, such as brighter areas where tasks are being performed and more ambient light elsewhere.
• Avoid the use of ‘up-lighting’ to reduce light pollution
• Ensure that energy efficient light bulbs, such as CFLs or LEDs, are used where possible.
• Consider the installation of independent renewable electricity generators such as PV panels or wind turbines
• Reduce the electrical energy used to heat water by installation of solar water heaters, or at least geyser blankets, pipe insulation and a geyser timer

Water efficiency

• No watering of residential gardens between 10:00 and 16:00
• Hosepipes must be fitted with automatic self-closing devises
• No automatic top-up systems fed from a potable (drinking) water source may be used to supply swimming pools and ponds
• No person may hose down a hard-surface or paved area using potable water, without getting prior written notice from Council
• Potable water may not be used to damp building sand and other building materials to stop them from being blown away
• The maximum flow rate from a tap installed in a wash hand basin may not exceed 6 litres per minute
• Toilet cisterns may not exceed 9.5 litres in capacity
• No automatic cistern or tipping tank may be used for flushing a urinal

Water-wise landscaping
Use water saving irrigation systems such as bubblers and drip irrigation to reduce the water that is lost by evaporation. Drip nozzles should have a low level focused spray to reduce evaporation and focus water where it is needed. Water can also be saved by using irrigation timers that limit watering to early evening and morning. Moisture and weather sensors can further reduce consumption by only watering when needed.

Rainwater harvesting
Harvesting rainwater for household use, saves using potable water on tasks that do not specifically require it, such as gardening, cleaning or flushing toilets.
To set up a simple system harvest water from the roof via a gutter down-pipe leading into an enclosed plastic or ferro-cement tank. A mesh over the top of the down-pipe keeps leaves out. Silt will still enter the rain tank. To prevent this being a problem locate the tap from the tank at least 50 mm above the bottom. Raise the tank about 300 mm above the ground in order to provide a little pressure.10

Plumbing layouts
Design the layout of the plumbing system to avoid creating a ‘dead leg’ in the hot water system, where a long pipe runs from the water heater to a supply point. This wastes a lot of cooled water while waiting for the hot water to discharge, it also wastes energy.
Ensure that the optimum pipe size and water pressure is used. A pressure reducing valve (PRV)
can be installed at a point nearest to where the supply enters the building to ensure that all water supplies in the building are balanced.

**Water-wise installations**

All plumbing installations in new or renovated buildings should be chosen with water efficiency in mind and must have SABS/JASWIC approval in accordance with the by-law requirements.

By simply using low-flow devices (taps, showerheads) and water efficient appliances (washing machines, dishwashers) savings of up to 50% can be achieved.

**Water-wise showers**

All showers should be fitted with low-flow showerheads to reduce the amount of water used during showering. However, these showerheads must still allow water to flow at a comfortable rate for the user because low-flow showerheads only work efficiently with a balanced pressure geyser (refer to section 4.1.8 for heating of water).

**Water-wise Taps**

All indoor taps should be fitted with aerators. These simple devices can be fitted onto most standard household taps, and aerate the water, thus increasing its efficiency while reducing the flow and thus the amount of water used. Metering taps, which have a timer to deliver a pre-determined, but adjustable, quantity of water when operated, should be used in public buildings and outside taps and showers to prevent taps being left on or dripping.

**Grey waste water systems**

Grey waste water is used water that comes from basins and baths as opposed to black water, which comes from toilets. Grey water can be re-used to flush toilets, or can be filtered to irrigate gardens. There are many ways to recycle grey water, such as having a pipe that feeds water from the basin into the toilet cistern, to simple gravity systems that use plants to filter the water, and sophisticated commercial systems that can clean water for large developments.
Water-wise toilets
Water used for the flushing of toilets is commonly delivered using one of two mechanisms:
• Cistern tanks with internal flush mechanisms. This stores 9-11 litres of fresh water, which is flushed into the toilet bowl when the mechanism is activated
• Flush valves deliver a preset amount of water regardless of the amount required. The flush valve is typically used in commercial buildings and public ablutions, and requires a nominally higher water supply pressure to operate than domestic units. Poor maintenance and incorrect adjustment often lead to water being wasted in these installations
It is preferable for all flush toilets to have cisterns fitted with duel-flush or multi-flush mechanisms. A multi-flush mechanism will only flush while the mechanism is held down, allowing the user to control the amount of water needed and prevent unnecessary flushing. Similarly, all urinals should be operated by a manual flush mechanism, as automatic flush systems are wasteful of water.

Recommendations for water efficiency
• Ensure that only water efficient devices such as low-flow taps, low-flow showerheads, washing machines and dishwashers are used
• Ensure that all toilets are low volume (9.5 litres or less), with dual-flush or multi-flush
• Ensure that public buildings and outside taps and showers are fitted with metering tap buttons, which have set timers to prevent taps being left on or dripping
• Design the layout of the plumbing system to avoid long pipe runs between the geyser and supply points
• Reduce hard surfacing to encourage rain water to seep back into the ground rather than being carried away into the sea by drainage systems
• Design paved areas so that water run-off is slowed down and where possible use soakaways and permeable paving that allows water to filter into the ground
• Ensure that the optimum pipe size and water pressure is used. A pressure reducing valve can be installed at a point nearest to where the supply enters the building to ensure that all water supplies in the building are balanced.
• Encourage rainwater harvesting and the re-use of grey water where appropriate. However, ensure that the local ecological system is not polluted and that it is managed correctly.
• Encourage the use of indigenous planting and efficient irrigation methods, such as drip irrigation.
• Consider the use of a pool blanket to reduce water loss through evaporation.
• Introduce waterless sanitation and alternative grey-water systems that clean black and grey water, while providing useful by-products such as fertiliser and biogas.

**Waste minimisation and management**
The design phase is a critical time for making decisions that impact on waste. This includes specifying materials that have resulted in minimal waste during their production, and that will result in minimal waste during the construction, maintenance and demolition of the building. Tender documentation should ensure that demolition and construction processes will be managed to reduce waste. Building rubble can be used, for example, as sub-grade for driveways, rather than being dumped. Old doors and windows can also be re-used which saves on costs and the environmental impact of using virgin materials. Waste management systems that facilitate separating waste at source for composting, re-use and recycling must be built into the design of a building.

**Recommendations for waste reduction**
• Aim for and promote Zero Waste in the planning, operation, management, maintenance and demolition of a building. Zero Waste emulates the closed loop processes found in nature, taking a ‘cradle –to–cradle’ approach to designing products and buildings.
• Build waste avoidance into the process at a design phase, by specifying products and materials that have less wasteful production processes and don’t create wasteful emissions during construction, maintenance and demolition of a building.
• Ensure that all buildings that are to be demolished compile a demolition plan, outlining how the building material and rubble will be used to avoid waste to landfills
• If waste is created, consider how this can firstly be re-used and then recycled to recover the value invested in these materials, rather than losing this value when the resource is dumped in a landfill or incinerated
• Provide waste compactors in buildings where large amounts of waste are created to reduce landfill air space and transport costs for removal of waste
• Facilitate the separation of waste at the source for composting, re-use and recycling when designing waste management systems. The building management plan should encourage people to recycle their waste

Human health and comfort

Heating, ventilation and air conditioning (HVAC)
Proper ventilation is vital for the health and comfort of a building’s occupants. Fresh air prevents bacteria and pollutants from building up in the air. It is preferable that windows can be opened so that users control the level of outside air coming into the building. Windows should also be positioned to aid the airflow through a room or building, without causing draughts. In areas where windows are inappropriate extractor fans should be installed.
Old air conditioners that are going to be re-used should be thoroughly checked to ensure that they don’t use CFC-based refrigerants, which are largely responsible for depleting atmospheric ozone. Also avoid materials which use CFCs or HCFCs in their production, such as plastic foamed materials.

Sick Building Syndrome (SBS)
This is a combination of ailments (such as headache, eye, nose and throat irritation, cough, itchy skin, dizziness, nausea, fatigue and difficulty in concentrating) typically associated with modern office and commercial buildings, although SBS has also occurred in residential buildings. A 1984 World Health Organisation report, found that up to 30% of new and remodelled buildings
worldwide may be linked to symptoms of SBS. Symptoms occur while one is in a SBS building and clears up once one has left the building.

Factors contributing to SBS include combinations of some or all of the following:
- Indoor air pollution caused by chemicals off-gassing from processed materials and finishes
- Artificial fragrances, such as dryer sheets
- Poor or inappropriate lighting (including absence of or only limited access to natural sunlight)
- Poor heating or ventilation
- Microbial contamination of HVAC
- Bad acoustics
- Poor ergonomics
- Electromagnetic radiation from equipment (e.g. computer monitors, photocopiers, etc.)
- Chemical and biological contamination

A ‘sick building’ results in high levels of employee sickness or absenteeism, lower productivity, poor job satisfaction and high employee turnover. Green buildings aim to eliminate SBS.

**Indoor air quality**

Although most people are aware of the negative impacts of air pollution, few consider the serious health impacts of unclean or contaminated air indoors. Maintaining good indoor air quality is an essential part of creating comfortable and productive living and work environments.

**Allergens**

Special attention should be given to creating a home and garden that are low on the allergens which can cause asthma and other allergies. Most people with asthma are affected by the allergen produced by dust mites, particularly in humid climates. Design buildings to avoid materials and fittings that gather dust. For example, avoid fitted carpets and pelmets and use angled skirtings.
Recommendations for human health and comfort
• Reduce the risk of sick building syndrome (SBS) through natural ventilation, natural light, good acoustic and ergonomics, etc.
• Ensure that microbial growth is prevented by regularly cleaning and servicing air conditioning equipment and ducts
• Prevent damp conditions that lead to microbial and bacterial growth by ensuring exteriors are properly sealed and drained. Rising damp and associated fungal and bacterial growth should also be prevented by using breathable paints so that water cannot accumulate under the paint surface
• Avoid building and decorating materials (such as paint, varnished wood, carpets, etc.) which may emit high levels of volatile organic compounds. Rather use natural wood finishes or paints (which are commercially available) and limit the use of particleboards
• Ensure that no CFC-based air conditioners are used
• Encourage the use of organic cleaning products which do not contain harmful chemicals.
• Provide fire blankets and extinguishers
• Use solvent free and flame retardant building materials
• Ensure that electric cables made from ‘low burn’ materials are fitted to avoid any toxic fumes during a fire

Visual mitigation measures

Recommendations for the mitigation of visual impacts
• Ensure that green building roof structures, such as solar panels, solar water heaters etc., are placed on the rear part of a building so that these are not visible from the road
• Where roof structures cannot be on the rear side of the building, position these to have a minimal effect on the façade of the building
• Place pipes and down pipes inside the roof or at the back of the building and paint these the same colour as the building
• Ensure that no structures, besides the chimney, protrude beyond the apex of the roof
• Position rainwater tanks to the rear part of the building and, if possible, screen with vegetation
• Bury grey water tanks underground in a less used vicinity of the site. Cover these with an appropriate cover, which is accessible but safe for a person to walk on