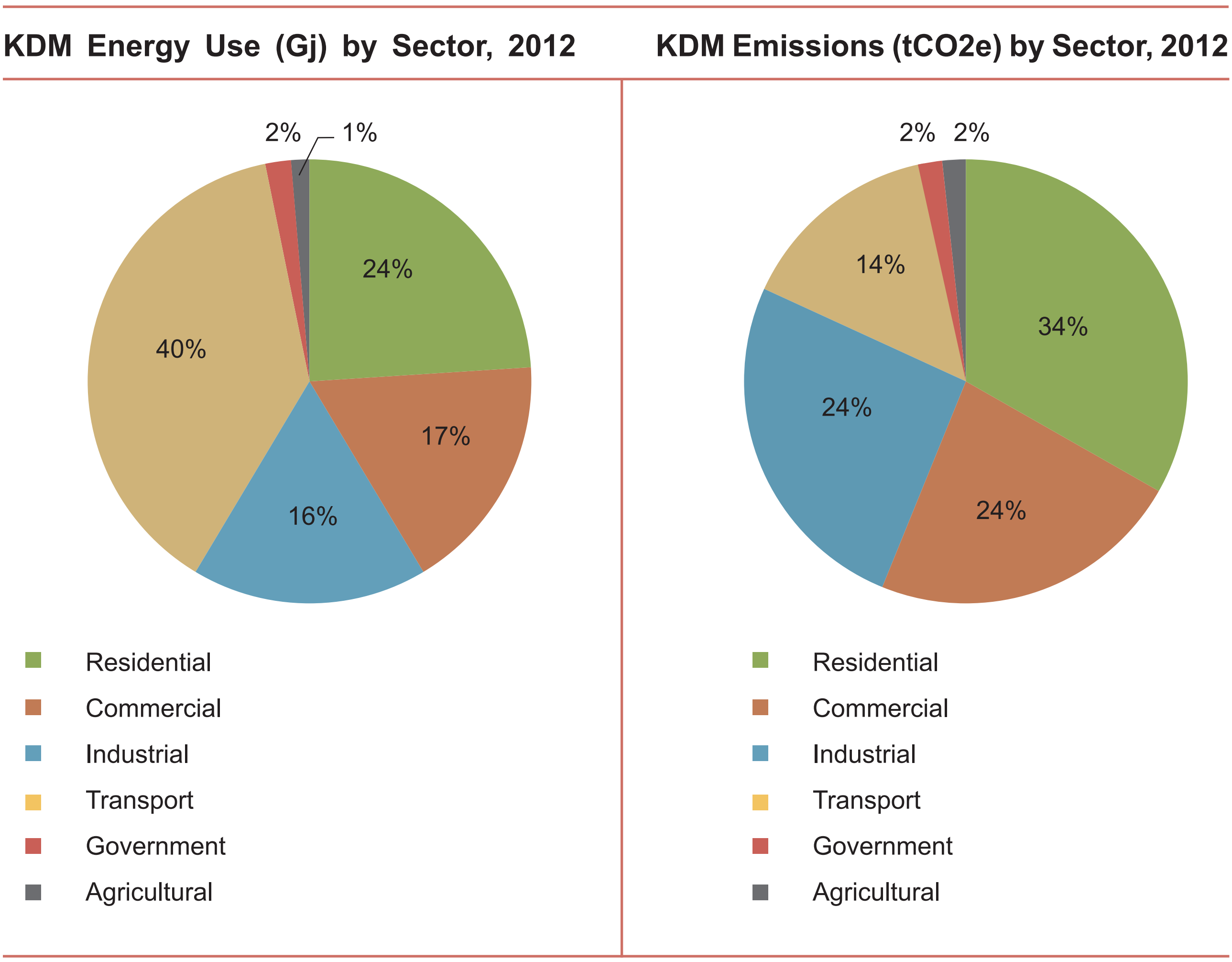
5. Energy

Energy is vital to the daily activities undertaken in homes, getting to work, in offices, shops, hospitals, libraries and industry. Energy is predominately used in the form of electricity, but also includes liquid fuel (petrol, diesel and paraffin), gas, wood, and coal. The majority of South Africa's energy supply comes from the burning of fossil fuels, especially coal. Electricity generation in South Africa is both a major emitter of greenhouse gases and a serious hurdle for development as demand is exceeding supply.

In KwaDukuza, as seen in the image below, the largest energy user is transport followed by residential homes. While the transport sector predominantly relies on liquid fuel for energy, the residential sector relies predominantly on electricity. In the residential and commercial sectors (which jointly account for 38% of energy use), electricity used in buildings is the predominant energy used. This indicates the opportunity for demand reduction and energy efficiency measures through implementing green building principles and practices.

Figure 5: Percentage distribution of energy use and greenhouse gas emissions in the municipality



Source: Greenhouse Gas Inventory 2012 Report, Urban-LEDS, ICLEI Africa

South Africa's energy challenges can be tackled with a drive to reduce demand through the implementation of strong energy efficiency initiatives, and through the promotion and roll out of renewable energy sources.

Green Economy Enabler

Renewable energy

Renewable energy is key to the green economy as it offers an alternative supply of electricity to businesses and industry that emits no greenhouse gases through the production process. The renewable energy sector can stimulate local jobs in areas that do not have fossil fuel resources available, and tends to be more labour intensive per gigawatt produced than fossil-fuel based electricity. Jobs can be created throughout the process of renewable energy production; from the design and manufacture of parts to the construction of power farms, to the production of energy and the ongoing maintenance and operations of these farms.

5.1 What changes do we need?

Buildings can account for up to 40% of total energy consumption and contribute 20% of global greenhouse gas emissions, but also provide an opportunity for improvement. Simple measures to conserve energy can be implemented at no cost and with a small increase in capital costs, large reductions in energy demand and increases in energy efficiency are possible. This can occur by encouraging and implementing passive design and energy efficient lighting, heating and cooling systems in buildings, energy efficient processes in industry and municipal infrastructure provision, and through the promotion and rolling out of alternative energy sources, namely investment in the renewable energy market.

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Fast Fact:

Energy Efficiency

Energy efficiency is using less energy to provide the same service. This can be done through technical interventions, such as changing equipment, or through behavior change, such as switching off equipment that is not required.

5.2 How do we design our buildings?

When designing a building, the following needs to be taken into consideration:

- Ensure compliance with mandatory requirements
- Include passive design elements
- Include energy efficiency and demand management features
- Consider on-site electricity generation

5.2.1 Compliance with mandatory requirements

Energy efficiency and demand management in buildings is regulated through national policy and standards. The purpose of these guidelines is not to provide a summary of these regulations. Rather, as it is essential to a full understanding of the current regulatory environment which frames and provides a base for these green building guidelines, to provide a brief overview and highlight sections of the **SANS 10400-XA Energy Usage in Buildings (what needs to be done)** while touching on the associated **SANS 204 Energy Efficiency in Buildings (how it should be done).**

Effective from May 2012, all new buildings and building extensions must comply with the energy usage and energy efficiency standards as detailed in the amended National Building Regulations.

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Fast Fact:

SANS 10400-XA

The SANS 10400-XA regulations include aspects such as orientation towards north, window sizing and positioning, shading, choice of materials with regards thermal and insulation properties, solar heating, natural cooling and daylighting.

Non-compliance with the SANS 10400: XA poses the risk of penalties under the National Building Regulations and Building Standards Act. It is also anticipated that over time these standards will become more stringent, and may become incorporated into existing and not only new buildings. It is thus critical that developers and building managers heed these requirements in both design and operation of buildings so as to future proof their portfolios.

A quick overview of SANS 10400-XA

SANS 10400-XA is presented in three sections:

- XA1 – Energy efficiency standards in buildings
- XA2 – Energy efficiency in water heating
- XA3 – Three routes to illustrate compliance with SANS 10400 XA

XA1 – Energy efficiency standards in buildings

The focus is to design the building in an energy efficient manner that still provides adequately for the needs of the users, its function and geographical location. This excludes garages, storage areas, equipment and plants that are required for conducting the business.

XA2 – Energy efficiency in water heating

At least half of the water, 50% (by volume) , that is required to be heated shall be provided by solar heating, heat pumps, heat recovery or fuel from renewable energy (sun, wind, geothermal, biomass, etc.). A typical geyser with resistance heating is discouraged.

XA3 – Three routes to illustrate compliance with SANS 10400-XA

There are three ways in which the property developer can show compliance with regards to the design and construction of the building:

- **Compliance Route 1 – The prescriptive route** where all the requirements are met as stipulated in the regulations.
- **Compliance Route 2 – The reference building route** is where a competent person can demonstrate the energy usage of the building is equivalent to or better than a “reference building”, which would have been achieved through the prescriptive route.
- **Compliance Route 3 – The performance route** is where the building has a theoretical energy usage performance, determined using certified thermal calculation software, less than or equal to that of a reference building in accordance with the regulations.

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Fast Fact:

Key SANS10400-XA definitions

A competent person is defined as "a person who has the necessary education, training, experience and contextual knowledge to make a determination in terms of a functional regulation". A competent person will typically be a mechanical engineer or architect, who has completed appropriate courses pertaining to the SANS 10400–XA 'Energy usage in buildings' regulations. Most multidisciplinary engineering consultancies should offer this service.

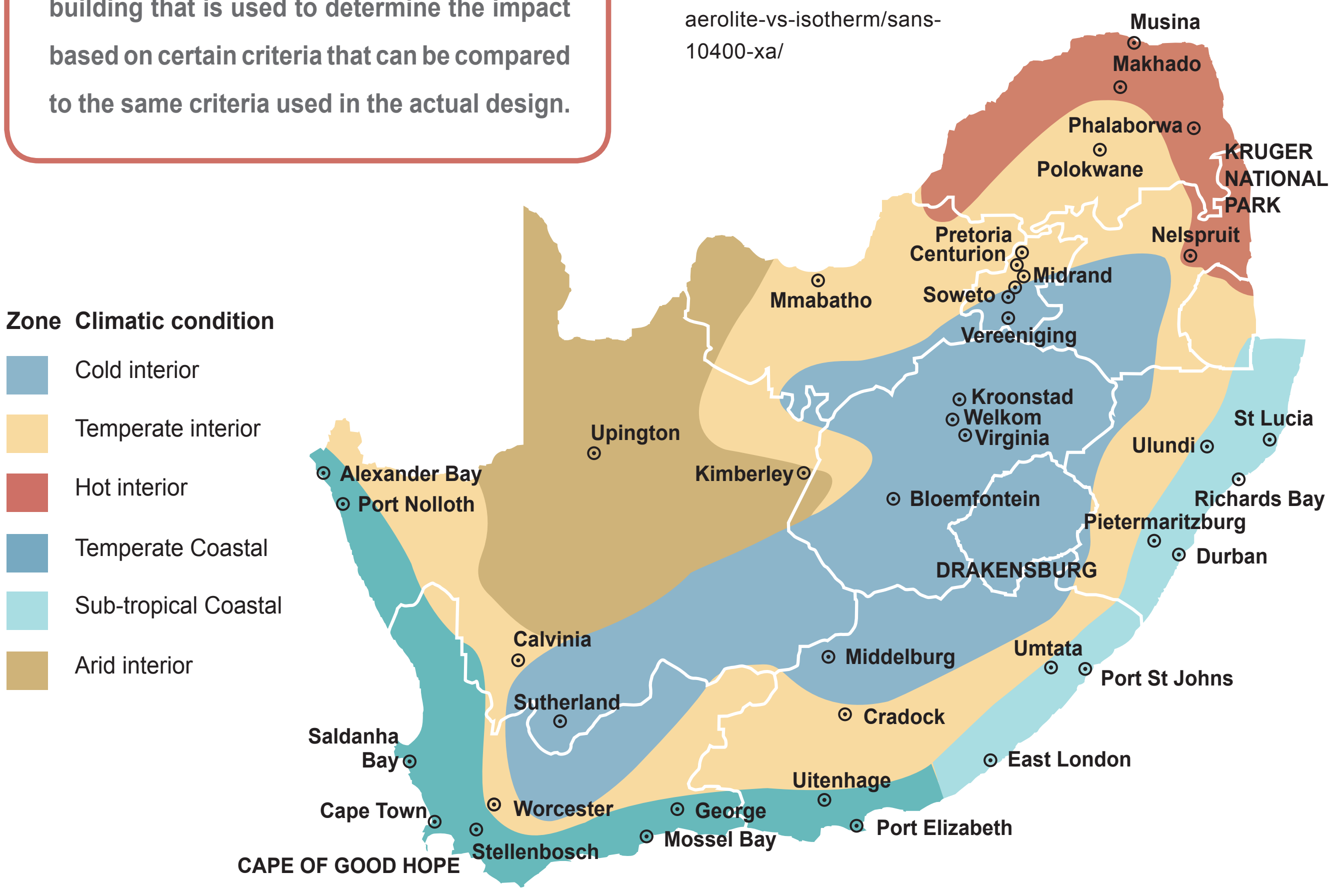
A reference building means a hypothetical building that is used to determine the impact based on certain criteria that can be compared to the same criteria used in the actual design.

5.2.1.1 A quick overview of the different climatic zones:

Essential to the implementation of SANS 10400-XA is the differentiation of South Africa into natural climatic zones. Due to the varied climatic conditions in South Africa, SANS 10400-XA sets different requirements for thermal insulation, and other aspects of building design. As seen in the image below (taken from SANS 10400-XA), there are a total of six climatic zones, which are labelled and referred to throughout the regulations as Zone 1 to 6.

Figure 6: Climatic Zones in South Africa used by SANS 10400XA

Source:
http://aeroliteinsulation.co.za
aerolite-vs-isotherm/sans-
10400-xa/



KwaDukuza Municipality is located in Zone 5, which is the sub-tropical coastal climate. This climate is characterised by higher humidity with warmer temperatures all year round and a smaller temperature variance between day and night and between seasons.

5.2.1.2 A quick overview of the key SANS 10400-XA requirements:

Confirmation by a competent person: Where a competent person is responsible for compliance, they need to submit the relevant form to the local authority on completion of the construction and commissioning of the building (form 4 as contained in SANS 10400-A).

Windows and overhangs: Where glass areas are larger than 15% of the net floor area, shading devices or performance glazing is required. Whilst double glazing or treated glass are options, it is expensive and can equally be achieved through overhangs or shading over the windows. It is best used in conjunction with internal blinds or curtains, which in summer should be drawn in the early afternoons to keep the heat out, and in winter can be closed around dusk to retain the heat.

Fast Fact:

Measuring the performance of insulation

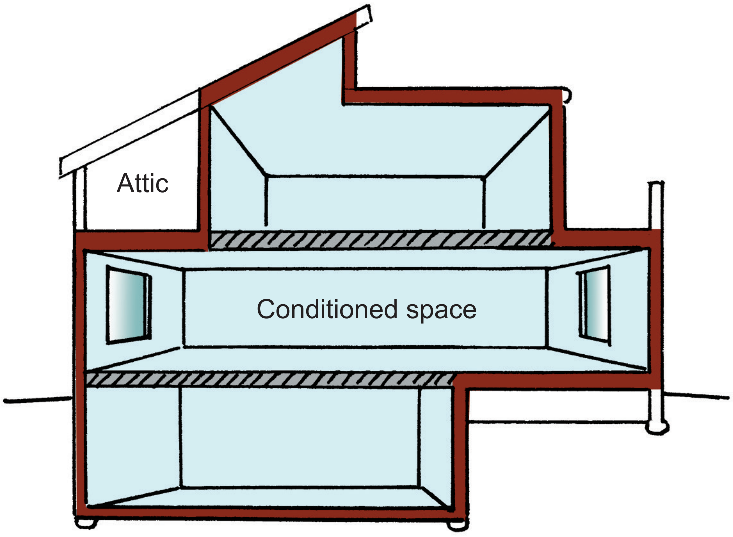
R-value: An R-value is a measure of thermal resistance in materials used in buildings. The higher the thermal resistance of a material, the harder it is for heat to move through it. If a building is built with high R-value materials, this means the building will stay cooler for longer in summer and will stay warmer for longer in winter. This makes the building more comfortable to be in. It is important in green buildings to reduce the amount of energy used to heat or cool a building, so the use of material with a high R-value is encouraged.

The U-value is always used within building regulations and indicates how much heat is lost through a given thickness of a particular material. It includes the three major ways in which heat loss occurs – conduction, convection and radiation. The lower the U-value is, the better the material is as a heat insulator, so the use of material with a low U-value is encouraged.

Figure 7: Building envelope description

The building envelope consists of:

- Fenestration
- Ceilings
- Walls
    - Above grade
    - Below grade
    - Mass walls
- Floors
- Slab
- Crawl space



Source: http://www.greenrushenergy.com/building-performance/

Provision of suitable building insulation: This serves to minimise temperature fluctuations within the buildings to reduce or eliminate the need for energy to be used for heating and cooling, as well as improve the indoor environmental quality of the building. The smaller the building is, the greater the effect the envelope will have on the internal environment. This is because in a smaller or narrower building, the building envelope is a greater proportion of the building's volume and therefore has more influence over the total internal space.

A minimum thermal resistance of R-value 2.7 as prescribed by SANS 10400-XA for the KwaDukuza Local Municipality in climatic zone 5 (sub-tropical coastal) which translates into 100mm of insulation required by SANS 10400-XA Deemed-to-Satisfy criteria.

Note: This insulation can take place via roof insulation alone, or be adapted as per insulating properties of the roofing materials. Hence the actual R-Value of building insulation will be less than the stipulated value and determined by roof type. Furthermore, when following the rationale design route for compliance with SANS 10400-XA, the insulation requirement may be less due to the use of good walling materials and shading.

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Fast Fact:

Insulated ceilings

Research has shown that indoor air temperatures can be managed much more effectively through installing a ceiling and insulation than by a coal stove or an electric heater, fans or air-conditioning.

Source: Energising SA Cities and Towns, SEA, 2003

- **All exposed hot water pipes** are to be insulated. Exposed hot water pipes with a diameter of less than or equal to 80mm should be insulated with a minimum R-value of 1.00. Exposed hot water pipes with a diameter of greater than 80mm should be insulated with a minimum R-value of 1.50.
- **Floors:** If an underfloor heating system is provided for in the design, then insulation with an R-value of no less than 1 must be provided for below the installed heating system.
- **Walls:** Wall insulation is required for non-masonry external walls. The requirements refer to the external walls of the habitable portions of the building fabric only.
  - For zone 5 the minimum R-value required for walls is 1.9

The following types of masonry walling comply with the R-value requirements:

- Double-skin masonry with no cavity, plastered internally, or rendered externally (Note: The cavity and grouted cavity walling systems exceed the minimum R-value of 0.35); or
- Single-leaf masonry walls with a nominal wall thickness greater than or equal to 140mm (excluding plastering and rendering), plastered internally and rendered externally.

Building sealing: Insulation works best when there is little infiltration of air through gaps in windows, walls and roofs. SANS 10400-XA therefore stipulates that ceiling voids should be designed so as to minimise air infiltration. Accordingly, wall plate and roof junctions shall be sealed. The joints in sheeted roofs shall be sealed.

Fast Fact:

Sealing windows

Old windows that don't seal well allow the warm air escape during the winter, so it is advisable to get self-adhesive weather stripping to seal the gaps around doors and windows. This is cheap and easy to do, while it can show a remarkable improvement of the heat retention during winter.

Insulation of hot water pipes: Exposed hot water pipes with a diameter of less than or equal to 80mm should be insulated with a minimum R-value of 1.00. Exposed hot water pipes with a diameter of greater than 80mm should be insulated with a minimum R-value of 1.50.

Provision of hot water: The regulation is fairly prescriptive with regard to hot water supply requirements. More than half of the annual hot water must be provided by means other than electric resistance heating (geyser) or fossil fuels. Various options exist, including solar heating, heat pumps, geothermal heat, renewable combustible fuel or heat recovery from alternative systems and processes.

The functional requirements of the provision of hot water (sub-regulation XA2) shall be satisfied when:

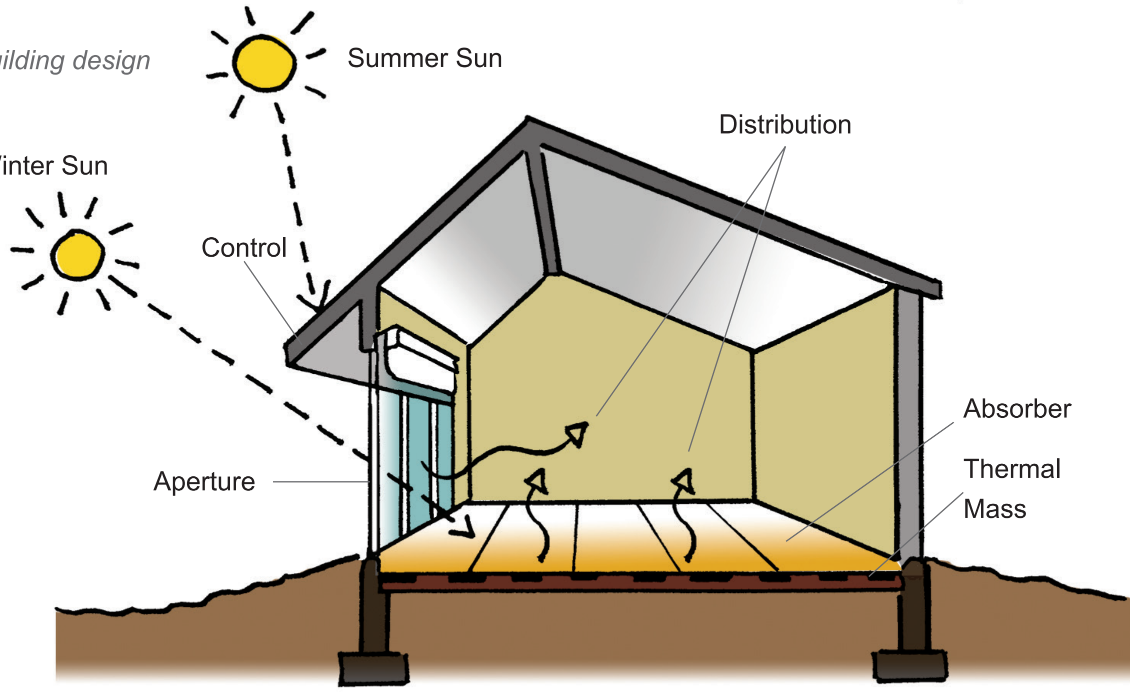
- The population for which such building is designed is determined in accordance with Regulation A21.
- The hot water demand is determined in accordance with table 2 and table 5 of SANS 10252-1:2004.
- The storage requirement is based on maintenance of a hot water temperature of 60°C.
- Solar water heating systems shall comply with SANS 1307, SANS 10106 and SANS 10254 based on the thermal performance determined in accordance with the requirements of SANS 6211-1 and SANS 6211-2.
- All exposed hot water service pipes (SANS 10252-1) shall be clad with insulation with a minimum R-value in accordance with SANS 204. (see section on insulation above).
- Thermal insulation, if any, shall be installed in accordance with the manufacturer's instructions.

Note: It is important that all buildings are designed in accordance with the existing national and local legislation and building standards. Whilst some of these key features have been highlighted, it is the responsibility of all who work in the built environment to ensure that they have a good working knowledge of existing legislation and where to confirm the detail as applicable to their current project.

5.2.2 Include passive design elements

Effective passive building design, which incorporates solar thermal performance and energy conserving measures, can only be achieved through incorporating the appropriate design principles into the planning process at an early stage. A building with good passive design is not more expensive to design or build than any other building, but is likely to save money throughout the life of the building, and is therefore considered a quick win in designing a green building.

Figure 8: Passive building design



Source: http://www.ecohome.net/news/ latest/saskatchewan-birthplace-high-performance-buildings-pasive-solar-home-design

Fast Fact:

Passive Solar Design

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun

Good passive design and orientation can also assist to maximise the potential for heating and cooling, solar water heat heating, as well as encourage natural lighting and so reduce the need for additional heating or lighting during the day.

Successful passive design is about capitalising on the specific location and climate of a building and making key decisions about building orientation, floor plate dimensions, solar access, massing and air flow at the earliest design stages. Unlike many other energy efficiency measures, these cannot be retrofitted later, and hence suitable foresight and planning upfront are essential.

5.2.2.1 Building orientation

Maximising the passive solar performance of a building requires careful building orientation and layout taking the surrounding environment conditions such as prevailing wind into consideration. An ideal building would be long and narrow and oriented on an east-west access, with the longest side of the building facing north. Such an orientation would allow the building to capitalise from heat gain in the morning, but minimise late afternoon solar gain when the sun is at its hottest and ambient temperatures are higher. It has been proposed that good orientation alone can generate estimated energy savings of 20% to 50% for a building.

5.2.2.2 Building layout

The service areas (i.e. the kitchens and bathrooms) in residential buildings should ideally be on the south/east facade, and the bedrooms and living areas on the north/west. In large public or commercial buildings, circulation spaces and non-living areas can be placed on the west or south periphery as these areas will have the greatest thermal discomfort and can shield thermally sensitive areas like offices from harsh glare and solar radiation or cold darker environments.

5.2.2.3 Shading devices or roof overhangs

At different times of the year the sun is located in a different position in the sky (higher or lower) and it may be good to use shading devices to control the heat coming into the building. These shading devises can either be fixed or automated to follow the seasonal patterns. Shading devices should block mid-summer sun, which is high in the sky, but allow the cooler lower winter sunbeams to penetrate the space. Shading devices will also assist with glare control and so contribute to a good indoor environmental quality of the space. It is possible to design a roof overhang so as to act as shading for windows below. This is especially useful in smaller commercial and residential buildings.

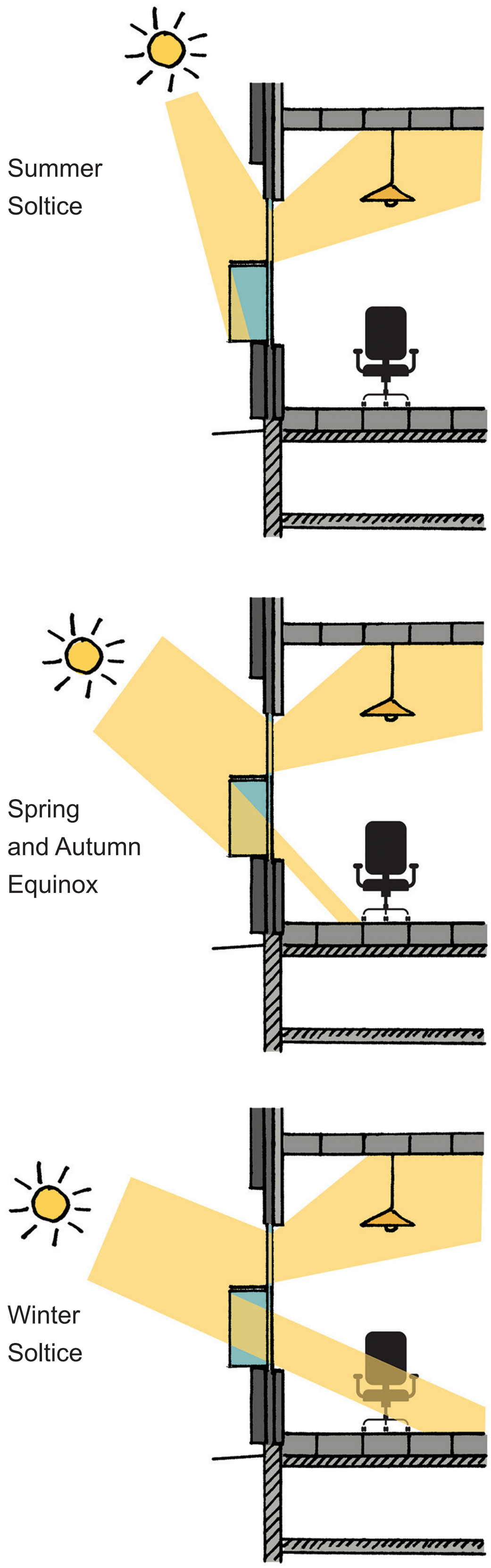


Figure 9: Good building design to minimise seasonal variations

Source: http://www.wbdg.org/resources/daylighting.php

5.2.2.4 High performance glass

The thermal property of glass is not as good as walls, so a lot of the building's internal winter warmth and summer coolth is gained or lost through the windows. This negative impact can be reduced through the use of double glazing, high performance glass and glass with special coatings. It aims to reduce the build-up of radiant and convective heat, manage the loads on the air conditioning system and thus keep energy requirements down.

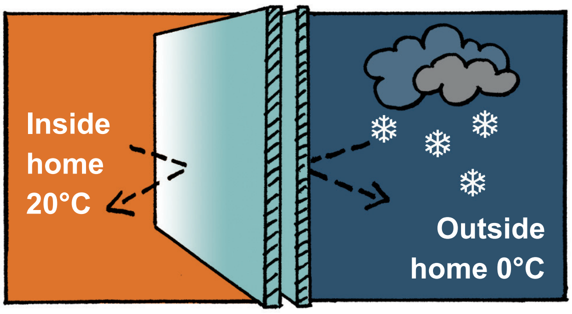
Building glazing, particularly on the north-facing facade, should have a low solar transmittance to reduce the heat coming in through the windows. **Low-E coating** on glazing can reduce the heat, while letting in useful light for daylighting. **Double glazing** acts as insulation and is appropriate for most climates, particularly those that require heating during part of the year and for areas where it is necessary to reduce the impact of external noise pollution. Triple glazing is commonly used in Europe where they experience cold winters.

However, this can be expensive and can equally be met by well-designed **overhangs or shading** over the windows. It is best used in conjunction with internal blinds or curtains, which in summer should be drawn in the early afternoons to keep the heat out, and in winter closed around dusk to retain the heat.

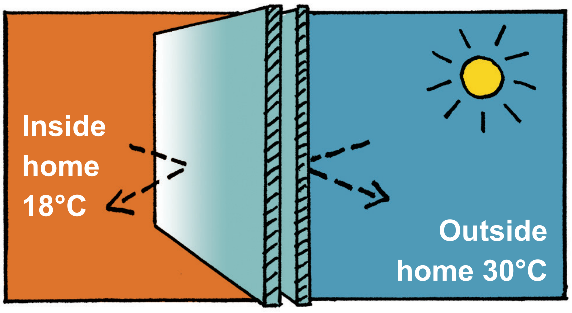
Fast Fact:

How double glazing works

Winter



Summer



Double glazing is made from two pieces of glass sealed together with an air space between. A double glazed window sits in your frame just as single glazing would, but provides a number of extra benefits. It keeps the space warmer in winter, cooler in summer, offers building owners a saving in utility bills due to less heating and cooling needed, acts as a security feature (more difficult to break), reduces noise from outside (acoustic attenuation), and dramatically reduces condensation on the inside of the glass. Clear glass accounts for less than 5% of a windows insulation, the rest is being supplied by the air layers on either side of the glass.

Since the heat flow resistance of still air is much greater than that of glass, a glass unit made from two panes, enclosing an air space will have about twice the insulation value. Double glazed units provide insulation to windows and doors of a building like fibreglass batts insulation to a wall, helping you to maintain a consistent internal temperature throughout the year.

Source: http://www.wellingtondoubleglazing.com

Fast Fact:

How high performance glazing works

One way in which to achieve the low U-values required by the building regulations is through the installation of high performance glazing such as low-emissivity glass (low-E glass), because it will:

- **Reduce heat loss, saving energy by maintaining a comfortable environment at lower thermostat settings.**
- **Reduce cold spots and downdraughts near windows, improving comfort and increasing usable floor space.**
- **Increase inner glass surface temperatures to reduce condensation inside the window.**
- **Reduce capital and running costs of heating systems, thus saving money.**

Low-E glass incorporates a very thin layer of metallic coating on one surface. To protect it from wear, the low-E coated surface is positioned in the outer face of the inner pane in a double or triple glazing layer. The coating allows heat from the sun to enter the building but significantly reduces heat loss from inside the building by reflecting radiant heat back into the room. In most instances, the transparency of the glazing is not significantly affected by the low-E coating although a very slight tint is discernable in certain circumstances, particularly from the outside.

Source: http://www.lowenergyhouse.com.

5.2.2.5 Wall and ceiling insulation:

Insulation contributes to better thermal comfort, which reduces the need for mechanical heating and cooling of the building, thus reducing overall energy requirements. Insulating the building envelope and glazing will improve thermal performance. In a home, carpets and thick curtains can improve the insulation of a room.

In any climate, insulation will not be effective without reduced air infiltration. South African buildings are notoriously leaky due to unsealed windows and doors and unnecessary air vents in walls. In more extreme climates, where there is a greater difference between internal and external temperatures, commissioning of the building envelope and even airtightness testing should be considered (this also helps for mould prevention).

5.2.2.6 Increasing the thermal mass in the building:

The thermal mass of a building refers to the thickness of material in the walls and floor. Buildings with higher thermal mass will absorb more heat during the day and release it slowly at night. This can help to keep the building warmer inside in winter and cooler inside in summer and is especially appropriate in drier areas with large differences in daytime and nighttime temperatures.

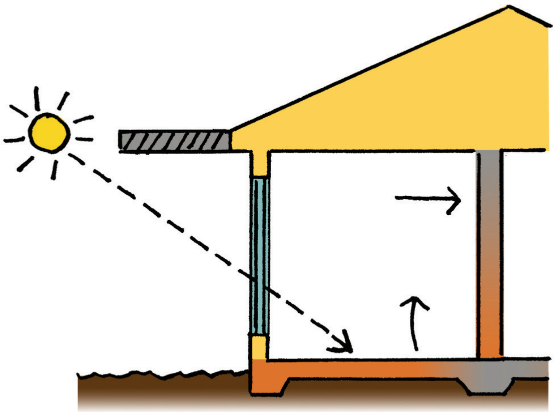
Fast Fact:

How thermal mass works

Thermal mass is an important component of passive solar design and refers to the material's resistance to change in temperature. Thermal mass works to regulate and reduce temperature fluctuations in buildings so that the building structure can retain and release heat. Dense materials such as concrete, rammed earth and bricks all have good thermal mass properties and could be used as walls, dividers or floors.

Thermal mass in winter

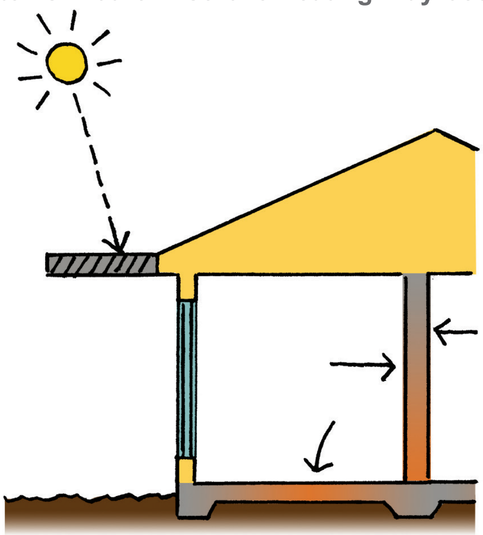
In winter, let the sun in and thermal mass will absorb heat from the sun during the day. The floors and walls store the warmth, releasing it back into the home at night and on cloudy days. It helps if carpets and other insulating materials do not cover floors exposed to the sun.



Source: http://www.level.org.nz

Thermal mass in summer

In summer, the thermal mass of a building can "soak up" excess heat from within the building. At night, the house can be ventilated to allow any excess heat to be lost into the cooler night air. Ideally, direct sunlight and excess solar gain should be prevented from entering the house by use of blinds, sails, a pergola, eaves or other external shading systems – otherwise overheating may occur.

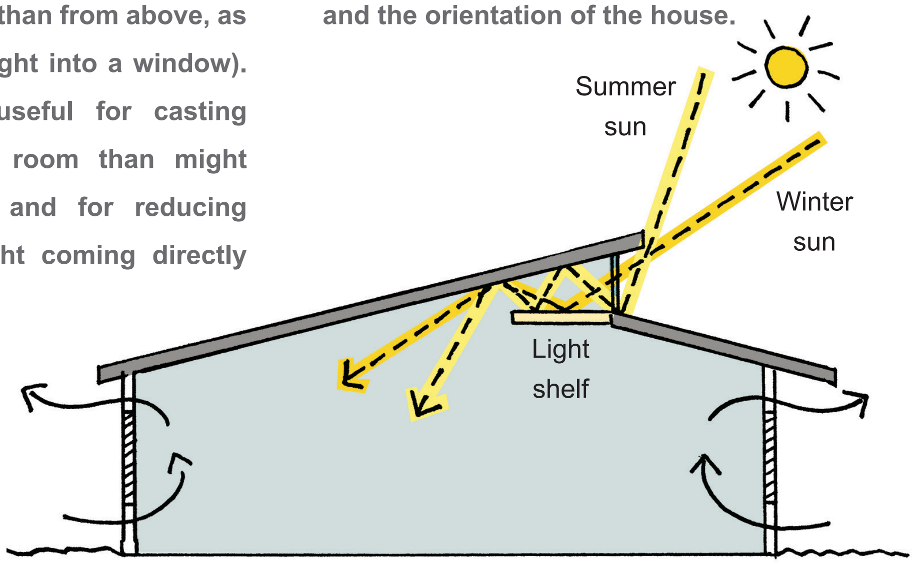


A building with incorrectly used or little thermal mass can experience large internal temperature fluctuations over a 24-hour period; heating up during the day and cooling down overnight. A building with well designed thermal mass would experience smaller temperature fluctuations over the same period in the same location. It would stay cooler during the day and warmer overnight.

Fast Fact:

How a light shelf works

Light shelves are placed horizontal next to windows and bounce light upwards into a room from below (rather than from above, as is the case with direct light into a window). They are particularly useful for casting daylight further into a room than might otherwise be possible and for reducing shadows caused by light coming directly through a window. The distance that light is cast depends on the time of day and year, and the orientation of the house.



Source: xbananasplitx.blogspot.com

5.2.2.7 Maximising natural light

Most of the windows can be on the northern side of the building, if suitable overhangs or shading is provided. Windows on the east and west should be reduced to avoid glare and heat gain. Windows on the south can provide diffused light, but will require additional high performance glazing to avoid heat loss through windows in the winter.

If the regulations are implemented (i.e. the window area is 15% of the floor area), then adequate natural light should be provided. Natural lighting can also be maximised through the use of light shelves to bounce light into deeper spaces – careful design is needed to ensure effective maintenance of reflective plane.

Daylight should become the primary light source in building for health, productivity and sustainability reasons. Natural light stimulates biological functions that are essential to human health, and has been observed to increase staff productivity and retention, to lead to higher retail sales, better school grades, and in the healthcare sector a reduction in the average length of hospital stay, quicker post-operative recovery; and reduced requirements for pain relief to name but a few of the myriad benefits.

5.2.2.8 Roof materials

Using reflective or light coloured roofing materials or installing a roof garden can reduce the building's cooling loads significantly as less heat is coming into the building.

5.2.2.9 Roof design for the installation of solar water heater (SWHs)

Roofs should ideally be tiled at 25 degrees to the horizontal for maximum solar energy collection with the best orientation for roofs bearing SWH being north facing, although this can vary between 15 degree east and 45 degree west. This will allow for maximum solar water heating and so reduce or omit the need for electrical backup or top up for most of the year. Even if SWHs are not included in the design at the time of construction, it is beneficial to design the pitched roof in such a way so as to allow for the easy installation of SWHs during a retrofit or refurbishment.

5.2.3 Include energy efficiency and demand management features

5.2.3.1 Energy sub-meters

If you can't measure it, you can't manage it! Sub-metering with a suitable monitoring system should be provided for all energy uses in a building of 100kVA or greater. Most modern building management systems (BMS) are able to perform this monitoring function.

Where practical it is advisable to provide separate sub-metering for lighting and power on each floor or tenancy (whichever is smaller) and ensure that appropriate mechanisms for monitoring are in place. This allows for quick identification of any excessive power so that it can be corrected, while flagging of large energy use areas or functions that can enable more accurate energy costs linked to actual consumption instead of floor space. Some of the common loads which need to be measured are car parks, chillers, air handling units, lifts (individually or as a bank), and common area lighting and power.

5.2.3.2 Building Management System (BMS) and building tuning

Building management systems (BMS) are an essential part of any modern building, and are used to measure and manage building performance. The effective control of building services and equipment, lighting and water, has a direct impact on operational costs and indoor environment quality. Electricity and water meters should be connected to the BMS, enabling the building manager to charge tenants for their use, but also to find leaks and to ensure that equipment and systems are running properly. Large and small buildings can all benefit from monitoring systems, and even well-designed building systems can get out of tune. It is recommended that full commissioning be done at practical completion with a re-commissioning after one year of occupation, followed by ongoing building tuning and a regular re-commissioning scheduled as part of the management regime.

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Fast Fact:

What is commissioning?

Verification that the building's energy related systems are installed, calibrated and perform according to the intended design and based on construction documents.

Fast Fact:

What is building tuning?

Building tuning is the process of assessing and adjusting all building systems to ensure that they function correctly during all weather seasons and adapt correctly to the building use and heat loads. This includes a period, normally 12 months, of trouble shooting and adjustment, and is required in order to ensure that a building achieves maximum energy performance.

5.2.3.3 Lighting in buildings

Use of energy efficient lighting: The use of energy efficient lighting is critical, specifically if it is solar powered. It is recommended that only light emitting diodes (LED) lighting be used, as the slightly higher upfront costs are soon balanced and superseded by the longer life spans and much lower energy requirements, allowing these to be powered by solar energy and save money on operational costs.

Design for lighting power densities of the lowest possible levels: Lighting power density refers to the total power consumed by lamps excluding ballasts in an area, and reflects good lighting design where artificial lighting with minimal energy consumption is specified. It is expressed as a function of the **nominal wattage of all lamps in the space divided by the floor area of that space.** In offices this should never exceed 3W/m2 per 100lux (measured at 720mm above finished floor level with the default maintenance factor of 0.8), but it is deemed desirable to target lower than this. Lux = Total Lumens ÷ Area in Square Meters

Various strategies can be used to achieve the goal of energy efficient lighting systems, including the use of electronic ballasts, efficient luminaires, metal halide lamps, designing to the correct lighting level (this is discussed in more detail in the section on Indoor Environmental Quality), and the efficient use of lighting control zones and daylighting.

Lighting power density worked example

A residential bedroom of 4m x 5m, has two 30 watt lamps.

- Determine total lamp capacity:
  30 Watt x 2 = 60 Watt
- Determine room area:
  4m x 5m = 20m²
- Determine lighting power density:
  60Watt/20m² – 3W/m²

Fast Fact:

Energy used for lighting

Only 10% of the energy used by an incandescent light bulb provides light. The other 90% is released as heat, which uses 30% of a buildings cooling energy.

5.2.3.4 Lighting zoning to promote energy efficiency

Older buildings often have a central switch for lights per floor, so that all the lights are on even if it is not needed. When the light requirements are designed in different zones it allows specific lights to be switched on where required, thus reducing the energy demand. This can result in enhancing the versatility of the space and promoting ongoing energy efficiency for the building. All individual or enclosed spaces should have individual switches, and the size of individually switched lighting zones should not exceed 100m². All lighting zones and switches should be clearly labelled and accessible by building users.

5.2.3.5 Motion occupancy and daylight sensors

It is becoming increasingly common for developers to specify motion occupancy sensors as part of the base build, and many tenants now require this as part of their fit-out. Daylight sensors, which are also becoming more common, allow for the automatic dimming of lights in peripheral zones that have greater natural daylighting, and the ramping up of lights in core zones which may have less natural light. A combination of the two may be used in parking garages, ensuring regular placement of lights thus providing orientation and safety, but with the remaining lights been zoned and motion controlled.

5.2.3.6 Peak energy demand reduction

Energy supply is most constrained at residential peak demand times between 07:00 to 10:00 and from 18:00 to 20:00. Project teams are encouraged to actively explore ideas to ensure that a building can reduce its peak electrical demand load on the grid by at least 15%. Alternatively, project teams can look to flatten loads so that the difference between peak and average demand does not exceed 40%.

5.2.3.7 Swimming pools

When designing a residential home it might also include a swimming pool. Natural swimming pools recreate pristine ponds and mountain pools found in nature. The water is kept sparkling clean by circulating it through an ecosystem of water plants. No salt, chemicals, or sterilisation equipment is needed, and thus it is very energy efficient.

If a standard pool is built, then ensure that a suitable pool pump is installed as per the size of the pool. A variable speed drive allows the pump to adjust to the requirements at any specific stage and is very efficient. Ensure that the pool pump is on a timer and set to optimum use depending on the seasonal conditions. If practical, consider running the pool pump during the daytime using solar power.

Case Study

My Green Home
– swimming pool pump
Pinelands
Cape Town

A family in Pinelands worked with the Green Building Council of South Africa to “green” their home. The swimming pool pump used to be their second highest electricity consumer (after the geyser), but they slashed its energy use by more than 80% by switching to an efficient variable-speed pump and reducing operating hours.

Source: www.mygreenhome.org.za

5.2.3.8 Good design of HVAC system

Mechanical heating, ventilation and air conditioning (HVAC) systems are typically responsible for about 40% of a building's energy use. Combining good base design principles (orientation and layout) with an efficient and suitably sized HVAC system can dramatically reduce energy consumption in the building

5.2.3.9 Use efficient and climatically appropriate mechanical cooling systems

A variable air volume (VAV) HVAC system uses water for cooling and has a building management system that controls the air volume and fan speeds. This allows for the targeted cooling of specific areas thereby increasing the energy efficiency of the overall system. The VAV system has sensors that open or close air valves as demand requires, causing fans with variable speed drives (VSD) to adjust their speed, resulting in a more efficient system than one that has a static volume of air. Energy is saved when the cooling and ventilation mechanisms are split as only the volume of air needed for ventilation is circulated. Also, in this system water rather than air is used as the temperature regulating mechanism. This system also enables different parts of the building to respond to different heating and cooling needs. Experience has indicated that the installation of a VAV system may show motor energy savings of up to 50%. Air-cooled systems are the least energy efficient HVAC systems and are only acceptable for small-scale uses such as in a small office in an industrial building

5.2.3.10 Design buildings with raised floors to allow for underfloor air displacement systems

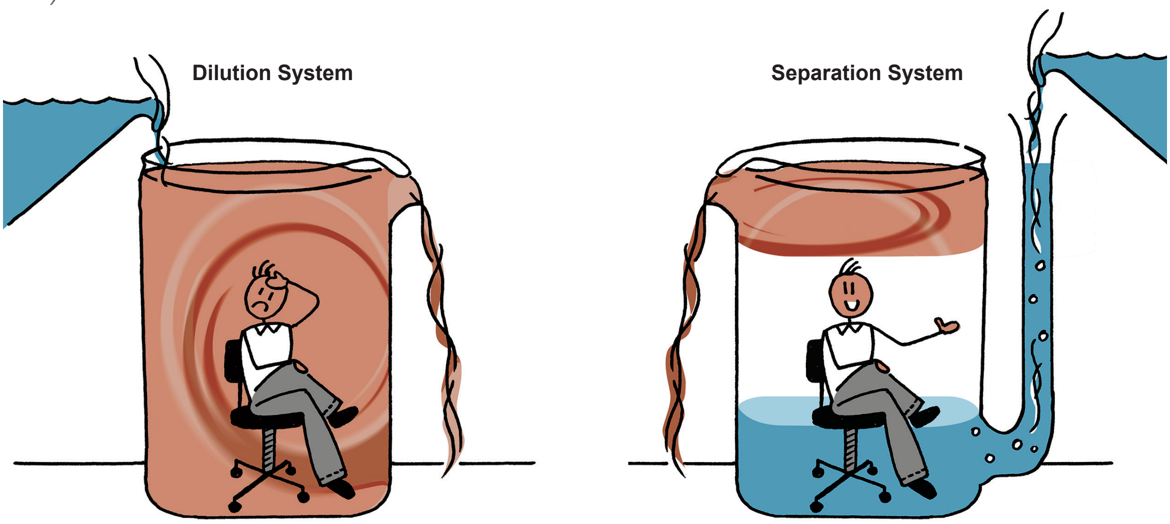
Underfloor air displacement systems allow air to be introduced from vents in the floor rather than being blown down from vents in the ceiling above as conventional HVAC systems do. Through these systems, the air released can be at a slightly higher temperature than when using conventional mechanical ventilation. This is both energy saving, and will have a positive impact on the indoor air quality as it displaces stale air upwards, instead of just diluting it. Warm air will naturally rise as cooled air from the top of the room moves down, also creating a healthy air exchange rate. Energy savings from displacement ventilation systems are estimated to be from 30 to 60% over standard systems.

Fast Fact:

How underfloor air displacement systems work

An underfloor air displacement system introduces low velocity fresh air at a lower temperature than the ambient room temperature via an underfloor plenum or void. This filters into the open plan space via grills in the floor. This air warms and rises, pushing the layer of stale hotter air and impurities upwards where it can be vented at a higher level. The image below clearly indicates the difference between the dilution system commonly used (where cold fresh air is introduced from above and mixes with the warmer air) and the underfloor displacement system which introduces air from below results in a separation and displacement of stale air.

Figure 10: Office stale air dilution (conventional HVAC systems) vs separation (underfloor air displacement systems)



Source: http://www.dnw.com.cn/dnw/show.php?itemid=4653&page

5.2.3.11 Design to include passive or active chilled beams

Chilled beams refer to a network of pipes located in the ceiling that circulate cool water to create passive (non-mechanised) conductive cooling – the cool air drops towards the floor and hot air rises to the top and is cooled again. This system is most appropriate in drier climates, such as in the interior of South Africa, as more humid climates, along the coast, can reduce the effectiveness of the system and lead to increased visible condensation of the beams.

This system saves energy as water is more efficient at cooling than air, water can be pumped in directly from the cooling tower, and less air needs to be supplied. This also allows smaller equipment to be sized, with additional reduced lifecycle energy costs.

Active chilled beam systems (also known as chilled ceilings) use the same cooling mechanism of chilled water running through pipes in the ceiling, but also include active air distribution systems, typically in the form of displacement ventilation systems where air is introduced through vents in the floor.

5.2.4 Consider on-site electricity generation

To reduce the reliance and demand on the national electricity grid and to reduce the greenhouse gas emissions associated with coal-fired power stations, it is possible to generate electricity on site using renewables such as the sun, wind, from agricultural waste products or through industrial processes. Local or on-site power generation also results in transmission losses being negligible whereas 8% of electricity is lost in transmission and distribution when using the national grid to transport electricity far from points of electricity generation.

The most appropriate solution will be determined by the following factors:

- The amount of electricity required
- The time of day that the electricity is required
- The space or site area available
- The presence of sufficient and accessible renewable resources

5.2.4.1 Design for on-site energy generation through renewable sources or co-generation: PVs (photovoltaics) are well suited to single buildings. PVs are panels placed on the roof and are designed to generate energy from sunlight, which is then transformed to usable electricity and stored in a battery until used. PV panels must be placed to be north-facing and at an angle of approximately 23° (in South Africa, with a latitude greater than 25°) to receive the greatest amount of direct sunlight to perform optimally and generate the maximum amount of electricity.

Co-generation is a method of electricity production that is more suitable for industrial plants. This process generates both heat and electricity. It can be a means of sharing heat as a by-product from one industrial process to another where heat is needed as an input to the process. This can reduce the amount of electricity required by industry.

5.3 How do we construct our buildings?

5.3.1 Implement site energy efficiency and demand management initiatives

Good construction practice will contribute towards a reduction of energy demand during construction and result in operational cost savings to the contractor.

The following strategies can be implemented on site to help ensure an on-site energy demand reduction:

- Ensure that all distribution boards are clearly labelled and metered to monitor and manage energy use.
- When working at night or in darkened areas of the building such as fire escapes, only light those sections which need to be illuminated for work or safety reasons by using targeted lighting. Installing motion detectors in site offices can be a useful tool to prevent wasteful use of lighting.
- Use energy efficient light fittings and equipment on site and in site offices.

5.4 How do we manage our buildings?

There are numerous initiatives which building managers and property owners can implement in order to reduce their energy load, and ensure the ongoing energy efficiency of a building. When undertaking a retrofit, the first step is to consider any of the design initiatives mentioned in the sections above which had not been included in the base build.

5.4.1 Energy efficiency through good operational practices

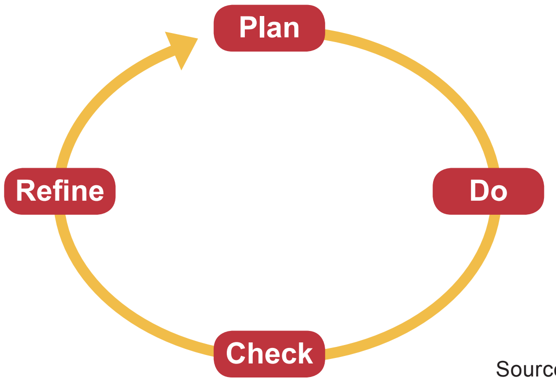
5.4.1.1 Brief overview of the energy management standards

SANS 50001:2011 provides for the implementation of the voluntary international ISO50001 standard by organisations in South Africa in order to improve their energy performance, energy efficiency, use and consumption. This aims to reduce greenhouse gas emissions and other related environmental impacts and energy costs through the systematic management of energy.

It outlines a four phase cyclical action plan requiring companies to:

- Plan: Conduct an energy review/energy audit of their operations and establish an energy baseline and retrofits that can be implemented.
- Do: Implement the energy management action plans.
- Check: Monitor and measure processes and key characteristics of operations that determine energy performance against the energy policy and objectives, and report the results.
- Refine: Take actions to continually improve energy performance and the Energy Management System.

Fgure 11 : The four-phase cyclical action plan for improved energy management in buildings



Source: SANS 50001:2011

Various voluntary standards are now incorporated into legislation in order to assist the government in achieving its energy efficiency targets. As time goes by, individuals and industry wishing to remain competitive and relevant are likely to comply with these standards. In particular, those wishing to obtain tax benefits through energy efficiency savings will need to comply with the requirements set out in ISO50001.

5.4.1.2 Energy audit and benchmarking

It is recommended that a full building energy audit be undertaken, in order to develop an understanding of the building's performance and to determine which areas should be targeted first for maximum gain at minimal cost. It is important to drive both energy efficiency and improved system performance. The intention is first to make existing systems as energy efficient as possible, and then to explore opportunities to supplement them with alternative forms of energy.

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Fast Fact:

What is an energy audit?

An energy audit is an analysis of the energy consumption of a specific building. The aim is to determine what could be done to improve energy efficiency in the building through technical interventions or behavior change. It will typically require a summary of the actual consumption of the various lights and appliances, while also taking into account the overall consumption (KWh), apparent demand (KVA) and related cost.

5.4.1.3 Energy meters and monitoring

In order to fully understand what a building's consumption is, it needs to be measured. This should work hand-in-hand with metering, monitoring and management. The facility manager should develop a thorough understanding of the energy flow in the building so as to reduce energy input without negatively affecting outputs. This can take the form of a visual inspection, coupled with metering (to provide energy use information to support energy management and identify energy saving improvements) and monitoring (to provide information to support the ongoing accountability and optimisation of building energy performance and identify opportunities for additional energy saving investments).

5.4.1.4 Energy Management Plan

Once the full picture is understood, an energy management plan can be drawn up to guide both maintenance and investment decisions going forward as buildings are transitioned towards greater energy efficiency and increased reliance on renewable energy sources.

5.4.2 Energy efficiency through maintenance planning

Some of the low or no cost initiatives that can be employed to promote energy efficiency are:

Consider formal or informal energy benchmarking: The GBCSA Energy and Water Benchmark Tool allows for free self-assessment of energy and water use in a building.

Energy consumption targets and monitoring: Set consumption targets and monitor against meter reading.

Change thermostat set points: Allow the thermal and humidity set points to vary with the season and ensure that building managers align these more closely to outdoor conditions. Modify thermostat set points towards the upper (24°C in summer) and lower (20°C in winter) thermal comfort boundaries. Research indicates that even a 2°C to 4°C increase in the temperature setting can save energy use by a factor of three.

Make use of a daytime cleaning service: This means that additional lighting is not required at night, and reduces the risk of energy waste through lights been left on in unoccupied zones.

Clear and easily understood light switch labelling is an effective way to reduce energy consumption especially after hours. This allows staff to only switch on those lights that they require.

Appliances: Select only energy efficient appliances for rental or purchase.

Case Study

Energy efficiency retrofits are affordable and shows returns

The V&A Waterfront, Cape Town, has managed to implement a 15% annual energy saving through retrofitting and refurbishment, with an anticipated payback period of less than three years

Source: Colin Devinish, V&A Waterfront

5.4.3 Energy efficiency through retrofitting or refurbishing

When considering a retrofit or refurbishment of a building it is advisable to "start from a clean slate" and review the initial design principles as outlined in the section "How do we design our buildings".

Some initiatives that show a rapid rate of return and could be argued easily for retrofit:

5.4.3.1 Repaint surfaces

Paint ceilings and walls light colours to reduce the amount of artificial lighting required as lighter colours help to reflect natural light deeper in to the building (especially soffits (ceilings) and walls of parking areas which should be painted white or off white). This should be in conjunction with painting the roof with reflective paint, to minimise the amount of heat coming into the building to reduce the energy required for building cooling.

5.4.3.2 Electrical lighting

An upgrading of the electrical lighting systems would include the replacement of inefficient fixtures, ballast upgrades, the phasing in of energy efficient lamps, luminaires and ballasts, and addressing over-lit spaces, especially parking garages

Fast Fact:

Impact of light replacement

"If we replaced all the incandescent light bulbs in the world with existing compact fluorescents we could close 705 of the world's 2400 coal plants."

Lester Brown

Founder, Earth Policy Institute

Lighting controls to incorporate the installation of motion sensors and zone lighting controls, sweep functions and photocell installations (timer with photocell to override if cloudy dark conditions outside).

Retrofit occupancy sensors as part of a lighting control system. As a minimum these are required in areas that are occupied less often such as libraries, meeting rooms, print areas and toilet blocks.

Retrofit daylight sensors to respond to current natural ambient light levels and so dim down or switch off lights.

Retrofit the installation electrical sub meters to allow building owners to identify where energy is been used and flag and remediate inappropriate usage.

Install time switches on small equipment, thus allowing them to switch off automatically when not in use.

Upgrade all motors to high efficiency motors which have the benefit of being both quieter and more energy efficient.

Retrofit power factor (PF) correction units to keep the PF of the building as close to 1 as possible. This enables improved energy efficiency and lowers operating costs for the building.

Fast Fact:

What is power factor?

Power factor is the ratio between the actual power load (kW) and the apparent power demand (kVA) drawn by an electrical load. It is a measure of how efficiently the load current is being converted into useful work output. More specifically, it is a good indicator of the effect of the load current on the efficiency of the supply system.

A power factor of 1 would mean 100% of the supply is being used efficiently. A power factor of 0.5 means the use of the power is very inefficient or wasteful.

So what causes Power Factor to change? In the real world of industry and commerce, a power factor of 1 is not obtainable because equipment such as electric motors, welding sets, fluorescent and high bay lighting create what is called an "inductive load" which in turn causes the amps in the supply to lag the volts. The resulting lag is called Power Factor.

By installing suitably sized switched capacitors into the power distribution circuit (also referred to as power factor correction), the Power Factor is improved and the value becomes nearer to 1 thus minimising wasted energy, improving the efficiency of a plant, liberating more kW from the available supply and reducing operating costs.

The purchase cost of the installation is usually repaid in less than 1 year's electricity savings.

Source: http://www.kwsaving.co.uk

Look to strategies for **Peak energy demand reduction**, which involves reducing the daily peak power usage of the building by means such as thermal ice storage or co-generation.

Specific green or renewable energy initiatives include the retrofitting of PVs to roofs, shading elements or facades, and the inclusion of on-site cogeneration of energy.

Domestic water and heating water can be upgraded through the installation of a new solar geyser to heat water, and a controls and or boiler upgrade.

Airside systems such as air handling and rooftop units and terminal units can also be upgraded.

Chiller plants should be considered for replacement or upgrade and control improvements. The ability to purge a building with fresh air before the chillers are started up should also be enabled.

The **heating plant** would benefit from an upgrade or replacement and control improvements (especially heating water supply temperature setpoint reset and review circulating pumps operation schedules)

The HVAC can be upgraded to the more **energy efficient VAV HVAC** system when the opportunity to replace the old one arises.

Install i**nternal blinds** or external shading devices.

Add **solar film** to existing glazing or replace single with double glazing.

Properly sized lighitng zones: Office lighting zones should not exceed 100m², and all enclosed areas should have their own operable and clearly labelled light switch.

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Fast Fact:

The decreasing cost of renewable energy

The cost of renewable energy sources is coming down. In 2008 the cost for solar was about R40 million per MW, but by 2013 the cost had reduced to R18 million per MW.

5.5 How do we enhance our precincts?

The economies of scale for renewable energy generation and district heating or cooling plants (central heating or cooling for groups of buildings) are possible at a precinct or community scale. This is because with a group of buildings relying on a system to provide electricity, or to heat and cool the buildings, there is less wasted energy and the capital, operational and maintenance costs are then shared between the users. Systems such as these can also make use of time-based sharing where some buildings use the energy during the day while others use it at night.

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Fast Fact:

Alternative energy in KwaDukuza

In KwaDukuza, the sugar cane industry is actively looking at diversification into cogeneration and biogas at an industry level.

5.5.1 Consider local energy production

Generating power within a precinct can be more viable than on a single building site as there is more space to be used to generate electricity, whether on the ground or on building rooftops. The most common and viable types of renewable energy production possible within a precinct include:

- Photovoltaics
- Wind power
- Geothermal
- Biomass

There are many incentives that can help to promote these, and the municipality and private developers should look at how best to harness these.