



THERMAL INSULATION PRODUCTS & SYSTEMS ASSOCIATION SA

A division of the Southern African Energy Efficiency Confederation



THERMAL INSULATION & ENERGY EFFICIENCY RETROFIT GUIDE

A summary of Energy Efficiency Regulations & Requirements, for thermal insulation products and systems used in the building industry.



THERMAL INSULATION & ENERGY EFFICIENT RETROFIT GUIDE

Prepared by

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(TIPSASA)

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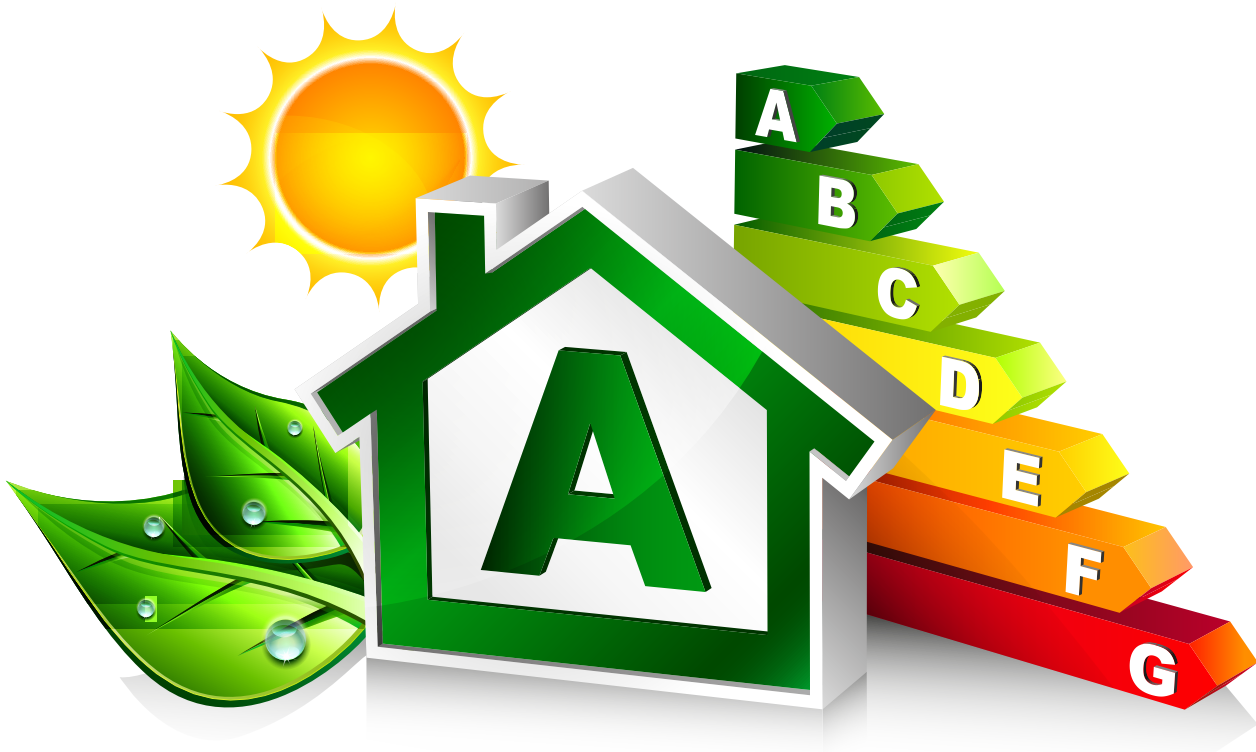
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CHAPTER 1

DEFINITIONS & TERMINOLOGY

The following section includes definitions, terminology and abbreviations which are relevant to energy efficiency and would benefit the reader in general.

Building envelope

The roofs, walls and floors of a building that bounds spaces that are either a habitable room or are conditioned and are protected against unnecessary energy loss or gain.

Note - The envelope controls heat gain in summer and heat loss in winter. Well-designed envelopes maximize cooling air movement and limits exposure to direct sunlight in summer. In winter, they trap and store heat from the sun and minimise heat loss to the external environment. The fundamental principles of passive design should be applied to a vast range of climates, building types and construction systems in South Africa.

Bulk insulation

Materials of low thermal conductivity, that mainly resists (slows) the transfer of conducted and convected heat, relying on pockets of trapped air or low conductive gasses within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through it and is proportional to its thickness, density and upper temperature.

Composite insulation

Two or more types of material combined to achieve a required level of performance, example: bulk insulation and reflective insulation used in combination

Condensation

The change of a vapour or gas into a liquid. The change of phase is accompanied by the evolution of heat.

Conduction thermal “C”

Is the transfer of heat through a solid (material)

Note: When one end of a metal rod (poker) is left in a fire the opposite end will also become warm although not in direct contact with the flame. The flow of heat along the length of the rod is by conduction.

The rate of heat (energy) flow is influenced by the temperature difference between one side and the opposite side (indoor to outdoor), the area of the material, the distance (thickness) through the material from warm side to cool side, and the thermal conductivity of the material. Most insulating materials (mass type) have low thermal conductivity, which combined with their thickness, density and the operating temperature, provides a barrier that slows conductive heat transfer.

Conductance thermal- Symbol (“C”)

A measure of the ability of a substance to conduct heat.

Conductivity thermal - Symbol “k”

The thermal transmission through a unit area of a building component or of a structure. Per unit temperature difference between the hot and cold faces measured in $W/(m^2.K)$ units.

Note - It is the time rate of heat flow through a unit area ($1m^2$) of 1 metre thick homogenous material in a direction perpendicular to isothermal planes, induced by a unit temperature gradient viz 1 metre cube of material will transmit heat at a rate of 1 watt for every degree of temperature difference between opposite faces. The measure of flow is given as $1W/(m.k)$

A “k” value cannot be given for Reflective sheet insulation as these are highly dependable upon surrounding air spaces, since heat flow for an air space is not directly proportional to its thickness. Variations in direction of heat flow, the position of the air space (viz horizontal, vertical, etc.) and variance in mean temperature, etc. have varying effects.

Convection heat

As air warms it becomes lighter, due to expansion, therefore it rises and it is replaced by cold air which is heavier. Liquids and gasses react in a similar fashion, as the liquid or gas warms it expands (become less dense - lighter) and rise, the warm liquid is displaced by denser colder material at a lower level.

Deemed-to-satisfy

The selective procedure and application of thermal insulation materials to a building system (structure) within a specific climatic zone and region, which will ensure an equable environment in respect of, temperature swing, humidity fluctuation, air and acoustic impact, to which the greater percentage (>80%) of persons express themselves comfortable in a prescribed enclosed area and through which the energy efficiency yields a satisfactory return on investment.

Deemed-to-satisfy requirement

Non-mandatory requirement that ensures compliance with a functional regulation.

Density

The mass of a substance per unit of volume. SI unit of measure is kgm^3 .

Emissivity – symbol “e”

The ratio of the power per unit area radiated by a surface to that radiated by a black body (surface) at the same temperature. A black body therefore has an emissivity of 1 and a perfect reflection has an emissivity of 0.03. The emissivity of a surface is equal to its absorbance.

Emittance- symbol “m”

The radiant of luminous flux emitted per unit area of a surface measured in watts per square meter (Wm^2)

Fabric

The basic building structure that includes components such as floors, walls, ceilings and roofs as would affect the internal environment.

Heat flow

The more significant of any heat flows.

Note: Heat flows from hot to cold environments and this is considered to be the direction of natural heat flow. Thus “upwards” implies heat flow from a conditioned space through the ceiling or roof and “downwards” implies the opposite. Likewise, horizontal flows can be described as inwards and outwards.

Heat transfer

The temperature of energy (heat) induced by a temperature difference by conduction, convection, radiation or any combination.

Insulation

Material or combination of materials that resist heat flow.

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

Insulation R-value

All insulation materials are rated for their performance in restricting heat transfer. This is expressed as the “R value”, which is the measure of the material’s resistance to heat transfer, alternatively known as thermal resistance. The higher the R value the greater the insulation effect. It is the reciprocal of thermal conductance.

Occupancy

Particular use or the type of use to which a building or portion thereof is normally put or intended to be put.

Note: Regulation A20 classifies and designates occupancies

Passive design

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

Performance

Behaviour of a building as a whole or any part of it related to use

Reflective insulation

Any material with a reflective surface such as a reflective foil laminate, reflective barrier, foil batt or the like capable of reducing radiant heat flow, in combination with air spaces and low emissive surfaces

R-Value

The measurement of the thermal resistance of a material which is the effectiveness of the material to resist (slow down) the flow of heat, i.e. the thermal resistance ($\text{m}^2\cdot\text{K}/\text{W}$) of a component calculated by dividing its thickness by its thermal conductivity.

System R-Value

The sum of the R-Values of the individual component layers in a composite element including the air space and associated surface resistances, as per an internationally recognized test or calculation method. It is reciprocal of the "C" value.

Thermal mass

The ability of building materials to store heat. Heavy weight building materials store a lot of heat and have high thermal mass where lightweight materials have a low thermal mass.

Thermal resistance symbol "R value"

The resistance to heat transfer across a material. It is the mean temperature difference between two defined surfaces of a material or construction system under steady state conditions

Note: Thermal resistance is measured as an R-Value. The higher the R-Value the better the ability of the material to resist heat flow is measured in $\text{m}^2\cdot\text{K}/\text{W}$



CHAPTER 2

INTRODUCTION

2.1 INTRODUCTION

TIPSASA (Thermal Insulation Products & Systems Association SA), in affiliation with the Southern African Energy Efficiency Confederation (SAEEEC), endeavours to promote energy efficiency principles for sustainable growth and prosperity. TIPSASA is a non-profit company that consists of manufacturers, suppliers, contractors and consultants in the South African Thermal Insulation Industry.

2.2 BACKGROUND

The Energy Efficiency Regulations were promulgated in November 2011, which made the installation of thermal insulation mandatory in certain occupancy classes. Yet, there are still some contractors who do not install thermal insulation even though it has been specified as there is little or no enforcement or, it has been installed but there is no adherence to the prescribed minimum thermal resistance values as indicated in SANS 10400-XA Energy usage in buildings. Sub-standard products are installed for the sake of “compliance”, resulting in under performance due to cheap products that have not been tested to SABS standards.

Compulsory occupancy classes are: entertainment & public assembly, theatrical & indoor sports, places of instruction such as schools, places of worship, exhibition halls. Museums, places of detention, hospitals, frail care centres, health care, shops, hotels, dormitories, houses and hospitality, i.e. B&B's.

2.3 MISSION

The mission of the Association is to promote and maintain the common interests of the members of the Association and to improve the social, economic and environmental sustainability of Southern Africa by the promotion of energy conservation through the greater use, better understanding and application of thermal insulation and to enforce guidelines and rules which govern the Association.

2.4 FOREWORD

The Building Sector has great potential for energy savings. Building design is the major factor determining the energy efficiency of a building. If a house or building is properly insulated the need for air-conditioning in summer or heating during winter will be reduced substantially.

The Regulation demands that new buildings be based on efficient design, with existing construction being energy inefficient. The challenge is to retrofit these into energy efficient buildings. Major energy savings can only be achieved through changes in people's attitude and behaviour, which depends on informed professionals and designers advising the consumer as to what options exist.

Fortunately homeowners are becoming increasingly interested in improving the energy efficiency of their homes to reduce costs, improve comfort and help protect the environment. However, many older houses in South Africa are relatively "drafty", lightly insulated or not insulated at all. This can result in higher heat losses and energy bills. Space heating accounts for a high percentage of residential energy use in winter and therefore makes up a good proportion of the overall energy.

2.5 OBJECTIVE

This Guide is intended to provide a basic overview of Energy Efficiency Regulations, requirements, and possible interventions (retrofitting) that relate to retrofitting insulation to improve thermal efficiency in buildings. These guidelines are not intended to prove suitability of any particular product for any given application.

This publication is intended as a useful reference to architects, building designers and building owners.

The National Energy Efficiency Strategy (NEES) proposes various measures and implementation targets, varying between 3 months to 5 years, depending on ease of implementation. The abovementioned is to reach the 20% reduction of energy consumption of the residential building stock by 2030.

These measures include:

- Tightening of building standards
- Tax incentives for building retrofits
- Energy Performance Certificates (EPC's) for residential buildings

The proposed measures will certainly have an impact on the property market. The purpose of an Energy Performance Certificate is to record and show how energy-efficient a property is. Shown as a chart, it uses a similar rating system to ratings provided with domestic appliances, for example, washing machines and fridges. The certificate will provide a rating of the property from A to G, where A is very efficient and G is very inefficient.

There are several options that a homeowner/building owner can consider to reduce heat loss or gain, including adding, or retrofitting, insulation in the building.

Retrofitting means "providing something with a component or feature not fitted during manufacture or adding something that it did not have when first constructed". It is often used in relation to the installation of new building systems, such as heating systems, but it might also refer to the fabric of a building, for example, retrofitting insulation or double glazing.

Refurbishment on the other hand implies a process of improvement by cleaning, decorating, and re-equipping. It may include elements of retrofitting. The term 'renovation' refers to the process of returning something to a good state of repair. A single project may include elements of retrofitting, refurbishment and renovation.





CHAPTER 3

SOUTH AFRICAN REGULATORY REQUIREMENTS

3.1 ENERGY EFFICIENCY REGULATIONS & STANDARDS

From the 9th of November 2011 it has become compulsory for all new buildings, and extensions to buildings, including homes, schools, shops, offices, places of worship and hotels, in South Africa to meet a set of standard energy efficiency regulations. These regulations, included as an amendment to the National Building Regulations and Building Standards Act, require building companies, local authorities, property owners, suppliers and architects to comply with the regulations so that energy that is used by buildings is reduced.

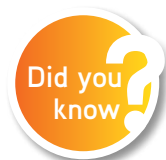
This amendment is the first of many amendments that will fit under the environmental sustainability section of the National Building Regulations and Building Standards Act in an effort to decrease the impact of the building sector on the environment. Future amendments include sections on water usage, materials and recycling.

At present the act only applies to new buildings and extensions to buildings, however regulations for existing buildings are going to be added in the near future. Building plans cannot be passed unless they meet the standards prescribed in the regulations.

The regulations focus on two major elements:

1. **Hot Water:** The regulations require that new buildings have to be built so that 50% (volume fraction) of the annual heating requirements of a building are provided by sources other than electrical resistance heating. Solar heating, heat pumps and other renewable sources of energy are all possible methods of meeting these heating requirements.
2. **Energy efficient design:** The regulations address the design elements of a building including orientation of the building, use of natural light, and insulation so that buildings are kept cool in summer and warm in winter naturally through design. This ensures that less energy will be consumed for heating and cooling purposes.

SANS 10400-XA Energy Usage in Buildings address the finer details of how to comply with the legislation.

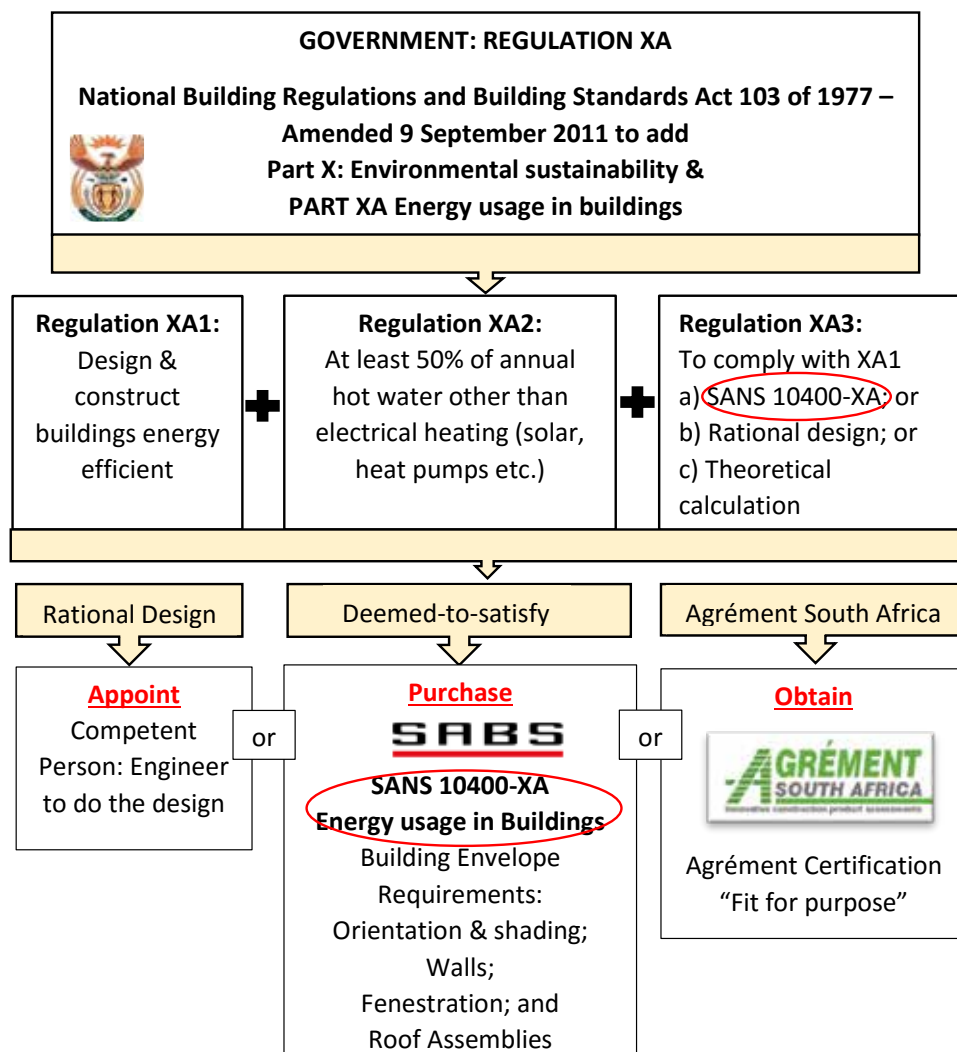


Energy used by the building sector account for up to 40% of the total energy used in the world.

3.2 BUILDING CODE REQUIREMENTS

When a building is being altered, the Building Act requires that it comply with SANS 10400-XA Energy usage in buildings. Regulation XA 1 reads “In order to contribute to the reduction of greenhouse gases, buildings and extensions to buildings in respect of which plans and specifications are to be drawn and submitted in terms of the Act, having A1, A2, A3, A4, C1, C2, E1, E2, E3, E4, F1, F2, F3, G1, H1, H2, H3, H4 and H5 occupancies or building classifications in accordance with Regulation A20, excluding garage and storages areas contained within such occupancies, shall be designed and constructed so that they:

- are capable of using energy efficiently while fulfilling user needs in relation to vertical transport, if any, thermal comfort, lighting and hot water; or
- have a building envelope and services which facilitate the efficient use of energy appropriate to its function and use, internal environment and geographical location”.



3.3 OCCUPANCY CLASSES EFFECTED BY LEGISLATION

This guide only addresses “deemed-to-satisfy provisions” to achieve compliance with the regulations. “Deemed-to-satisfy provisions” means to ensure compliance with the functional regulation.

The installation of thermal insulation is compulsory in the occupancies highlighted in green.

SANS 10400 PART A REGULATION A20 CLASS OF OCCUPANCY APPLICABLE TO REGULATION XA1			
A1	Entertainment & Public Assembly	E3	Other institutional (residential)
A2	Theatrical & indoor sport	E4	Health care
A3	Places of instruction	F1	Large shop
A4	Worship	F2	Small shop
A5	Outdoor sport	F3	Wholesalers' store
B1	High risk commercial service	G1	Offices
B2	Moderate risk commercial service	H1	Hotel
B3	Low risk commercial service	H2	Dormitory
C1	Exhibition hall	H3	Domestic residence
C2	Museum	H4	Dwelling house
D1	High risk industrial	H5	Hospitality
D2	Moderate risk industrial	J1	High risk storage
D3	Low risk industrial	J2	Moderate risk storage
D4	Plant room	J3	Low risk storage
E1	Place of detention	J4	Parking garage
E2	Hospital		

3.4 EPC - ENERGY PERFORMANCE CERTIFICATE

What is an Energy Performance Certificate?

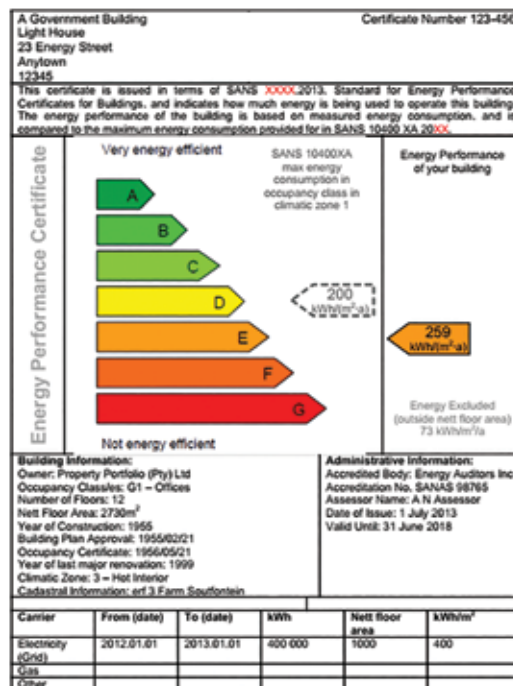
EPC's for buildings are documents that contain statistics about the energy consumption and efficiency of a building or facility. EPC's enable building owners or managers to thoroughly assess the energy performance of buildings and consequently determine energy efficiency interventions that will reduce energy consumption, energy costs and greenhouse gas emissions from buildings. EPC's are considered as drivers of energy efficiency for buildings because they can provide information on the energy performance of buildings and be used as tools to track the energy efficiency of buildings over time.

Similar to the "white goods" labelling, i.e. electrical goods used domestically such as refrigerators and washing machines, the EPC tells you how energy efficient a home/building is on a scale of A-G. The most efficient homes/buildings – which should have the lowest energy bills, i.e. low energy consumption – are in band A.

The Mandatory Display and Submission of Energy Performance Certificates (EPC's) for Buildings under section 19 (1) (b) of the National Energy Act, was published in the Government Gazette No.43972 on 8 December 2020.

EPC's are used extensively around the world as a mechanism:

- To focus on energy efficiency
- To benchmark the energy performance of a building against industry benchmarks or national norms
- For establishing a register of information on energy performance of buildings, which can be used to support policy development by government and/or to support retro-fitting programs by building owners and operators.



3.5 IMPLICATIONS OF ENERGY PERFORMANCE CERTIFICATE FOR RESIDENTIAL BUILDINGS

The Energy Performance Certificate of Residential Buildings could introduce a number of new requirements similar to electrical certificates; i.e.

- a seller to secure that an energy performance certificate (EPC) has been commissioned before marketing of the property;
- an EPC has been commissioned by an accredited Assessor and paid for;
- a new duty on the person acting on behalf of the seller (estate agent) to be satisfied that an EPC has been commissioned before commencing marketing.





CHAPTER 4

ENERGY EFFICIENCY PERFORMANCE PRINCIPLES

4.1 THE BUILDING ENVELOPE

The building envelope is the outer layer of the building that separates the indoor living space from the outdoor environment. It is made up of the floors, walls, windows, doors and roof.

The building envelope is an important part of energy efficiency retrofit projects as many older homes have high rates of air leakage and building envelope areas that are not well insulated — and high space heating and cooling energy costs.

Like any renovation, retrofitting the building envelope requires careful planning. Before you decide to go ahead with the project, it is important to clearly identify the areas that you want to improve. A thorough inspection of the existing structure should be done so that any current problems can be corrected before starting with the renovation. Many homeowners experience houses that are cold, drafty or have high heating bills, especially during winter. In addition to protecting the building occupants from the prevailing outdoor elements, the conditions inside the building must be maintained within a range that is conducive to the occupant's comfort, health and safety.

The process of improving the energy efficiency of the entire building envelope can seem like an overwhelming task. An understanding of the principle that the house functions as a system is critical for anyone undertaking a building envelope retrofit. Prioritizing the different aspects of the work and learning about viable retrofit techniques can help you to work through the many decisions that must be made. A retrofit of the building envelope should not be started until all decisions about construction details have been thought through. Thorough planning will help you to develop a realistic understanding of the work to be done and the costs involved.



PASSIVE DESIGN

Always consider “passive design” as an option. Passive design is a design that does not require mechanical heating or cooling. Buildings that are passively designed take advantage of natural energy flows to maintain conditions required for human thermal comfort.

Incorporating the principles of passive design:

- Significantly improves comfort
- Reduces or eliminates heating and cooling bills.
- Reduces greenhouse gas emissions from heating, cooling, mechanical ventilation and lighting.

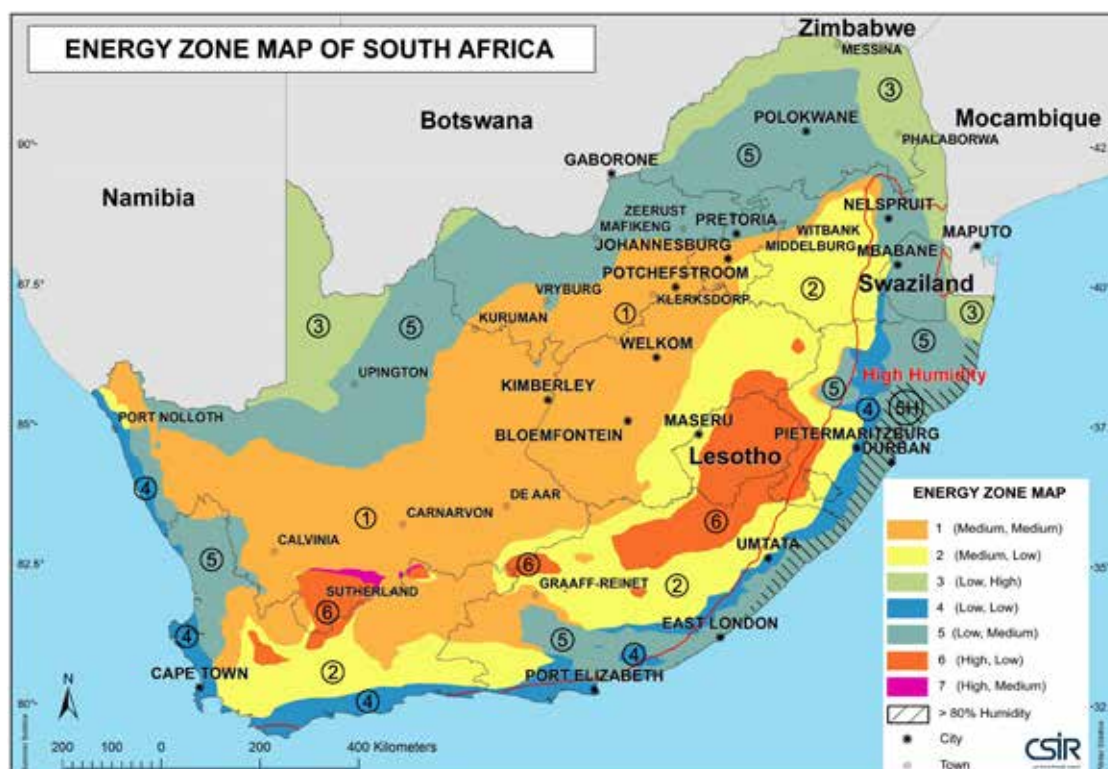
4.2 ENERGY ZONES

Design for comfort and energy efficiency is influenced by climatic considerations. The maximum energy demand and consumption per building classification shall be established in accordance with the energy zones.

To achieve best results, building design and construction materials should be appropriate to the climate of a region. While each of the zones have different heating and cooling needs, the same principles of energy efficient design apply, with their application varying slightly, e.g. different levels of insulation or thermal mass or variations in window sizes, orientation and shading.

The deemed-to-satisfy provisions of the thermal resistance (R-value) are based on the climatic conditions and energy conservation measures of the particular zones, including dry bulb temperatures; thermal neutrality, humidity and southern coastal condensation risk (see map below and table with example of locations and zones).

ENERGY ZONE																
	1		2		3		4		5				6		7	
												5H				
Heating & Cooling	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Low, Medium, High	M	M	M	L	L	H	L	L	L	M	L	M	H	L	H	M
NOTE: Zone 5H high humidity to be taken into account																



ENERGY ZONE MAP

The map indicates graphically the areas and boundaries of the 7 energy zones throughout South Africa.

The energy zones was determined by the amount of heating and cooling energy required to bring the internal temperatures of buildings into thermal comfort levels. The legend on the map indicates the level of heating and cooling energy needed in accordance with the Energy zone is as follows:

- Zone 1 = Medium heating and medium cooling
- Zone 2 = Medium heating and low cooling energy
- Zone 3 = Low heating and high cooling energy
- Zone 4 = Low heating and low cooling energy
- Zone 5 = Low heating and medium cooling energy (Zone 5H – 85% humidity area)
- Zone 6 = High heating and low cooling energy
- Zone 7 = High heating and medium cooling energy

ANNUAL HEATING & COOLING DEMAND							
Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 5H	Zone 6	Zone 7
Medium, Medium	Medium, Low	Low, High	Low, Low	Low, Medium	High, Humidity	High, Low	High, Medium
Aberdeen Amalia Bakerville Beaufort West Bloemfontein Brandvlei Calvinia Carletonville Citrusdal Colesberg De Aar Douglas Edenburg Garies Germiston Hartswater Hoopstad Jacobsdal Johannesburg Kimberley Klerksdorp Kuruman Lichtenburg Loxton Makwassie Malmesbury Mangaung Odendaalsrus Orkney Parys Pilgrim's Rest Postmasburg Potchefstroom Prieska Richmond Roodepoort Smithfield Springbok Taung Theunissen Tulbagh Venterstad Virginia Vryburg Welkom Winburg	Adendorp Alice Aliwal North Amersfoort Balfour Bedford Belfast Bergville Bethal Bethlehem Burgersdorp Calitzdorp Carolina Ceres Colenso Cradock Darlington Dullstroom Eloff Emalahleni Ermelo Estcourt Ficksburg Harding Harrismith Heidelberg Kokstad Ladismith Maclear Marquard Maseru Memel Middelburg Moorivier Nigel Ogies Rouxville Springs Standerton Villiers Volksrust Wakkerstroom Warden Wepener Witbank Worcester	Augrabies Falls Bela Vista Chokwe Ellisras Giyani Kakamas Komatipoort Langklip Magude Macia Manhica Maputo Messina Mhlume Phalaborwa Punda Maria Thohoyandou Usakos	Albertinia Alexander Bay Alexandria Bisho Bredasdorp Butterworth Cape Town George Gourits Grahamstown Greytown Heidelberg WC Hopefield WC King William's Town Knysna Langebaan Mosselbaai Patensie Paulpietersburg Piet Retief Pietermaritzburg Port Elizabeth Port Nollith Riversdale Saldanha Bay Simonstown Uitenhage Umtata Vredenburg WC Vryheid KZN	Addo Algoa Bay Barberton Belfast Brits Clanwilliam Colenso Duiwelskloof East London Graskop Groblersdal Hluhluwe Hotazel Keimoes Kirkwood Ladysmith Lambert's Bay Loskop Dam Louis Trichardt Mahikeng Mmabatho Modimolle Mbombela Pienaarsrivier Piketberg Pofadder Polokwane Port Alfred Pretoria Rustenburg Settlers Sishen Soekmekaar Tzaneen Vaalwater Vrendendal WC Waterberge Zebediela Zeerust	Beacon Bay Darnall Durban East London Empangeni Eshowe False Bay Harding Hamburg Ixopo Kranskop Lusikisiki Margate Melmoth Pietermaritzburg Pinetown Port Shepstone Port St Johns Ramsgate Richards Bay St. Lucia Tonga Stanger Ulundi Umkomaas Uvongo	Bergville Cedarville Clarens Elliot Fouriesburg Hofmeyer Indwe Jamestown Lady Grey Lesotho Matatiele Molteno Sutherland Ugie	Fraserburg

4.3 THERMAL PERFORMANCE REQUIREMENTS

Thermal Insulation shall comply with minimum required R-values and be installed so that it

- abuts or overlaps adjoining insulation, or is sealed,
- forms a continuous barrier with ceilings, walls, bulkheads or floors that contribute to the thermal barrier, and
- does not affect the safe or effective operation of any services, equipment or lighting installation.

	ENERGY ZONE																	
	1		2		3		4		5				6				7	
									5		5H							
Heating & Cooling	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C		
Low, Medium, High	M	M	M	L	L	H	L	L	L	M	L	M	H	L	H	M		
Minimum required Total R-value(m².K/W)	3.7		3.7		3.7		3.7		3.7		2.7		3.7		3.7			
Direction of heat flow	Up		Up		Up and Down		Up		Down				Up		Up			
NOTE: Zone 5H high humidity to be taken into account.																		

All tile roofs in zones 1, 2, 3, 4 and 6 shall have a tile underlay or radiant barrier and the joints shall be sealed.

The thermal resistance of a reflective material or assembly shall be expressed as system R-value (R_{sys}), and shall be the combined thermal resistance arising from:

- Contributions by any bulk material that is part of the material or assembly; and
- Contributions by the adjacent spaces or air spaces that the material or assembly reflectively bounds.

Note: The R-value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. The thermal performance of reflective insulation is influenced by dust and could be adversely effected.

Bulk insulation shall be installed so that

- it maintains its position and thickness, other than where it crosses roof battens, water pipes or electric cabling; and
- in ceilings, it overlaps the wall member by not less than 50mm, or is tightly fitted against a wall where there is no insulation in the wall. Table 1 in Chapter 5.4 gives typical data and deemed-to-satisfy thicknesses of generic insulation products.

A roof assembly that has a metal sheet roof fixed to purlins, rafters or battens shall have a spacer, the depth of the spacer to be equal to the material thickness required, to eliminate the compression of flexible bulk insulation.

Caution

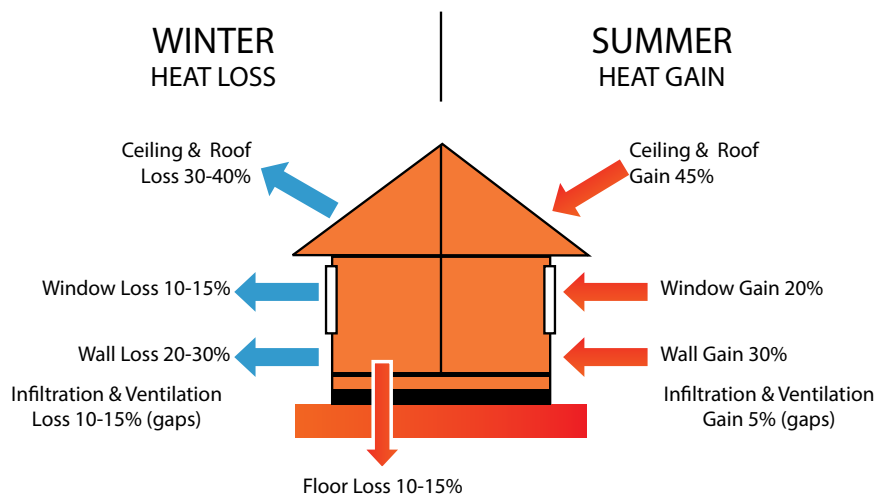
Compression of flexible bulk insulation, severely impacts the thermal performance of the insulation installed over purlin. Allowance must be made to compensate for any compression by using mechanical spacers in accordance with the manufacturer's installation specification.

CHAPTER 5

THERMAL INSULATION

5.1. INSULATION

Insulation is installed to reduce heat loss or gain through the building envelope. Insulation acts as a barrier to heat flow, reducing heat loss in winter to keep the house/building warm or reducing heat gain in summer to keep the house/building cool. Inadequate insulation and air leakage are the main causes of heat loss in homes.



Approximate winter heat loss and summer heat gain

The most economical time to install insulation is during construction. Retrofitting may be more difficult and costly, depending on the application. Ensure compliance with the Energy Efficiency Regulation XA and SANS 10400-XA Energy usage in Buildings. See Chapter 4.3. Thermal Performance Requirements.

Insulation can be installed in the ceiling, walls and floor.

The key choices to be made are:

- the insulation format (radiant barrier, blanket, rigid or loose fill) and material (for example, reflective foil membrane, glass-fibre, cellulose-fibre, wool, polyester) used in various parts of the building, and
- the amount specified to achieve the desired R-value (that is, the desired level of thermal resistance).

The format and material specified will depend on client preference, the type of construction and on which part of the building envelope is being insulated.

When specifying insulation materials, the key consideration is the thermal performance of the material over the life of the building. Also consider the sustainability of the insulation material – for example, the emissions associated with its manufacture.

See General Requirements of the South African National Building Regulations SANS 10400 Part XA: Energy usage in buildings to ascertain insulation requirements.

Ensure products comply with fire safety requirements. All insulation products must be tested for flame spread and must have a fire test report.

5.2 HOW INSULATION WORKS

There are many types of insulation, derived from natural, mineral or petrochemical sources. Thermal insulation acts as an inhibitor to heat transfer/heat flow either by conduction, convection, radiation or a combination of these, reducing heat loss in winter to keep the house/building warm and/or reducing heat gain in summer to keep the house/building cool.



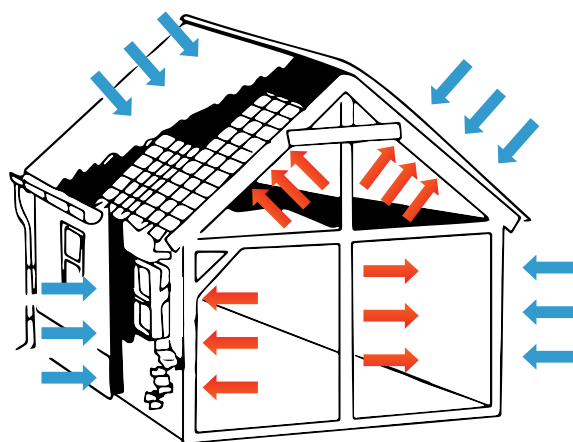
Conduction and convection types of heat are both dealt with using bulk insulation. This type of insulation is made of low density materials, normally incorporating trapped air pockets (which don't conduct heat very well).

Radiant heat can be reflected, and this is where reflective insulation like foil barriers come into their own. Reflective Insulation (radiant barrier) works on a different concept to conventional bulk insulation materials, i.e. it reduces heat transfer by radiation.

Understanding that the basis of insulation is to trap either air or gas is fundamental when designing or installing insulation into a retrofit scheme – reducing air movement between, around or across the surface of the insulation (referred to as thermal bypass) is crucial if insulation materials are to perform to their optimum.

Depending on the construction of the fabric, insulation products are retrofitted outside, between or inside the existing wall, floor and roof elements. For walls, these are designated as cavity insulation, external wall insulation (EWI) or also known as external thermal insulation composite systems (ETICS) and internal wall insulation (IWI). Where they are located will depend on a number of external factors necessitating a pre-installation assessment by the specifier or the installer.

Insulation is a very significant element in a building's thermal performance, but it is not the only one. Even if a home is well insulated, heat can still escape through air gaps, windows, gaps in the insulation, and building elements such as framing, as explained in thermal bridges below. A building's thermal performance depends on all elements of the building working together.



Thermal insulation prevents the flow of heat in and out of a building

5.3 WHAT ARE R-VALUES?

Insulation materials are rated for their performance in restricting heat transfer. This is expressed as the R-Value, also known as thermal resistance. The R-Value is a guide to its performance as an insulator - the higher the R-Value, the better the insulation (i.e. resistance to heat flow) it provides.

R-Values are expressed using the metric unit's $\text{m}^2\cdot\text{K}/\text{W}$, where:

- m^2 refers to one metre squared of the material of a specified thickness;
- K refers to a one degree temperature difference (Kelvin or Celsius) across the material;
- W refers to the amount of heat flow across the material in watts.

Use the nominal R-Values as listed by the manufacturer on the packaging of the insulation to determine the performance.

Bulk Insulation which have the same R-Value will provide exactly the same insulating effect as each other, provided they are correctly installed. The higher the R-Value the more effective the insulation. Products must be installed in accordance with the manufacturer's installation specifications.

Reflective insulation makes use of a low emissivity surface to increase the thermal resistance of adjacent or enclosed air space(s). Emissivity is a measure of the efficiency in which a surface emits thermal energy. The thermal resistance of a reflective material or assembly is expressed as system R-value (R_{sys}) which is the combined thermal resistance arising from contributions by the adjacent air spaces that the material or assembly reflectively bounds.

Reflective insulation has very low emittance values "E-values" (typically between 0.03 – 0.05, compared to 0.90 for most insulation) and that significantly reduces heat transfer by radiation.

The information available on the product data sheet and/or label must include the R-Value. Ensure that the insulation is suitable for the particular application. Ask if performance guarantees and/or test certificates are available.

R-Values can differ depending on the direction of heat flow through the product. The difference is generally marginal for bulk insulation but can be pronounced for reflective insulation.

- Up R-Values describe resistance to heat flow upwards (also known as 'winter' R-Values).
- Down R-Values describe resistance to heat flow downwards (also known as 'summer' R-values).

The thermal performance of a building depends not only on the insulation material but also on the thermal performance of other elements such as roof covering materials, fenestration etc.

High density materials such as concrete, brick or stone provide excellent thermal mass but have low R-values and so are poor insulators. Thin metals such as profiled steel claddings and fibre-cement sheets also have low R-values and are therefore also poor insulators.

To determine insulation requirements, see section 4.3 Thermal Performance Requirements.

WHAT IS THE DIFFERENCE BETWEEN R-VALUE AND TOTAL R-VALUE?

The R-Value is the material thermal resistance, i.e. product only. The total R-Value describes the total thermal resistance of the system to heat flow that is provided by a roof and ceiling assembly, a wall or a floor (inclusive of all materials and air films). These values are calculated by adding the thermal resistance of each component, including the insulation. Total R-Values are the best indicator of performance, with insulation generally contributing the most within the building envelope.

5.4 HOW TO ESTABLISH R-VALUE REQUIREMENTS

Thermal Insulation shall comply with the minimum required added R-values according to the energy zones. All insulation must be marked on the packaging of each roll, or bundle of batts or on a label inside or securely attached to the package with the following information:

1. the manufacturer's name, and trade name or trade mark, or both;
2. the product type identification;
3. the batch identification or date of manufacture;
4. the nominal length in metre, width and thickness in mm of the material;
5. the nominal area of the material in m²;
6. **the nominal thermal resistance (R-Value) of the material, in m².K/W;**
7. a statement that the material is suitable for use as a water vapour barrier, where relevant;
8. **the fire performance classification in accordance with SANS 428/SANS 53501-1;**
9. a statement that the material is "combustible" or "non-combustible", as relevant; and
10. a warning, referring to precautions for health and safety during handling and installation of the insulation material.



Data sheets and installation guidelines for the product should be obtained from the supplier of the material to ensure correct usage and installation.

The following deemed-to-satisfy rules are to be applied by the building owner at the design stage of the building if they chooses not to consider rational design option. A roof and/or ceiling that are part of the building envelope must achieve the Total R-Value specified in the table below, for the direction of heat flow.

MINIMUM TOTAL R-VALUES OF ROOFS AND CEILINGS							
	Energy zone						
	1	2	3	4	5		6 & 7
					5	5H	
Minimum required Total R-value (m ² .K/W)	3.7	3.7	3.7	3.7	3.7	2.7	3.7
Direction of heat flow	Up	Up	Up and Down	Up	Down		Up
Minimum Total R-value (m ² .K/W) of roof and ceiling materials (Roof covering includes outside air film, non-reflective unventilated air space and plasterboard only).	0.30 – 0.35				0.36-0.48		0.30 – 0.35
Estimated Minimum added R-Value of Insulation (m ² .K/W)	3.35	3.35	3.35	3.35	3.34	2.22	3.35
Note: Zone 5H high humidity to be taken into account. Vapour barriers, adequate ceiling insulation and roof ventilation must be provided.							

The direction of heat flow in the table is considered to be the predominant direction of heat flow for the hours of occupation of the building. It takes into account the higher rate of occupancy of houses at night time rather than day time. Where "downwards" is specified in the table, this indicates summer heat (a downwards heat flow into the building) as the major concern. A combined downward and upwards requirement means that summer and winter (heating and cooling) have a roughly similar level of energy use on an annual basis, while an upward flow indicates that heat loss from the building during winter as the major concern.

TABLE 1- EXAMPLE OF GENERIC INSULATION PRODUCTS MINIMUM DEEMED-TO-SATISFY THICKNESSES IN mm IN ORDER TO COMPLY WITH R-VALUE REQUIREMENTS OF SANS 10400-XA.

Description			Energy Zones						
			1	2	3	4	5		6
							5	5H	
Minimum required Total R-value(m ² .K/W)			3.7	3.7	3.7	3.7	3.7	2.7	3.7
Direction of heat flow			Up	Up	Up and Down	Up	Down		Up
Minimum Total R-value (m ² .K/W) of roof and ceiling materials (Roof covering includes outside air film, non-reflective unventilated air space and plasterboard only).			0.30 - 0.35				0.36 – 0.48		0.30-0.35
Estimated minimum added R-value of insulation(m ² .K/W)			3.35	3.35	3.35	3.35	3.34	2.22	3.35
Example of Product			Recommended levels (thickness in mm) of Thermal Insulation to be used equivalent to R-Value required. Thermal conductivity values used are generic.						
Generic Insulation Product	Density Kg/m ³	k-value W/m.K	mm	mm	mm	mm	mm	mm	mm
Cellulose Fibre Loose-Fill	27,5	0,040	135	135	135	135	135	100	135
Glass Wool Blanket	10-18	0,040	135	135	135	135	135	100	135
Glass Wool Blanket	18-28	0.033	115	115	115	115	115	80	115
Polyester Fibre Blanket	11.5	0.046	160	160	160	160	160	110	160
Polyester BOQ Board	24	0.038	130	130	130	130	130	90	130
Expanded Polystyrene (EPS) Standard Density (SD)	15	0,035 ^a	120	120	120	120	120	85	120
Extruded Polystyrene (XPS)	32	0,028 ^a	100	100	100	100	100	65	100
Fibre Glass Board	47,5	0,033	115	115	115	115	115	80	115
Flexible Ceramic Fibre	84	0.033	115	115	115	115	115	80	115
Rock / Mineral Wool	45-140	0,035	115	115	115	115	115	80	115
Polyester BOQ Fibre Board	61	0,034	115	115	115	115	115	80	115
Polyurethane Board	32	0,025 ^a	85	85	85	85	85	60	85

NOTES: 1. Zone 5H high humidity to be taken into account.

2. Thermal conductivity values used are generic.

3. Thermal efficiencies are dependent on material thickness, density, age, operating temperature and moisture.

4. Manufacturers will round of thicknesses to nearest production standard.

5.4.1. FIRE SAFETY

The selection and specification of thermal insulation material should always be read in conjunction with the fire safety requirements given in SANS 10400-T Fire Protection.

The thermal insulation material shall be either:

- non-combustible when tested in accordance with SANS 10177-5 and may be installed in all occupancy classes; or
- material classified as combustible in accordance with SANS 10177-5, shall be tested and classified in accordance with the application of the South African National Building Regulations SANS 10400-T Fire protection.

REGULATION A20 CLASS OF OCCUPANCY APPLICABLE TO SANS 10400 PART T FIRE PROTECTION					
Class	Description	Fire No	Class	Description	Fire No
A1	Entertainment & Public Assembly	1	E3	Other institutional (residential)	1
A2	Theatrical & indoor sport	2	E4	Health care	2
A3	Places of instruction	2	F1	Large shop	3
A4	Worship	2	F2	Small shop	3
A5	Outdoor sport	4	F3	Wholesalers' store	3
B1	High risk commercial service	2	G1	Offices	3
B2	Moderate risk commercial service	2	H1	Hotel	1
B3	Low risk commercial service	3	H2	Dormitory	1
C1	Exhibition hall	2	H3	Domestic residence	3
C2	Museum	2	H4	Dwelling house	3
D1	High risk industrial	2	H5	Hospitality	3
D2	Moderate risk industrial	2	J1	High risk storage	2
D3	Low risk industrial	3	J2	Moderate risk storage	2
D4	Plant room	1	J3	Low risk storage	3
E1	Place of detention	1	J4	Parking garage	4
E2	Hospital	1			

CLASSIFICATION CRITERIA FOR USAGE:

The "fire" number 1 indicates that only non-combustible materials must be used and there is no limitation. The "fire" numbers 2 - 4 as listed, implies that products with equal or better classifications are also suitable. For buildings of more than two storeys all roof/ceiling constructions shall be non-combustible

Important Notice

FIRE TESTING FOR THERMAL INSULATION PRODUCTS & SYSTEMS

Insulation, composite insulation products and composite panels shall be tested with the maximum core or insulation thickness.

DO NOT use insulation products in conjunction with other insulation types for "cheaper options" in order to comply with SANS 10400-XA Energy usage in buildings, unless the combination of the different types of products that have been added together has been fire tested to be used as such.

The fire classification shall apply to material thicknesses equal or less than the thickness as indicated in the test report.

When in doubt please contact the Association for assistance Tel: 0861 000 334.

5.5 TYPES OF INSULATION

5.5.1 BULK INSULATION - HOW BULK INSULATION WORKS

Bulk insulation works by trapping dry air in lightweight, bulky materials. Still air is a poor conductor of heat, so bulky materials that can trap large amounts of air or gas can reduce the ability for heat to be transferred by conduction. If a material consists of many small pockets of trapped air rather than a large, contiguous volume of air, the ability to transfer heat by convection is also reduced. Bulk insulating materials such as wool, polyester, glass wool and foam boards work by trapping air and reducing the speed of heat transfer. Each product has a material R-Value for a given thickness, density and temperature. Its thermal resistance is essentially the same regardless of the direction of heat flow through it.



5.5.2 TYPES OF BULK INSULATION

5.5.2.1 Flexible Bulk Insulation

- Glass Mineral Wool (GMW) Batt & Roll Insulation

Glass Mineral Wool manufactured from molten glass spun and formed into batts, rolls and blankets of fine fibres coated with a binding resin. Batts and blankets are light weight, fit standard tie beams and stud spaces, easy to cut and install. Should not be compressed or moistened. Butt all ends and edges together firmly. If installed carefully it will not slump or settle. During installation some glass wool could cause eye and skin irritation, and manufacturer's safety recommendations should be followed. Depending on type and density, maximum limited operating temperature ranges between 200°C up to 350°C.

Glass mineral wool insulation is non-combustible, improves acoustic performance in buildings and does not deteriorate during its lifetime and has Zero GWP (Global Warming Potential).



- Ceramic Fibre

High-temperature insulation wool (HTIW), also known as kaowool (a portmanteau of the words kaolin and wool), known as ceramic fibre wool until the 1990s, is one of several types of synthetic mineral wool, generally defined as those resistant to temperatures above 1000°C. The first variety, aluminium silicate fibre, developed in the 1950s, was referred to as refractory ceramic fibre.

Due to the costly production, and limited availability compared to mineral wool, HTIW products are almost only used in high temperature industrial applications and processes.



- Loose Fill Insulation

Cellulose Fibre insulation is made from finely shredded recycled paper which is milled into a light fibrous matrix, which is chemically treated to resist fire and fungal growth. Due to the small size of the particles, cellulose can 'flow' around obstructions (nails, electrical wires, trusses, etc) to give a uniform fill. If the insulation is not blown to manufacturer's recommended density and thickness it can settle over time, and the intended R-Value will not be achieved and maintained. Blown cellulose can be installed in vertical wall cavities using a variety of specially designed, reinforced interior sheeting products.



- Rock Mineral Wool
(Slag/Rock Wool/Stonewool/Ulimate)

It is manufactured from molten industrial slag, which is fiberized, treated with oil and binders to suppress dust, and maintain shape. It is similar to glass fibre in texture and appearance but denser than glasswool so R-Value per unit thickness is higher. Rock Mineral Wool is manufactured in a similar manner except that natural rock is used instead of slag. Other patented technology used to manufacture mineral wool provides products being shot free and made of long interwoven fibres.

The high density materials are generally used in industrial applications as it has a high fire resistance, the limiting maximum operating temperature ranges from 200°C to 850°C. In addition it is non-combustible, improves acoustic performance and does not deteriorate during its lifetime and has Zero GWP (Global Warming Potential). Generally rock mineral wool is more expensive than glasswool.



- Polyester Fibre

Polyester Fibre made from polyester fibres (including recycled PET bottles) spun into a flexible mat. Available as blankets. Easy to cut and install, non-irritable, with no known physical or health hazards. When exposed to a direct flame the product would melt and shrink away from the flame. Maximum limited operating temperature 150°C.



- Polyester Fibre batts

Polyester Fibre bats or ceiling panels are produced using a mix of virgin and recycled polyester fibre, or Kenaf, a renewable plant fibre which is thermally bonded. It is a non-toxic and nonharmful, low VOC product. The density can vary between a 24-100kg/m³ bat or a 50-300kg/m³ board-product.



5.5.2.2 Rigid Bulk Insulation (Typically Board Insulation)

- Expanded Polystyrene (EPS)

Boards are made of a lightweight, plastic foam insulation produced by trapping small amounts of pentane gas into solid beads of polystyrene. The pentane gas expands under the action of heat, applied as steam, to form perfectly closed cells of EPS. These cells occupy approximately 40 times the volume of the original polystyrene bead. The EPS beads are then moulded into blocks or boards in three standard densities. EPS has excellent thermal properties, is moisture resistant, and provides environmentally safe lifetime durability. EPS is easy to install, non-toxic, contains no CFC's or HCFC's and is recyclable.

Limited surface operating temperature 100°C



- Extruded Polystyrene (XPS)

Extruded Polystyrene is a closed cell polystyrene rigid foam board, with high compressive strength and excellent long term thermal resistance performance, due to its inherent resistance to moisture transfer. It is produced on a continuous, fully automated extrusion process. In South Africa, it is manufactured in a single density range, suitable for most local applications.

Boards are available in various lengths and thicknesses to suit most residential, commercial, agricultural and industrial thermal insulation requirements, including under floor slab, cavity wall, over purlin and rafter, inverted roof and insulated ceiling applications. Polystyrene will deteriorate if continually exposed to ultra violet radiation, and will dissolve in solvents. Compatible with all water-based adhesives and paints. Limited surface operating temperature 100°C



- Polyurethane and Polyisocyanurate

These insulations are manufactured by chemical reactions between poly-alcohols and isocyanurates creating or forming tiny air cells. The cells contain refrigerant gases (fluorocarbons) instead of air. The boards are usually double-faced with foil, or sometimes come bonded with an interior or exterior finishing material. The boards must be protected from prolonged exposure to water and sunlight, and if used on the interior must be covered with a fire-resistant material, such as drywall. Due to the relatively high cost of these insulations, use is generally limited to areas which require a high R-Value but where space is very limited.



- Phenolic Foam

These boards are manufactured from phenol formaldehyde resin, and is available as either an open or closed cell product. The boards usually come with a foil facing on one or both sides. It is much less combustible than other rigid insulations. It should be protected from prolonged exposure to sunlight and water. It is suitable for wall sheathing, and for use on the interior, both above and below grade. Use is generally limited to areas which require a high R-Value, but where space is very limited.



5.5.2.3 Spray Foam Insulation

Polyurethane Foam is closed cell foam, which is usually pale yellow in colour, and can be used for a variety of spray applications. The material is mixed on site with special equipment for large applications. For small applications, single component foam is available in spray cans, for sealing around windows, doors, etc. The foam will act as an air barrier, but not a vapour barrier and should be protected from prolonged exposure to sunlight. When the foam is used in the interior of a house, it must be covered with a fire-resistant material, such as drywall.



5.5.3 COMPOSITE BULK INSULATION

Composite bulk and reflective materials are available that combine some features of both types.

Examples include Foil bonded to bulk insulation, whether blankets, bats or boards, i.e. foil faced blankets, foil faced bats and foil faced boards.



Caution

FIRE SAFETY is the number one priority!

DO NOT use insulation products in conjunction with other types of insulation in order to comply with SANS 10400-XA Energy usage in buildings, unless it has a fire report to verify that it was tested together and can be used as such.

5.5.4 REFLECTIVE FOIL INSULATION

Reflective Foil Insulation as a barrier to heat flow, predominantly Radiant Heat, is effective only when installed/applied in combination with air spaces. These products are commonly referred to as reflective foil laminates "RFL" and are tested in compliance with SABS standard SANS 1381 Part 4.

The principles on which their performances are based differs from and is more complicated to appreciate than mass or bulk type materials however, the common denominator is air. Whereas bulk, mass and fibrous products entraps great numbers of air or small gas pockets, Reflective Foils in turn is the division of and creation of defined air spaces, together with high reflective/low emissive surfaces facing the air spaces. The reflective surfaces should be positioned to face the brighter side downwards.

To simply define this method of insulation as reflective is a misnomer, as the principles which determine their performances are based on Reflection, Absorption, Conductance and, most importantly, the ability of high reflective surfaces to only emit a small percentage, between 3-5%, of the heat absorbed to an accompanying air space. Therefore highly polished surfaces in combination with air spaces, within the insulation system or below the membrane, is important in reducing the level of emitted radiant heat together with reducing conductive heat transfer.

Reflective insulation is more effective at reducing summer heat gain than reducing winter heat losses and this must be considered at design stage. The thermal resistance of reflective insulation varies with the direction of heat flow through it, i.e. vertical, horizontal or sloped, the number of air spaces and defined thicknesses of the air spaces. Furthermore, that the bright surfaces facing the air space/spaces remains untarnished on at least one surface.

The system "R"-values for reflective foils is stated as being up or down, alternately as winter or summer. When evaluated in accordance with SABS standard SANS 1381 part 4, they are tested at a given air space thickness and air temperature. Users must ensure that the system values provided by the manufacturers relates to their particular application.

An R-Value resistance or k-value conductivity cannot be given for the membrane/laminate by itself; the heat flow values, thermal transmittance or "U"-value is given for the system based on the thicknesses and orientation of the air spaces, in combination with the materials. Values for total "R"-resistance or "U" stated in this guide is based on the upper surface, facing the roof cover, being completely and totally dust covered, as dust build-up reduces the reflectivity and therefore the R-Values.

Reflective Foil Insulation materials are often Aluminium Foil laminates with reinforcement strands or low density polyethylene bubble encapsulated with air laminated to foil supplied in rolls. In addition to their thermal performances they are effective dust-proofing, waterproofing and air barriers, as well as affording protection from U.V., providing they comply with SABS standard SANS 1381 part 4, in terms of physical properties such as tear, puncture tensile resistance and U.V stabilising.

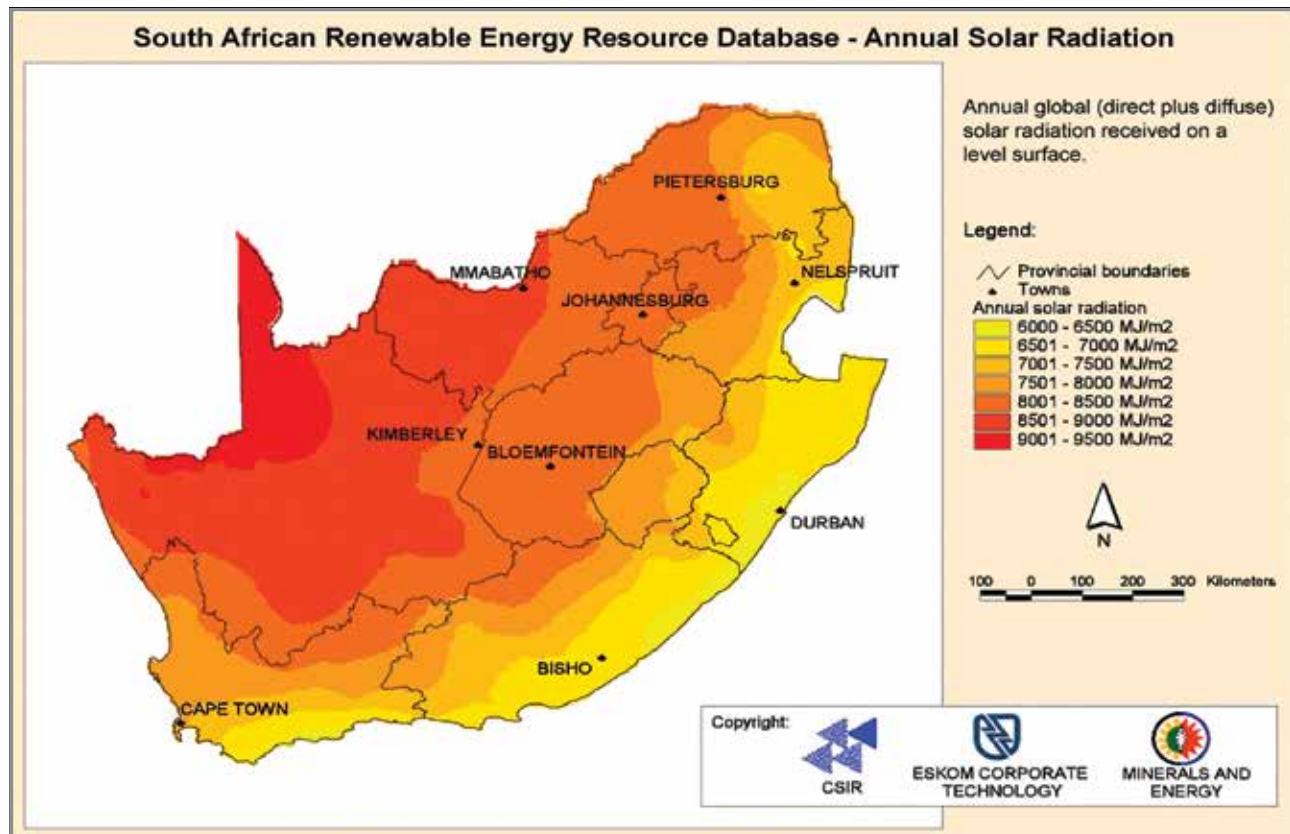
Damages to surfaces such as excessive severe creasing, scuffing, puncture holes or openings will reduce the performance and needs to be repaired or made good. Reflective Foils are valuable when used in combination with bulk insulation for improved performance.



WHY USE RADIANT HEAT BARRIER/REFLECTIVE FOIL INSULATION MATERIALS?

Most areas in South Africa average more than 2 500 hours of sunshine per year, and average solar-radiation levels range between 4.5 and 6.5kWh/m² in one day.

The southern African region, and in fact the whole of Africa, has sunshine all year round. The annual 24-hour global solar radiation average is about 220 W/m² for South Africa, compared with about 150 W/m² for parts of the USA, and about 100 W/m² for Europe and the United Kingdom. This makes South Africa's local resource one of the highest in the world.



In accordance with SANS 10400-XA, all tile roofs in climatic zones 1, 2, 4 and 6 shall have a tile underlay or radiant barrier and the joints have to be sealed.



Reflective Foil Insulation/Radiant barrier installed over rafters.

5.6 EXPLANATORY THERMAL TERMS

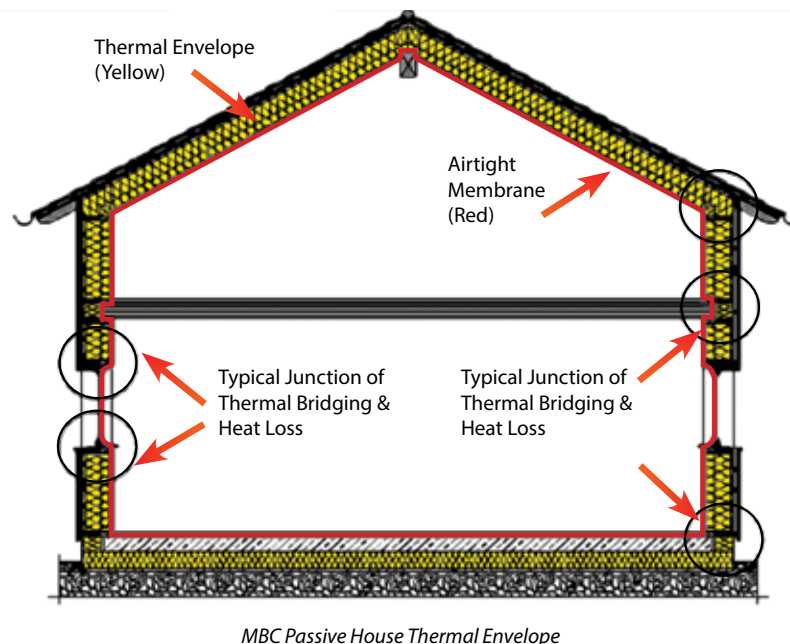
5.6.1 WHAT ARE THERMAL BRIDGES

Thermal bridges, are parts of the building envelope where heat can escape more readily because the building material connects – or bridges – both sides of the building envelope. Examples of thermal bridges include:

- timber or steel framing in external walls that connect to both the interior and exterior faces of the wall
- aluminium window frames that do not have a thermal break
- gaps in (poorly) installed insulation.

If insulation has simply been installed between joists or studs, the R-value of the building element is likely to be less than the R-value of the insulation used because of the thermal bridging. Thermal bridging can be reduced through correct installation of insulation.

A comprehensive thermal insulation retrofit should create a continuous insulated and, ideally, avoid any residual thermal bridging of the structure. The extent of residual thermal bridging will vary depending on the insulation strategy selected and is generally the result of structural elements breaching the insulation zone.



5.6.2 WHAT IS THERMAL MASS

‘Thermal mass’ is the capacity of a material to store heat energy. Thermal mass can be used for passive heating and cooling.

In building terms, it reduces temperature fluctuations by absorbing heat when the ambient temperature is hotter than the mass, and then releasing the heat when the ambient temperature falls below the temperature of the mass. When used effectively, this results in improving indoor comfort.

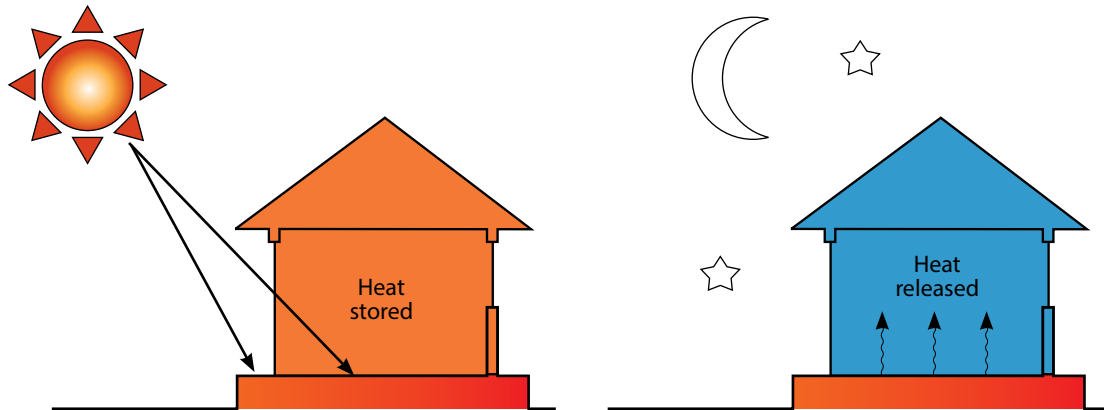
For passive heating, thermal mass works by exposing a high-density material in the building’s interior – such as concrete or stone – to direct sunlight. Often, this will be a concrete slab floor, though it can also be a wall or a specially designed thermal mass element such as a Trombe wall. The sun’s warmth is absorbed during the day and then radiated into the home as the temperature cools at night.

For passive cooling, thermal mass is combined with ventilation – so heat is absorbed during the day, then ventilation is used to dissipate the heat when it is released at night.

To be effective, thermal mass must be considered along with other passive design features such as insulation, location, orientation and layout, window size and placement, and shading.

5.6.3 HOW THERMAL MASS WORKS

Thermal mass works by absorbing heat and re-radiating it as temperatures drop.



By utilising the thermal mass of a heavyweight material, temperature fluctuations can be reduced, resulting in a more constant indoor temperature.

Thermal mass is most effective when the diurnal temperature range (the temperature difference between day and night) is at its largest.

5.6.4 DENSITY AND THERMAL MASS

High density materials such as concrete, brick, tiles, earth and water require a lot of heat to increase in temperature. They also lose heat slowly and are referred to as having high thermal mass.

Low density, lightweight materials such as timber or timber products require little heat to increase in temperature but lose heat rapidly. These are referred to as low thermal mass materials.

A material suitable for thermal mass must have:

- high heat capacity
- high density
- low reflectivity (i.e. a dark, matt or textured finish).

Note that thermal mass is not the same as insulation, which, in building terms, describes a building's ability to reduce the conduction (or flow) of heat between indoors and outdoors. In effective house designs, thermal mass and insulation work in harmony.

5.6.5 RATE OF STORED HEAT DISSIPATION

The period of time that thermal mass is able to retain heat for depends on the time the mass is not able to be heated and the level of insulation. Without high levels of insulation, the stored heat indoors dissipates quickly.

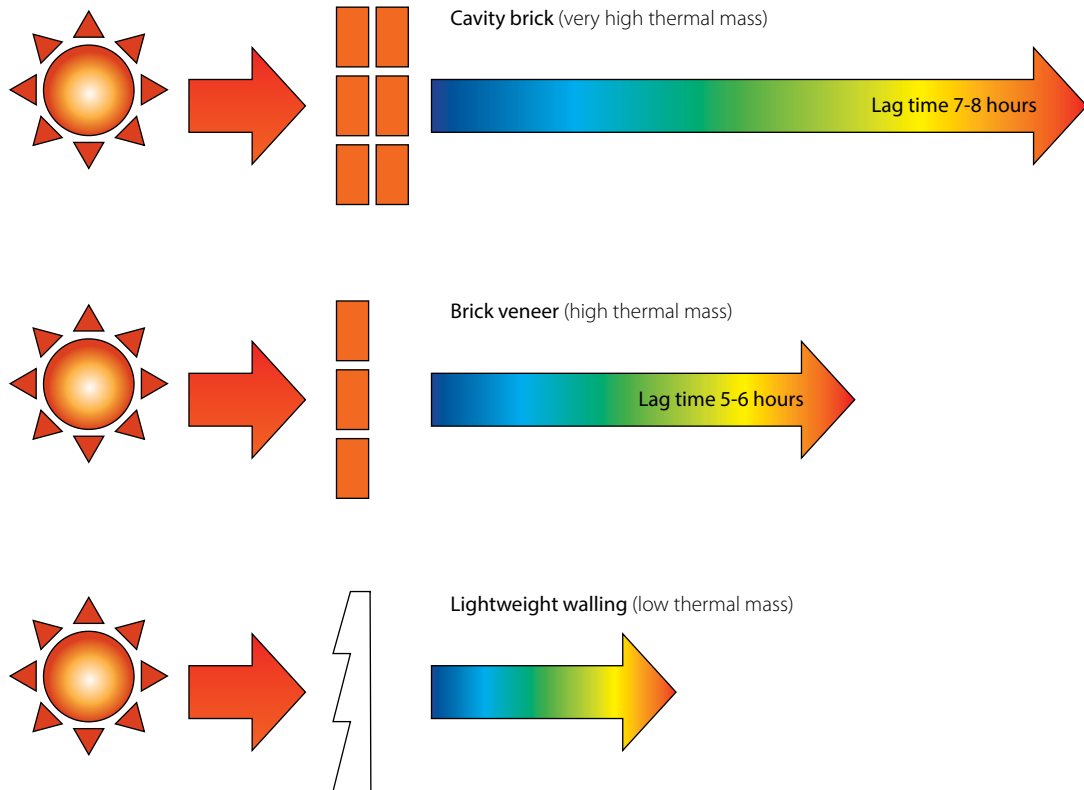
The rate of dissipation is dependent on factors such as the:

- outdoor ambient temperature
- amount of insulation in the building envelope
- amount of thermal mass and stored energy
- levels of air infiltration or draughts.

5.6.6 THERMAL LAG

Thermal lag is the name given to the delay in the stored heat being released from the massive material as the ambient temperature falls. The thermal lag of a material depends on the:

- heat capacity of the material
- conductivity of the material
- temperature change and differential





CHAPTER 6

INSULATION REQUIREMENTS

6.1 DETERMINING INSULATION REQUIREMENTS

South Africa is divided into different energy zones. Each zone has its own particular requirements. See the map in Chapter 4.2 for guidance.

6.1.1 HOW TO CHOOSE INSULATION

There are many different choices when it comes to choosing insulation for your home or building. Choosing the right option will depend as much on your location and situation as it will on your budget, your need for soundproofing, and the temperature where you live and whether or not you're building new or renovating.

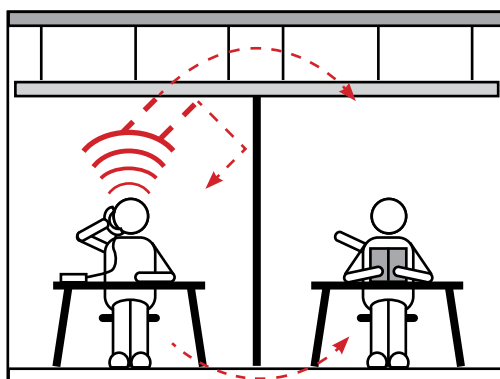
Below are a few of the questions you'll need to be able to answer.

6.1.2 DO YOU NEED SOUNDPROOFING?

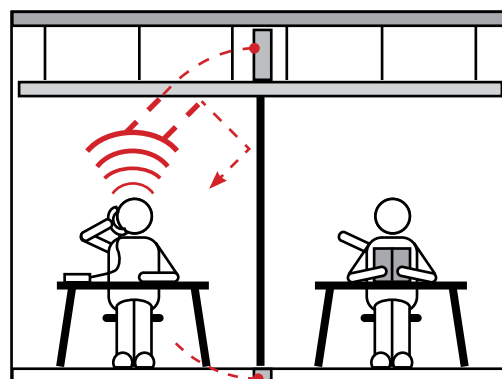
It is advisable to include soundproofing if one lives near a major highway, railroad or any area with a lot of latent background noise.

Other areas such as home theatres are also good candidates for sound insulation. How much of it and what type you'll need will depend on the level and frequency of the noise you want to isolate. Mineral wool or fibrous insulation already provides a certain amount of soundproofing, but if it's a particular concern then you'll need to choose carefully.

Without barrier



With barrier



6.1.3 NEW BUILD OR RENOVATION?

If you're considering insulation for a home or building you intend to build, then the options are wide open and one can accommodate any type of insulation, provided that it meets the requirements as set out in the National Building Regulations (NBR).

Consider renovating an existing house, rather than demolishing the old and building from scratch as very little of the demolished house is recycled or reused. Recycle resources that are left over or have reached the end of their useful life. This reduces demand for new materials and lowers the volume of waste going to landfill.

Existing buildings will often benefit from insulation retrofits. It is easier and less costly to fit insulation in a new home or building than to retrofit. However, many existing houses in South Africa have little or no insulation, and they will benefit from any improvements that can be made to the levels of insulation.

Proposed regulation changes will make ceiling insulation a legal requirement in private rental properties from 2025.

In most houses, insulation can be reasonably easily added to roof spaces. It is more difficult to retrofit insulation to walls. Retrofitting wall insulation also requires building consent unless the local council has made an exemption for this work.



Retrofitting thermal insulation in the ceiling area is an easy energy efficient intervention method.



CHAPTER 7

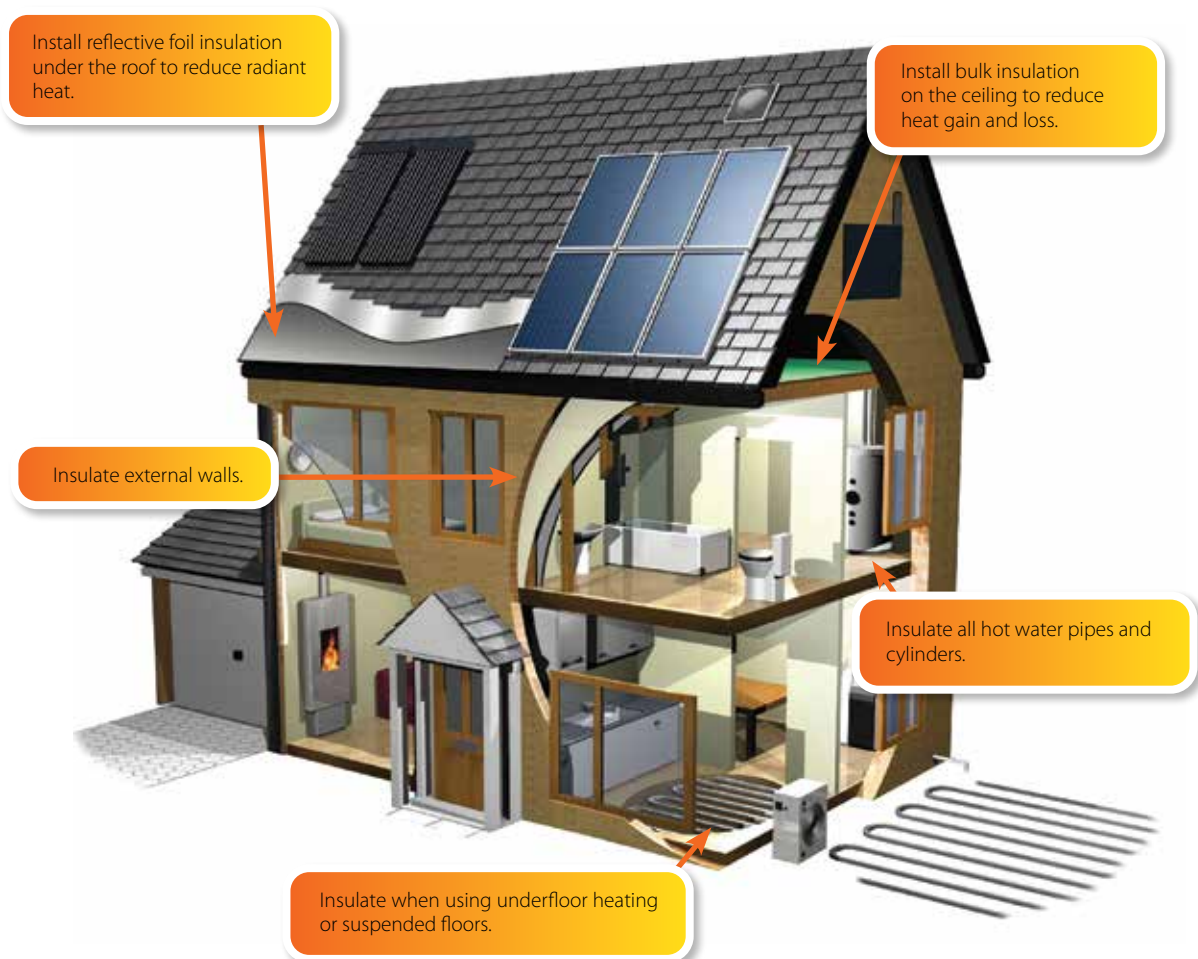
INSULATION OPTIONS

7.1 ROOF INSULATION OPTIONS

Depending on the design, roofs and ceilings account for between 25% and 45% of heat gain or loss as a result of poorly insulated roofs. Good roof insulation ensures comfortable thermal and acoustic benefits for you all year round, and offers the best cost to benefit ratio; higher energy efficiency can be achieved with minimal costs.

An insulated ceiling is often considered a luxury, however to properly insulate one costs less than 1% of the initial total per square meter building costs. This will save you money for the lifespan of your home/building.

The best time to install insulation is in new built as it can be done from the start. Alternatively there are various options available for existing buildings.



As most heat is lost through the roof of uninsulated homes, ceiling insulation is highly effective and should be the first priority in retrofit situations.

OPTION 1: PITCHED ROOF OPTIONS

If the ceiling space is:

- Fully accessible, fit radiant barrier to underside of trusses, and
- If fully accessible, fit bulk insulation between and over ceiling joists; or



*Reflective Foil Insulation retrofitted under roof.
Photograph courtesy of Africa Thermal Insulations.*



Photograph courtesy of Aeropink.



*Insulation installed on top of ceiling.
Photograph courtesy of Knauf Insulation*



Photograph courtesy of Brits Nonwoven

- If partially accessible or not at all, install blown-in, loose-fill insulation.



*Cellulose blow in fibre can be used in areas difficult to reach.
Photographs courtesy of Eco Insulation.*

- Where there are recessed downlights in the ceiling, see section on downlights.

Note

When retrofitting insulation in the ceiling void, dust masks should be worn as the existing dust and dust-mites on the ceiling is a health hazard.



If the roof is a pitched roof, options include:

- fitting battens under the existing ceiling, installing insulation and a new ceiling; or
- building a suspended or dropped ceiling and including insulation (can only be done if there is sufficient height); or
- removing the existing ceiling and installing insulation – the most cost-effective time to do this is when the ceiling needs to be replaced. Some insulation materials can be used as insulation and a ceiling “2 in 1” without the need to remove the old ceiling; or
- removing the roofing and installing insulation, then replacing or reinstalling the roofing.

Rigid foam boards, such as expanded and extruded polystyrene or glass wool rigid boards, can be used to thermally insulate many existing buildings which require upgrading with respect to comfort levels or energy efficiency. The boards are suitable to be installed as a ceiling, either beneath an existing ceiling, or between trusses or rafters.



Installation as ceiling and insulation “2 in 1”
Photo acknowledgment: Isofoam SA (Pty) Ltd



Installation between rafters
Photo acknowledgment: Isofoam SA (Pty) Ltd

ROOF VENTILATION

In hot dry climates the roof space should be ventilated where possible, to allow the built up heat to dissipate. Even in cooler climates a minimal amount of ventilation is desirable to allow built up moisture to escape. Sufficient ventilation is often achieved through the air gaps along the ridgeline or between tiles. Gable or eaves vents may also be considered.

Ventilated roof spaces in hot humid (tropical) climates can result in excessive condensation under the roof. Minimise roof ventilation in these conditions. Note that roof ventilation only has a marginal effect on cooling compared to good insulation design in these climates. However roof ventilation improves the performance of Reflective Foil insulation for downward heat flow. As a caution to fire risk, cover any openings with fine stainless steel mesh to prevent cinders from entering the roof space. Keep roof spaces weather tight and vermin proof.

Loose-fill insulation should not be used in excessively draughty roof spaces or ceilings with a slope of 25 degrees or more. In other applications, keep the density of the insulation consistent to avoid reducing the R-value. Note that loose-fill insulation may settle by as much as 25 percent over time. Ask your contractor for a guaranteed ‘settled R-value’. For safety reasons, clearances must be left around hot objects such as recessed downlights and their transformers.

Without proper ventilation, a property could suffer from condensation issues after insulation has been added in a roof. It is therefore essential that ventilation is either maintained, or enhanced (where required).

OPTION 2: ADDING INSULATION AND A “NEW CEILING” TO A PITCHED ROOF (2 IN 1 SOLUTION)



Photo 1: Existing ceiling being prepared.



Photo 2: Cornices removed.



Photo 3: Special clip fixed to existing ceiling



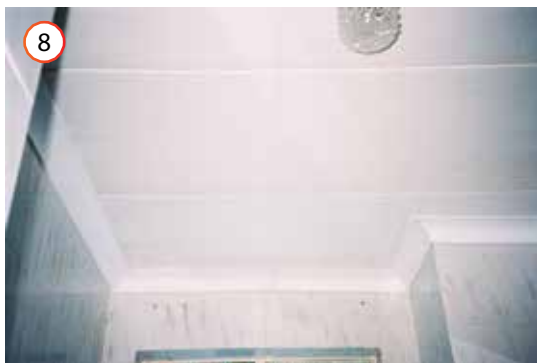
Photo 4: Close-up view of clip



Photo 5: Clips installed and ready for next board to slot in.



Photo 6: Second board fitted.



7.1.2 DOWNLIGHTS / RECESSED LIGHT FITTINGS

Downlights create a hole in your ceiling and insulation which lets warm heated air escape into the roof space. While downlights have been a popular option in recent years, they can undermine the effectiveness of ceiling insulation. This is made worse by the need to leave a safety gap between the downlight and any insulation in the ceiling.

Because the incandescent or halogen bulbs used in downlights get very hot, fire is a risk. Safety regulations mandate a 150mm uninsulated gap around the downlights, and downlight covers should never be covered with insulation.

When warm heated air is drawn up into the colder roof-space the ceiling insulation cannot work as well as it should. The more downlights, the less effective the ceiling insulation. Installing downlights every five square metres, reduces insulation effectiveness by 10%. Downlights in wet areas, like bathrooms and kitchens, can allow moist air into roof spaces and around concealed framing, resulting in condensation and possible moisture damage.

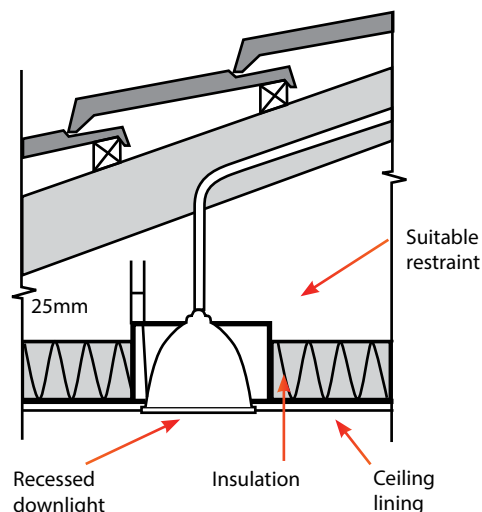
To get the most benefit from ceiling insulation, don't use downlights in new homes except in lower storeys. If you have downlights consider replacing them with surface-mounted fittings especially if renovating. You may be able to source a surface-mounted fitting which will cover and seal the downlight hole, or if you are undertaking major renovations, re-do the ceiling plasterboard.

Warning

Electrical wiring must be appropriately installed and should not be covered by insulation or it may overheat.

Unless otherwise specified by manufacturers of insulation;

- Do not install insulation within 90mm of hot flues or exhaust fans, or within 25mm of recessed light fittings.
- Retain a clearance of 90mm for low voltage downlights.
- Restrain loose-fill insulation with non-combustible barriers.



*Correct installation of non-combustible cone installed; pre and post-installation.
Photos courtesy of Eco Insulation.*



Incorrect usage of combustible PVC Pipes as restraint. This is a potential fire hazard.

7.1.3 STEEL-FRAMED ROOFS

The general principles of roof insulation are the same for steel-framed roofs, although there are some slight changes required to where and how insulation is installed in practice for the best results.

OPTION 1: BUILT-UP STEEL ROOF STRUCTURE - BULK INSULATION WITH CONTINUOUS SOLID SPACER

The addition of mechanical or continuous spacers prevents the compression of the bulk insulation, which enables the insulation to retain its thermal resistance i.e. R-Value.

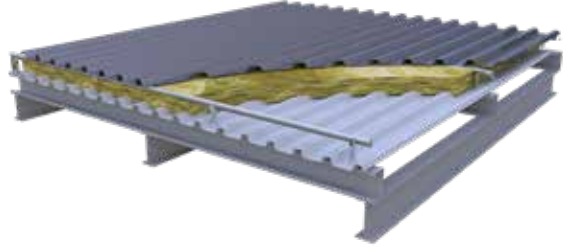
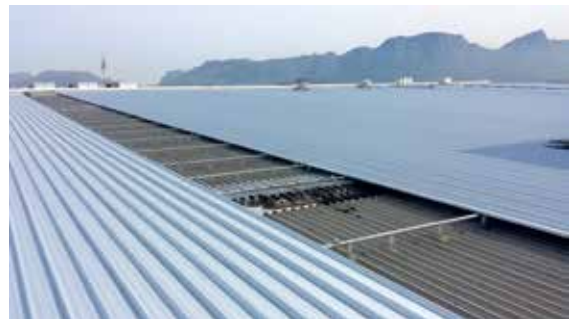


Image supplied by Ash&Lacy

OPTION 2: STEEL FRAMED SHEETED COMMERCIAL & INDUSTRIAL ROOFS

The structural mechanical spacer systems are an ideal component for over-roofing or over-cladding of any building where an improvement in the thermal performance is required

The structural mechanical spacer systems are installed over the in-situ roofing or cladding, providing a stable platform for the new weather sheet. This also creates a cavity between the new and the old where insulation is installed to increase the building's thermal performance to current building regulations and reduce carbon emissions. This allows for a completely new weather sheet to be installed with minimal disturbance to operations within the building, improves thermal & acoustic performance whilst improving the overall aesthetics of the building.



*Example of Ash-grid system.
Photograph courtesy of Ash & Lacy*

7.1.4 FLAT ROOF CONVERTED TO PITCHED ROOF WITH INSULATION

For all their aesthetic benefits, flat roofs can come with some serious downsides, too. Flat roof surfaces are more prone to leaks, water damage, and problems with mould. Not to mention, you'll need to replace your flat roof more frequently and maintain it with waterproof coatings and seals. All that moisture exposure tends to wear down roofing materials. Modern systems are now available to make the conversion less cumbersome.



Photograph courtesy of Ash & Lacy

7.2 EXTERNAL WALL INSULATION

External wall insulation (EWI) comprises an insulation layer fixed to the outside of an external wall, using a combination of mechanical fixings and adhesive depending on the material used, with a protective render or cladding finish. It is suitable for solid wall, non-traditional and cavity wall properties and offers several advantages, as well as the improvement of energy efficiency standards:

- The work is done externally so there is very little disruption and no loss of living space.
- The system will protect the property and the results can improve the appearance of the building through a range of external finishes.
- Improved acoustics.
- Condensation risk is managed to the outside of the home and there should be little thermal bridging if the insulation layer is continuous.
- It needs little maintenance while, internally, no redecoration is needed.

Proprietary insulation systems use a variety of rigid insulation types depending on the characteristics needed, such as mineral wool batts, expanded or extruded polystyrene and phenolic foam boards.

Key selection considerations are: fire resistance; thermal performance (i.e. thickness); weight and cost.

The following are some of the options available depending on the type of building:

1. Thermal insulation such as expanded polystyrene (EPS) sheets can be installed on the outside and covered with plaster coat. An advantage is to prevent thermal bridges (materials that are poor insulators, allow heat to flow through them, significantly reducing the effectiveness of thermal insulation).

Structural thermal bridges might occur around windows; doors and unheated parts of the building. Insulation of the outer walls is therefore directly connected to the frame of the windows and doors and should overlap adjoining cold parts of the building. In addition, cavity walls built with two brick or concrete block rows at 50mm distance from each other can be insulated with expanded or extruded polystyrene insulation inside the cavity.



*Thermal insulation applied to the external wall and rendered.
Photograph courtesy of Technopol SA (Pty) Ltd.*

2. Metal Framed Building – Rail & Bracket Systems Profiled metal cladding systems use Glass Mineral Wool of high tear strength which is ideal for this application. Typically the installation comprises of a rail & bracket spacer system with thermal breaks and profiled inner liner. The system provides an improved thermal performance for saving energy costs and acoustic performance. In conjunction with the correct insulation the system can potentially reduce insurance premiums. A range of thermal performances is available depending on the insulation's R-value.



Image supplied by Knauf Insulation Ltd

3. Insulation can be installed on the inside of a brick wall by way of dry-lining. To dry line, a drywall framework is installed on the inside of a brick wall and lined with gypsum board and thermal insulation is installed in the cavity. The advantage is that the drywall framework offers space for installation of services in the cavity; an opportunity to easily update technology, fix any wall imperfections and reach better sound insulation.

In certain climates e.g. the Southern Cape Condensation Zone, it is important to monitor moisture, because the outer walls will be comparatively colder than the internal walls with this system resulting in moisture accumulation inside.

To avoid damage caused by condensation it is advisable to install an air tight vapour membrane or barrier (a plastic or foil sheet) on the room facing (internal) side.

Notes: (1) Concrete or concrete masonry walls with external insulation will act as a thermal mass, whereas concrete or concrete masonry walls with insulation on the interior cannot. (2) To determine R-values, solid masonry walls that are strapped, lined and insulated to achieve the minimum R-value requirements should be considered as non-solid walls.



Drywall frame work.

Photograph courtesy Saint-Gobain Construction Products.

4. *The External Wall Insulation of Masonry Wall* requires a high density, high strength Rock Mineral Wool batt for impact resistance, compressive strength and with water repellent additive. The batts can be adhered or mechanically fixed to the building's external substrate (can be brick or block masonry or solid concrete) and then overlaid with mesh and finished with render. In addition to thermal and acoustic improvements this approach significantly improves the aesthetic appearance of existing building stock. This system can also be used in new build projects.



External wall insulation system.

Photograph courtesy of Knauf Insulation Ltd.

For information about performance, durability and environmental properties of each material, request information directly from material manufacturers.

7.3 VENTILATED FAÇADE CLADDING SYSTEMS

There is a variety of proprietary Façade cladding systems with insulation installed to the external face of a masonry wall. This helps to keep internal temperatures stable by storing heat in the winter and reducing solar gains in the summer. Ventilated Façade cladding systems – sometimes referred to as 'Rainscreen' - are lightweight compared to brick / masonry and can be used on new build or retrofit projects. In addition to improving thermal and acoustic performance on existing buildings, a key feature is that upgraded façades allow the designer to improve the aesthetic appearance of existing building stock.

Ventilated Facades cladding systems are designed to keep both the structural frame and the thermal insulation dry, due to the Rainscreen cladding itself but also due to the airspace between the cladding and the insulation which allows the 'stack affect' and natural drainage from the inside face of the system's cladding. It is crucial that Ventilated Façade systems are installed with Fire Barriers which should be manufactured from non-combustible material, be at least 100mm high and penetrate the full depth of the insulation to form a continuous barrier through the insulation layer. If the insulant is Rock mineral wool the whole surface of the building is effectively acting in the same way as a fire barrier plus this material also resists compression forces generated when the insulation is installed on a masonry substrate.

BENEFITS OF VENTILATED FAÇADE / RAINSCREEN SYSTEMS

- Friction fitting behind and between cladding rails prevents air movement and infiltration through or around the insulation
- Lightweight, flexible slab is quick to install and also accommodates imperfections in the substrate
- Upgrades thermal efficiency saving energy
- Improves acoustics
- Updates the aesthetic appearance of the building

TYPICAL CONSTRUCTION

Rainscreen cladding systems comprise outer cladding panels that are bolted to a supporting framework of rails which are supported by brackets fixed through a thermal break pad back to the building frame. A layer of insulation is fixed independently against the building substructure using proprietary insulation fasteners.

Rainscreen Slabs / Batts are positioned between the support brackets for the Rainscreen cladding system and across the whole area to be insulated. Cut the slabs with a sharp knife to fit around the brackets so there are no gaps in the insulation. To minimize thermal bridging, the brackets should be of sufficient depth to allow the panel support rails to be located clear of the face of the insulation which should be close butted and fixed independently against the building substructure using proprietary insulation fasteners in accordance with the design specification. Once the insulation is firmly in place, the application of the outer cladding can proceed. Ensure that a ventilated cavity remains between the insulation and the external cladding. The dimensions of the ventilated cavity should not exceed the limits in the Building Regulations.



Photograph courtesy of Knauf Insulation Ltd



*Example of Rainscreen cladding system.
Photograph courtesy of Knauf Insulation Ltd*

7.4 CAVITY WALL INSULATION

Cavity wall insulation (CWI) is a common form whereby insulation is installed into the void between inner and outer leafs of masonry walls. The best is to install cavity insulation in new buildings. Extruded (XPS), Expanded (EPS) polystyrene or glass wool batts is suitable for this type of installation.



*Example of XPS cavity wall insulation.
Photo courtesy of Isofoam SA (Pty) Ltd.*



*Example of EPS cavity wall insulation.
Photo courtesy of Technopol SA (Pty) Ltd.*



Example of Cavitybatt glass wool wall insulation.

7.5 GROUND INSULATION OPTIONS

OPTION 1: FLOORS WITH UNDERFLOOR HEATING

A substantial amount of heat is lost through the foundations and floor into the ground. Floors with under floor heating should have insulation installed with an R-Value of 1 m².K/W. Heating elements can be installed above expanded or extruded polystyrene insulation.

If the floor is not heated, it is more economical to insulate the foundation walls where heat loss is greatest. Expanded or extruded polystyrene can be used as under floor and perimeter insulation.



OPTION 2: INSULATING CONCRETE SLAB

Improving the thermal resistance of an existing concrete slab on the ground is not usually a practical option. If renovations are to be carried out (provided there is sufficient ceiling height within the space), one option is to cover the existing slab with a polythene membrane, 30 mm thick polystyrene board and a 75 mm (minimum) thick topping slab.

Alternatively, installing carpet and underlay will reduce the heat loss through an existing floor. This is however not a "recognised method" to achieve minimum energy efficiency requirements.

In new buildings, insulate under a concrete slab-on-ground by placing a continuous layer of 30 mm minimum, SD (Standard) grade expanded or extruded polystyrene (EPS/XPS) board over the damp-proof membrane before the slab is poured. It is essential to use perimeter insulation. Slab perimeter insulation is more essential than the underside of the slab as most of the heat loss from the slab occurs at the edges between the air and the ground.

Depending on the circumstances, combining under slab with slab edge insulation can result in thermal performance of the slab improving by 100% or more. Perimeter insulation can bring significant gains in energy efficiency. Much of the thermal performance improvement can be achieved with a perimeter insulation R-value of less than 1.0.



*Example of XPS slab on ground insulation and perimeter insulation.
Photos courtesy of Isofoam SA (Pty) Ltd.*

OPTION 3: ACOUSTIC FLOOR

Often referred to as a 'floating floor', the high density thin Rock Mineral Wool batt is used as a resilient layer providing acoustic insulation against impact noise. There are two prospective installation methods. The first option has a screed directly on top of the concrete intermediate floor slab, then the Rock Mineral Wool high density acoustic batt with a floor finish such as timber based decking or fibreboard sheeting. The second option is to place the Rock Mineral Wool high density acoustic batt directly onto the concrete intermediate flooring slab, overlay with a polythene sheet prior to finishing with a screed top layer.

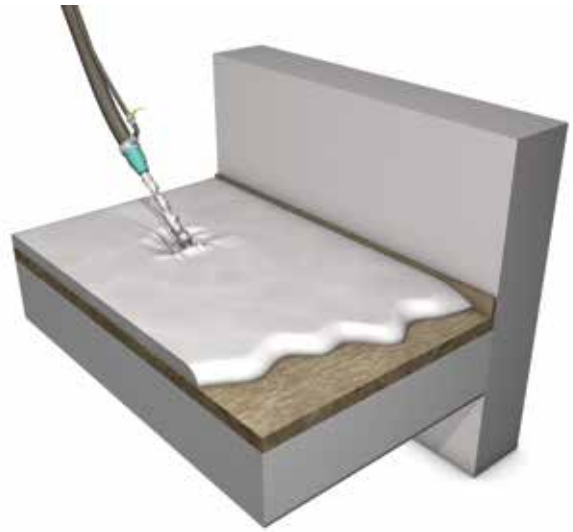


Image supplied by Knauf Insulation



CHAPTER 8

OTHER FACTORS TO BE CONSIDERED

8.1 PIPE INSULATION

Hot water pipe cladding or insulation significantly reduces heat losses to the atmosphere while hot water is in transit to outlets and taps. All exposed pipes from and at least within 1 meter of the connection to the hot water cylinders and central heating systems must be insulated, with insulation material with an R-Value in accordance with table below.

TABLE 2	
Minimum R-Values for Pipe Insulation	
Internal Diameter of Pipe (mm)	Minimum R-Value of Insulation ^a
≤80	1.00
>80	1.50
^a Determined with a hot surface temperature of 60°C and an ambient temperature of 15°C	

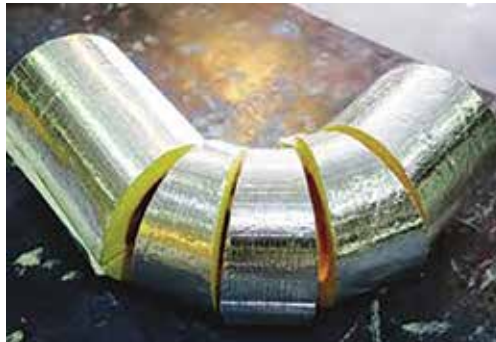
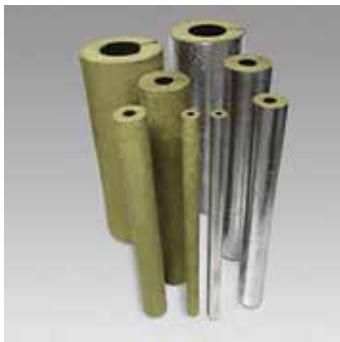
Insulation shall:

- be protected against the effects of weather and sunlight,
- be able to withstand the temperatures within the piping, and
- achieve the minimum total R-Value given in Table 2.

Example: Snap on pipe insulation is a pre-formed, rigid, resin bonded Glasswool section of 1 metre in length. A single longitudinal slit allows the section to open to encompass the pipe and snap closed after placement. Standard finishing options are available in plain, canvas and reinforced foil.

Other insulation cores are:

- Polystyrene
- Polyurethane
- Polysocyanurate



Photographs courtesy of Isover

Photograph courtesy of IPC Industries

8.2 GEYSER INSULATION

According to Eskom approximately 39% of electrical energy is consumed by a geyser in an average household in South Africa. The most obvious way to an efficient geyser is to install a geyser blanket and geyser timer. Specially designed geyser blankets and timers are relatively inexpensive but the saving to your monthly electricity bill will enable you to recoup your costs in no time. You can also insulate your geyser pipes to prevent unnecessary heat loss and improve efficiency. The 2 meters of pipes closest to your geyser are the most important to insulate to optimize efficiency.



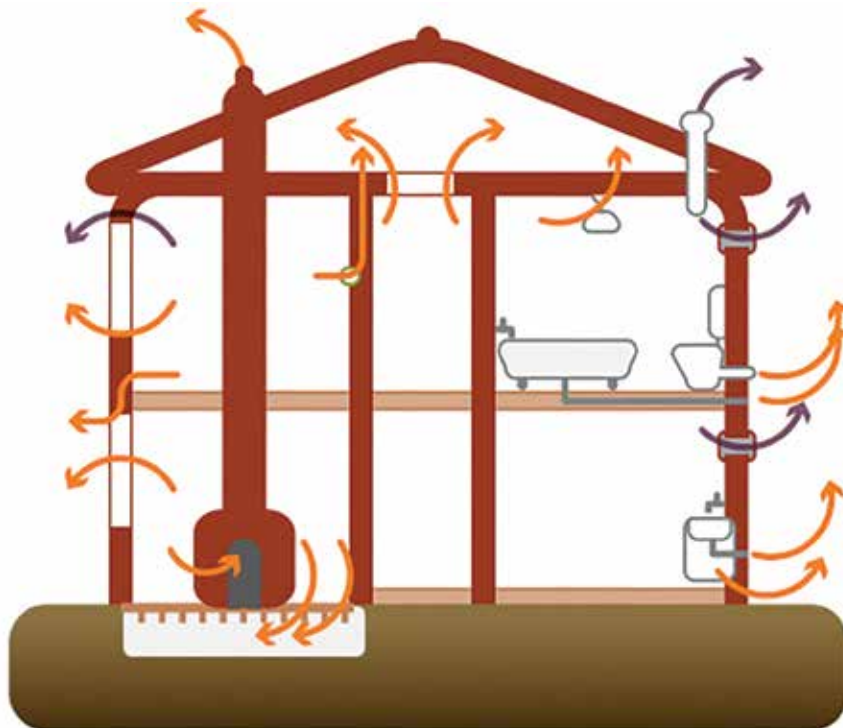
Photograph courtesy of Isover

8.3 AIR LEAKAGE & DRAUGHT PROOFING

In construction, the term “air tightness” refers to a building’s capacity to prevent air leaking from its fabric (i.e. walls, floors, ceilings, doors and windows) through unintended paths. All inhabited spaces need to be ventilated with fresh air in order to maintain good air quality. However, poorly sealed building fabric can be a major source of heat loss and occupant discomfort.

Draught proofing, also called weatherization, is reducing the uncontrolled and unwanted air leakage of outside air into or out of a house. The outside air should not leak into the house because it is too warm in summer and too cold in winter (cold draught). This would defeat the objective of insulation, thermal mass and heating.

Air leakage can occur through gaps around exterior doors and windows, airbricks, ceilings and other small holes in the building envelope. Where ever there is air leakage there is also acoustic penetration.



Typical unintended air leakage paths (orange) and intended ventilation (purple)

8.4 HUMIDITY AND CONDENSATION

Humidity and condensation can compromise building occupants' health and comfort, damage interior finishes, and raise heating costs.

8.4.1 RELATIVE HUMIDITY (RH)

Air usually contains water vapour, the amount depending primarily on the temperature of the air. Warm air can hold more moisture than cold air, so as the air temperature falls, the maximum amount of water the air can hold also falls.

The ratio of water vapour in the air to the maximum amount of water vapour the air can hold at a particular temperature is expressed as relative humidity (RH). For example, a RH of 30% means that the air contains 30% of the moisture it can possibly hold at that particular temperature.

When air can hold no more moisture at a given temperature (i.e. the RH is 100%), the air is said to be saturated.

As air temperature increases, its capacity to hold moisture also increases, so if air temperature rises and its moisture content remains the same, the RH decreases.

Humidity affects both thermal comfort and indoor air quality. For example:

- high RH (very moist air) will make people feel chilled in cold weather and hot and sticky in warm weather
- low RH (very dry air) can cause dryness and discomfort in the nose and make skin feel dry and itchy.

In addition to the direct effect on comfort, damp air:

- facilitates the growth of fungi (mould) and bacteria that can cause respiratory problems and/or allergic reactions
- provides the conditions for dust mite populations to grow, which can affect asthma sufferers
- results in odours in poorly ventilated spaces because of fungal growth
- will result in condensation forming on windows, walls and ceilings that are colder than the air temperature and potentially damaging building materials.

8.4.2 REASONS FOR HIGH HUMIDITY

Household activities such as cooking, washing and using un-flued gas heaters, as well as peoples' breathing, provide the primary sources of moisture that cause humidity indoors. (A person exhales approximately 200 millilitres of water vapour per hour while awake and approximately 20 millilitres of water vapour per hour during sleep).

Other sources of moisture may also include:

- water leakage through the building envelope
- damp ground conditions under suspended timber floors
- retained construction moisture, i.e. moisture retained in building materials such as timber framing, concrete floors and plaster, after installation
- plumbing leaks.

8.4.3 CONTROLLING HUMIDITY

Internal humidity can be controlled by:

- passive ventilation by opening windows for cross ventilation
- removing moisture at source, for example, using an extract fan in the bathroom, using a range hood in the kitchen, venting a dryer to the outside and using only externally vented gas heaters
- raising indoor temperatures by heating or insulating, since warmer temperatures imply lower relative humidity
- occupants not drying clothes on racks inside.

To prevent moisture from the space under a floor getting into the building and increasing the levels of internal moisture:

- ensure there is good ventilation under suspended timber floors
- cover the ground with a vapour barrier such as polyethylene sheet where there is high ground water content under the building or where sufficient underfloor ventilation cannot be provided.

The most effective passive ventilation to remove internal moisture is simply to open windows. These should preferably be on opposite sides of the building to maintain a good cross air flow.

8.4.4 CONDENSATION

Condensation occurs when warm, moisture-laden air comes into contact with a colder surface such as glass. The air temperature in contact with the colder surface suddenly drops, reducing the amount of moisture it can hold. This results in moisture formation, or condensation, occurring on the cold surface.

Condensation is most obvious on uninsulated, heat conductive surfaces like glass, and is less noticeable on surfaces such as plasterboard. Nevertheless, it does occur on all surfaces that are cold enough and becomes apparent by mould growth on walls and ceilings. It can also be seen where 'pattern' staining on walls identifies the location of timber framing behind the wall lining.

Condensation causes damage to interior paintwork, the inside surface of wall linings, floor coverings, curtains, and furnishings. It results in increased heating costs (as additional energy is required to convert condensation back into vapour which is taken up by the air as the temperature rises), and presents a health hazard.

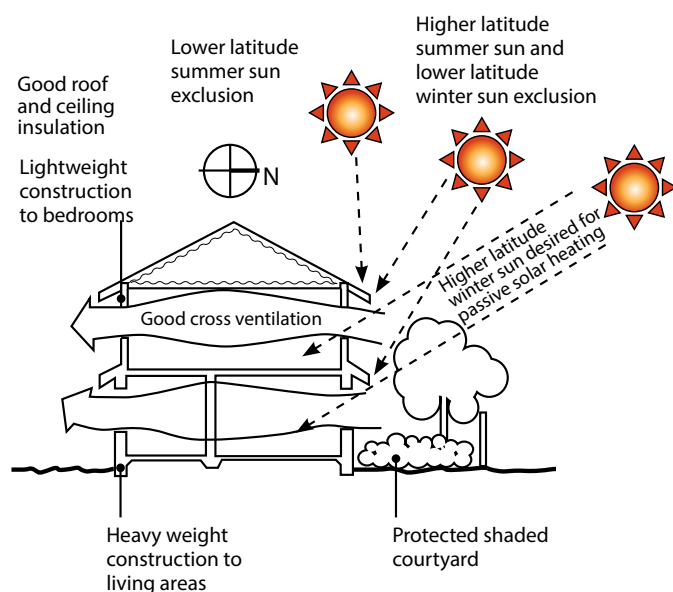
Condensation can be controlled in two ways: first, by reducing humidity (by reducing sources of humidity and through effective ventilation as explained above) so that air is less likely to become saturated; second, by reducing the likelihood of warm air coming into contact with cold surfaces. This can be achieved through insulation.



8.5 PASSIVE COOLING

Passive cooling includes shade to keep the summer sun out, good insulation and good ventilation. Take steps to create cross-draughts in your home in your design, and by leaving doors and windows open (always keep personal safety in mind). Think about shading your windows with eaves, plantings, awnings or louvres, and thermal-lined curtains.

Passive cooling isn't just for new homes. Passive cooling features can be added to existing homes - it may be as easy as planting trees to provide shade or leaving windows open to get breeze circulating inside.



8.6 MECHANICAL COOLING OPTIONS

8.6.1 FANS

If natural ventilation doesn't keep you cool enough, a fan may make you feel several degrees cooler - the air movement increases the rate at which moisture evaporates from your skin.

Fans are cheap to buy, easy to install and comparatively cheap to run. Portable floor and desktop fans are widely available, and can be stored away when not in use.

8.6.2 CEILING FANS

A ceiling fan circulates air in summer and helps to keep you cooler. In winter it can re-circulate warm air that collects near the ceiling.

A ceiling fan uses very little energy compared to an air conditioning unit. It needs a reasonable ceiling height to give good clearance and an electrical connection.

8.6.3 EVAPORATIVE COOLERS

Evaporative coolers are a form of air conditioner.

They cool air by evaporating water, so work best in dry climates. If humidity is high, as in KZN, these coolers will not work well.

The only energy used is for the fan, so evaporative coolers are reasonably energy-efficient. They use water and portable units must be topped up regularly.

To keep the humidity low, let outside air into your house.

Note

Evaporative coolers use a lot of water and are not recommended in water poor climates.

8.6.4 HEAT PUMPS

Heat pumps provide heating in winter, but most models can be switched to reverse - which means they can be used to cool your home in summer.

However, using a heat pump isn't an energy-efficient way of cooling. If you run it in summer to keep your home cool, you'll wipe out any savings you made on your heating bill in winter.

If you do use your heat pump:

- Try using the fan only setting to create a breeze.
- Use the dehumidifying mode to reduce humidity that can make it seem much hotter.
- Only use cooling mode on really hot days, shut doors and windows and only cool one room.
- Avoid using auto settings so that it doesn't start heating when the temperature drops.

Select a heat pump the right size for your home.

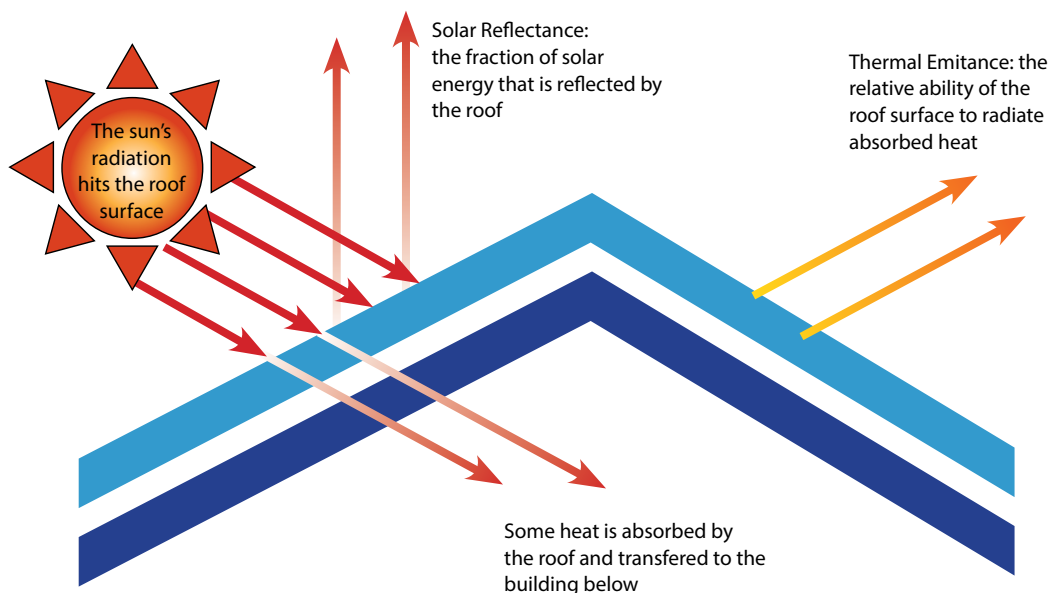


CHAPTER 9

COOL ROOFS

A cool roof can help keep heat absorption of a building to a minimum.

A cool roof is one that has been designed to reflect more sunlight and absorb less heat than a standard roof.



Cool roofs can be made of a highly reflective type of paint, a sheet covering, or highly reflective tiles. Nearly any type of building can benefit from a cool roof, but consider the climate and other factors before deciding to install one.

Just as wearing light-coloured clothing can help keep you cool on a sunny day, cool roofs material that is designed to reflect more sunlight and absorb less heat than a standard roof.

Standard or dark roofs can reach temperatures of 65°C or more in the summer sun. A cool roof under the same conditions could stay more than 10°C cooler and save energy and money by using less air conditioning. There is a lot of potential for energy savings by installing what is known as a “cool roof”. Over 90% of the roofs in South Africa are dark-coloured.

Most cool roof applications have a smooth, bright white surface that allows them to reflect solar radiation, reduce heat transfer to the interior, and save on summertime air conditioning costs.

The properties of a cool roof is determined by the solar reflectance and emittance.

Highly reflective (high albedo) roof surfaces can reflect solar energy into the atmosphere away from the building interior and away from the ambient air around the building. SR is expressed either as a decimal fraction or a percentage. SR is measured typically as the proportion of solar energy reflected on a scale from 0.0 (no energy reflected) to 1.0 (100% energy reflected).

In addition to reflecting solar energy into the atmosphere, roofs also radiate (emit) back to the atmosphere a portion of the solar energy that is initially absorbed and not reflected. The thermal emittance of a roofing surface is measured as the relative proportion of energy that is radiated back to the atmosphere and is expressed on a scale from 0.0 to 1.0.

BENEFITS OF COOL ROOFS

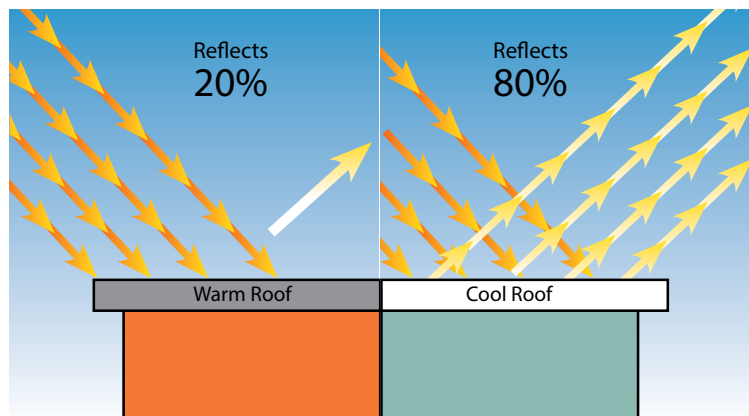
A cool roof can benefit a building and its occupants by:

- Reducing energy bills by decreasing air conditioning needs
- Improving indoor comfort for spaces that are not air conditioned, such as garages or covered patios
- Decreasing roof temperature, which may extend roof service life.

Beyond the building itself, cool roofs can also benefit the environment, especially when many buildings in a community have them.

COOL ROOFS CAN:

- Reduce local air temperatures (sometimes referred to as the urban heat island effect)
- Lower peak electricity demand, which can help prevent power outages
- Reduce power plant emissions, including carbon dioxide, sulphur dioxide, nitrous oxides, and mercury, by reducing cooling energy use in buildings.



RECOMMENDATIONS FOR REFLECTANCE AND EMITTANCE REQUIREMENTS FOR UPPER ROOF SURFACES.

	INITIAL SOLAR REFLECTANCE	⁽¹⁾ WEATHERED SOLAR REFLECTANCE	INITIAL THERMAL EMITTANCE	⁽²⁾ SOLAR REFLECTANCE INDEX
	ρ	ρ_{aged}	ϵ	SRI
Roof	≥ 0.65	≥ 0.49	≥ 0.75	≥ 75

WHAT ARE THE DIFFERENCE BETWEEN “COOL ROOFS” AND THERMAL INSULATION?

Thermal Insulation and Cool Roofs complement each other. Thermal insulation acts as a barrier to heat flow/heat transfer and cool roofs prevent absorption of the heat by means of solar reflectance.



CHAPTER 10

TIPS ON ENERGY SAVINGS



There is a golden rule that applies to saving electricity in a home or building: **If you're not using it, switch it off.**

By changing the way we use energy every day, we can make a difference to the electricity supply shortage in our country.

10.1 WINDOWS AND DOORS

Moveable glass louvres cannot be made airtight. Standard opening sections (top, bottom and side hung) of steel windows are not designed to be draught proof and are most certainly not. In retrofit situations a sealer strip can be applied. Follow the manufacturer's installation specifications.

10.2 CURTAINS

Heavy curtains at windows reduce heat flows between the interior and exterior of a home. In summer, the curtains may be closed during the day to reduce heat penetration from outside. In winter, the curtains may be closed at night to prevent heat loss to the outside.



10.3 WATER HEATING (GEYSER)

Water heating accounts for 30-40% of energy use in an average South African house, so achieving energy efficiency can make a significant difference to energy use and costs.

A hot water system must be designed to provide sufficient hot water for household needs. It must meet health and safety requirements such as controlling temperature and pressure to ensure there is minimal risk of scalding or of a storage cylinder exploding, and to prevent the growth of *Legionella* bacteria.

A well-designed system will also support efficient energy and water use, by:

- using a heating source that is efficient and minimises environmental harm
- locating the heating source close to points of use, and ensuring that pipe runs are relatively short
- insulating hot water pipes
- heating and storing only as much water as is needed to meet peak demand
- only heating water to the temperature needed to meet regulatory requirements
- using low flow fixtures
- using energy efficient and water efficient appliances, or appliances that heat their own water (unless you use solar or heat pump water heating).

The amount of energy (electricity) used by a geyser depends on the following:

- How high the thermostat is set
- How much heat is lost from the geyser and water pipes
- How much hot water is used

THERMOSTAT SETTING

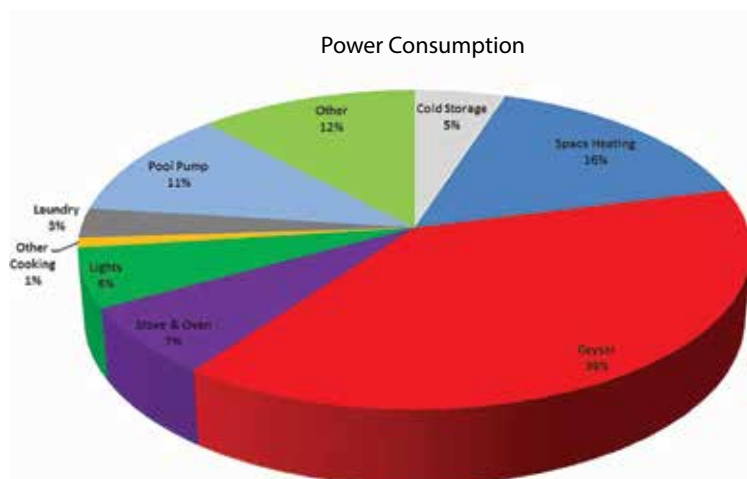
To save energy, the ideal setting for the geyser thermostat is 60°C. Any higher settings results in wasted energy from increased standing losses and from producing water that is too hot for comfort and which has to be mixed with cool water for washing and bathing purposes. Lower settings could result in the growth of *Legionella* bacteria.

GEYSER INSULATION

Most geysers are installed in the roof of the house where cold winter air can cool down the hot water. A geyser blanket can be installed around the geyser to insulate the hot water in the geyser from the cold air outside. A geyser blanket keeps the water hot.

Geysers may be installed in a horizontal position, as is common inside the roof, or in a vertical position, either wall mounted or free standing.

An advantage of vertical alignment is that the hot water is drawn off, the incoming cold water mixes with a smaller surface area of hot water than in a horizontal geyser and therefore does not cool it to the same extent.



Photograph courtesy of Brits Nonwoven

WATER PIPE INSULATION

Ideally, geysers should be located as close as possible to the points of use, this reduces the amount of cold water in the “dead leg” which needs to be run-off before the hot water flows. Shorter pipe runs also reduce the amount of heat lost from the pipes themselves. Like the geyser, water pipes should be insulated against heat loss.



For Building Code requirements, information about controlling temperature and pressure, and information about system layout and capacity, contact IOPSA, the Institute of Plumbing SA. www.iopsa.org.za

In general, the most energy efficient system for most household purposes will be an appropriately sized storage system with solar or heat pump water heating. For outlets that are rarely used or remote from the main hot water supply, a continuous flow system may be more convenient and minimise energy use.

10.4 ELECTRICAL APPLIANCES ENERGY

HEATERS ENERGY TIPS

- Heat as few rooms as possible.
- An electric blanket will use about four times less electricity than a small heater.
- Close a heated room's doors and windows.
- Insulate ceiling spaces above the rooms with thermal insulating material.
- Use low-power heater.
- Switch off heaters when not in use.
- A 2-kW heater used for five hours each night uses 10 units a night, which amounts to 300 units a month.
- On the other hand, the same heater left on continually will consume $2 \times 24 = 48$ units a day = 1440 units a month.



FRIDGES AND FREEZERS ENERGY TIPS

- Ensure that the fridge door seals are in a good condition.
- Do not open the fridge doors unnecessarily.
- Do not leave the fridge door open while you are busy with other things.
- Do not put hot food or liquids in the fridge.
- Defrost your fridge regularly. A heavy build-up of ice increase the running cost of the fridge.

LIGHTING ENERGY TIPS

- Use a bulb with as low wattage as possible. But remember that a 100-watt bulb provides the same light as two 60-watt bulbs.
- Switch off unnecessary lights.
- Switch off lights when not needed. Use low wattage globes where possible.
- Do not leave the outdoor light on during daylight hours.
- Use energy efficiency light bulbs.

KETTLE ENERGY TIPS

- It costs a lot less to boil water in a kettle than to boil water on a stove.
- Boil only as much water as required. (But always make sure that the kettle element is covered with water).
- Pour excess hot water into a handy thermos flask for future use, this can save time and money.
- Do not overfill kettles. Many people fill kettles to the brim to make tea for only one or two people. For small quantities, merely cover the element in an electric kettle.

STOVE ENERGY TIPS

- Electric frying pans and microwave ovens use less electricity than a stove.
- Pressure cookers and stackable pots use less electricity than standard pots.
- Match your pots to your stove's plates. A big pot on a small plate means uneven cooking.
- Do not use pots with distorted bottoms; they require a lot more heat.
- Do not use a small pan on a large plate as the heat goes up past the pan, along with your electricity bill.
- High temperatures are only required at the start of the cooking process. So turn the heat down as you proceed.
- Switch off your oven and stove plates just before the food is fully cooked.
- Do not use your oven to make toast. A bread toaster costs far less to run.
- Do not use your oven to heat the kitchen. It is far less efficient than a space heater. Overheating will not only damage the stove elements, but may also cause a fire.
- Avoid using the oven for cooking a single dish at a time.
- Switch off when not in use

The table below indicates the amount of power that different electrical appliances use:

APPLIANCE	WATT
Geyser	3000
2 Plates and oven together	3000
Microwave oven	1500
Dishwasher	2100
Freezer	600
Washing machine – not heated	800
Washing machine – heated	2000
Tumble dryer	3000
Frying pan	1500
Fryer (rotating)	1400
Toaster	1100
Coffee Filter	600
Kettle (1500 – 3000w)	2000
Hi-fi	100
Radio	100
TV (66cm colour)	300
Blanket	100
Hair drier (400 – 1000w)	600
Vacuum cleaner	600
Iron (600 – 2000w)	1400
Floor polisher	400
Heater - fan	2000
Ceramic	1500
Panel	1100



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