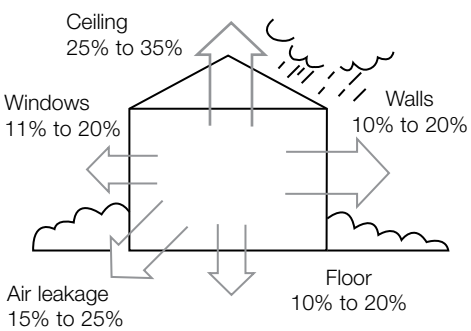
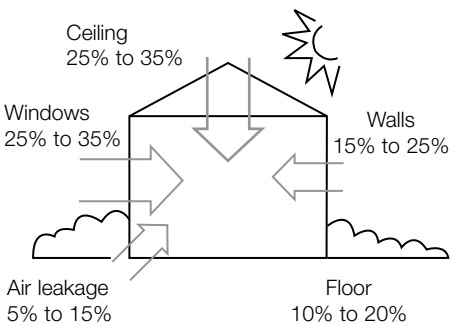
Insulation

Insulation acts as a barrier to heat flow and is essential to keep your home warm in winter and cool in summer. A well insulated and well designed home will provide year-round comfort, cutting cooling and heating bills by up to half. This, in turn, will reduce greenhouse gas emissions.

Climatic conditions will influence the appropriate level and type of insulation. Establish whether the insulation will be predominantly needed to keep heat out or in (or both). Insulation must cater for seasonal as well as daily variations in temperature, see 'Insulation levels for your Climate'.





Source: SEAV Insulation Guide

Typical heat gains and losses in a temperate climate.

Passive design techniques should be used in conjunction with insulation. For example, if insulation is installed but the house is not properly shaded, built up heat can be kept in by the insulation creating an 'oven' effect. Draught sealing is important, as draughts can account for up to 25 per cent of heat loss from a home in winter. **[See: 4.5 Passive Solar Heating; 4.6 Passive Cooling]**

Insulation can assist with weatherproofing and eliminate moisture problems, such as, condensation. Some types of insulation also have soundproofing qualities.

The most economical time to install insulation is during construction. For information on retro-fitting insulation, see 'Adding insulation to existing buildings'.

There is little insulating value in most common construction materials, but there are some exceptions where little or no additional insulation may be required. Suitable materials include aerated concrete blocks, hollow expanded polystyrene blocks, straw bales and rendered extruded polystyrene sheets. Check with your local building information centre for more details.

> Total R-values for roofs, ceilings, walls and floors may provide only one value for total thermal resistance of construction which may not be adequate to achieve compliance with the Building Code of Australia (BCA) requirements for energy efficiency of building fabric.

> Under the BCA, total R-values of the building fabric vary depending on climate zone and the height above the Australian Height Datum at the location where the building is to be constructed.

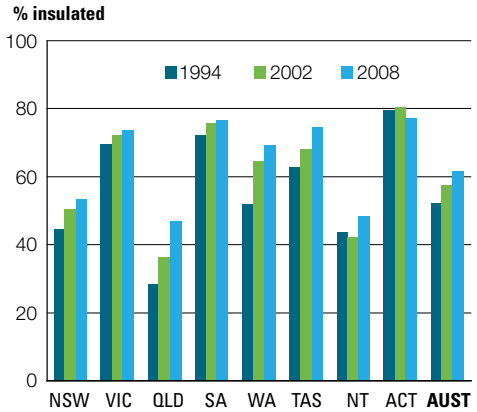
CHOOSING INSULATION

Insulation products come in two main categories – bulk and reflective. These are sometimes combined into a composite material. There are many different products available, see 'Insulation types and their applications' for further information.

To compare the insulating ability of the products available look at their R-value, which measures resistance to heat flow. The higher the *R-value* the higher the level of insulation. Products with the same R-value will provide the same insulating performance if installed as specified.

Check the information supplied on the product, including the R-value, the price per square metre and whether it must be installed professionally or can be DIY – some types of insulation require the use of masks and protective clothing. Ensure that it suits your particular application and will fit within the space available. Ask if performance guarantees or test certificates are available.

Insulation in Australian homes (2008)



Source Australian Bureau of Statistics, 2008.

Compare the environmental benefits of different products. Ask about recycled content and how easily the product can be recycled after use. For example, some brands of glasswool, polyester and cellulose fibre insulation contain significant amounts of recycled context. Contact the manufacturer or industry association to find out more.

The appropriate degree of insulation will depend on climate, building construction type, and whether auxiliary heating and/or cooling is to be used. Refer to the section headed 'Insulation levels for your climate'.

The Building Code of Australia (BCA) sets out minimum requirements for the R-values of materials used in construction of buildings. For reference, please refer to BCA 2010 Volume Two Part 3.12. It is generally advisable to exceed these for greater comfort and energy savings.

The higher the R-value the better the thermal performance.

Material R-values are supplied with bulk insulation and refer to the insulating value of the product alone. The higher the R-value the better the thermal performance.

Total R-values are supplied with reflective insulation and depend on the product being installed as specified.

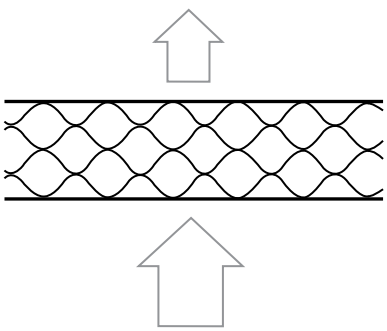
R-values can differ depending on the direction of heat flow through the product. The difference is generally marginal for bulk insulation but can be pronounced for reflective insulation.

> **Up R-values** describe resistance to heat flow upwards (sometimes known as 'winter' R-values).

> **Down R-values** describe resistance to heat flow downwards (sometimes known as 'summer' R-values).

Up and down R-values should be quoted when installing reflective insulation in roofs, ceilings and floors.

INSULATION TYPES AND THEIR APPLICATIONS



Source: SEAV Insulation Guide

Bulk insulation traps air in still layers.

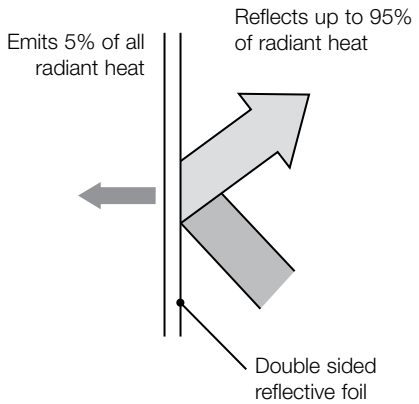
Bulk insulation mainly resists the transfer of conducted and convected heat, relying on pockets of trapped air within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through it.

Bulk insulation includes materials, such as, glasswool, wool, cellulose fibre, polyester and polystyrene. All bulk insulation products come with one Material R-value for a given thickness.

Reflective insulation mainly resists radiant heat flow due to its high reflectivity and low emissivity (ability to re-radiate heat). It relies on the presence of an air layer of at least 25mm next to the shiny surface. The thermal resistance of reflective insulation varies with the direction of heat flow through it.

Reflective insulation is usually shiny aluminium foil laminated onto paper or plastic and is available as sheets (sarking), concertina-type batts and multi-cell batts. Together these products are known as reflective foil laminates or RFL.

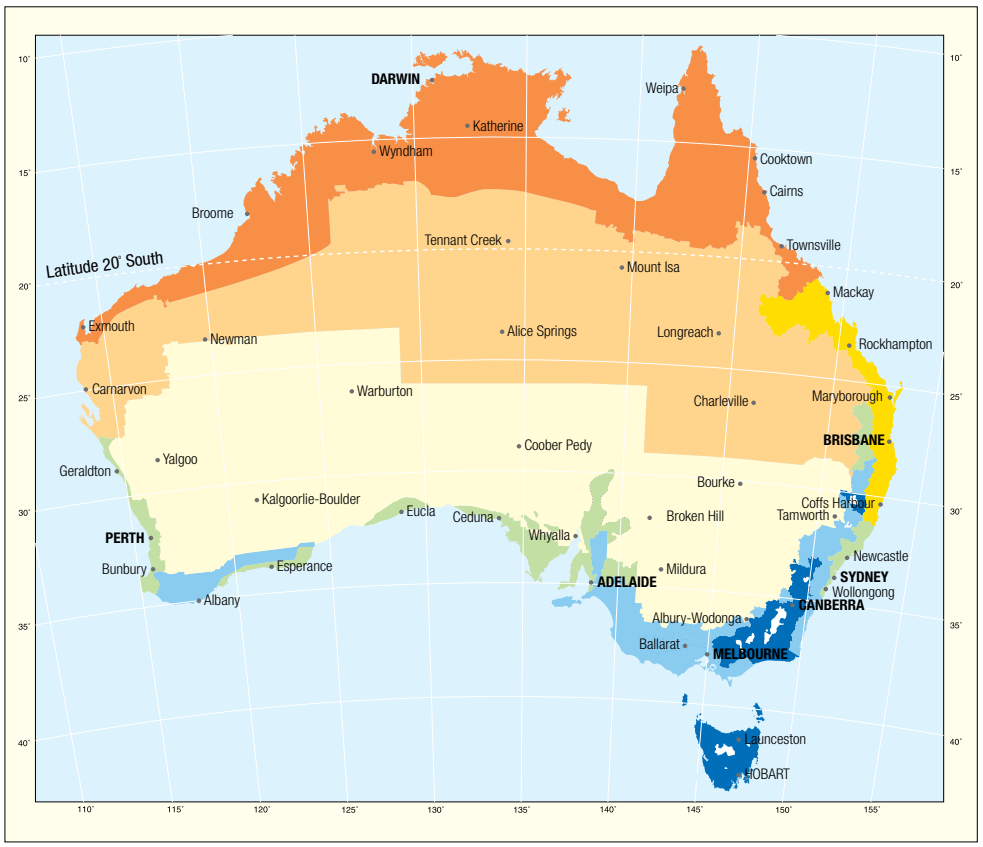
Dust settling on the reflective surface will greatly reduce performance. Face reflective surfaces downwards or keep them vertical. The anti-glare surface of single sided foil insulation should always face upwards or outwards.



The Total R-values for reflective insulation are supplied as up and down values. Total values depend on where and how the reflective insulation is installed. Ensure system values provided by the manufacturer relate to your particular installation situation.

Composite bulk and reflective materials are available that combine some features of both types. Examples include reflective foil faced blankets, foil backed batts and foil faced boards.

The properties and uses of some common insulation materials are shown in the table at the end of this sheet.



ZONE	DESCRIPTION
1	High humid summer, warm winter
2	Warm humid summer, mild winter
3	Hot dry summer, warm winter
4	Hot dry summer, cool winter
5	Warm temperate
6	Mild temperate
7	Cool temperate
8	Alpine

INSULATION LEVELS FOR YOUR CLIMATE

The following table gives recommended minimum insulation levels for a range of locations.

These are the minimum requirements of the building code. Some experts believe that additional insulation can further improve building performance.

The table does not distinguish between directional R-values for roofs and ceilings. The most important thing to remember is that in high humid climates where houses are naturally ventilated, high down values and lower up values are appropriate for roofs and ceilings.

CLIMATE TYPE AND EXAMPLE LOCATIONS	MINIMUM INSULATION LEVELS (Material or Total R-values)	
	ROOF/ CEILING*	WALL
Cool Temperate and Alpine		
Reducing heat loss is the main priority		
Melbourne, VIC	4.1	2.8
Canberra, ACT	4.1	2.8
Hobart, TAS	4.1	2.8
Mt Gambier, SA	4.1	2.8
Ballarat, VIC	4.1	2.8
Thredbo, NSW	6.3	3.8
High humid and Hot Dry		
Reducing heat gain is the critical priority		
Darwin, NT	4.1	2.8
Cairns, QLD	4.1	2.8
Broome, WA	4.1	2.8
Marble Bar, WA	4.1	2.8
Mt Isa, QLD	4.1	2.8
Tennant Creek, NT	4.1	2.8
Townsville, QLD	4.1	2.8
Warm/Mild Temperate and Warm Humid		
Reducing heat loss and heat gain are equally important		
Brisbane, QLD	4.1	2.8
Perth, WA	4.1	2.8
Alice Springs, NT	4.1	2.8
Bourke, NSW	4.1	2.8
Sydney, NSW	4.1	2.8
Adelaide, SA	4.1	2.8
Katoomba, NSW	4.1	2.8

* Note: These minimum insulation levels will be higher if your roof has an upper surface absorptance value of more than 0.4.

Source BCA 2010 Volume Two

WHERE TO INSTALL INSULATION

Roofs and ceilings work in conjunction when it comes to insulation.

> Install insulation under the roofing material to reduce radiant heat gain.

> Install insulation in the ceiling to reduce heat gain and loss. In most cases ceiling insulation is installed between the joists.

[See: 4.8 Insulation Installation]

Verandah roofs should be insulated in hot climates where outdoor living spaces are used extensively, to reduce radiant heat gain. Heat build up under verandahs not only affects the space below but can affect conditions inside the house.

Bulkheads (wall sections between ceilings of different heights) must be insulated to the same level as the ceiling, as they are subjected to the same temperature extremes.

Save up to 45 per cent on heating and cooling energy with roof and ceiling insulation.

External walls should be insulated to reduce radiant, conducted and convected heat transfer. Wall insulation can be installed:

> Within cavities.

> Within stud frames.

> On the outside of stud frames.

> On the inside or outside of solid walls.

Depending on the particular situation, some forms of insulation can double as a vapour or moisture barrier.

Save up to an additional 20 per cent of heating and cooling energy with wall insulation.

Floors require insulation in cool climates and often in other climates.

Insulate the underside of suspended floors:

> In cool temperate and alpine climates.

> In temperate climates in some cases (See previous section).

> In high humid and hot dry climates where air conditioning is used.

Insulate the edge of slabs on ground:

> In cool temperate and alpine climates.

> In temperate climates where slab heating is used.

Insulate the underside of slabs on ground:

> In alpine climates.

> Where groundwater is present.

Enclosing sub-floor spaces in mixed climates may be sufficient to reduce heat loss.

Save up to 5 per cent on winter energy costs with appropriate floor insulation.

ADDING INSULATION TO EXISTING BUILDINGS

Insulation can be added to existing buildings with varying effectiveness and cost depending on the construction type and where the insulation is being placed.

Ceilings and suspended floors with easy access are relatively simple to insulate post-construction.

Insulation board can be laid beneath floor finishes if there is no under-floor access.

Walls and skillion roofs are the hardest to insulate post-construction, as the internal or external lining must be removed. A good time to insulate walls is during re-cladding or re-plastering. Specialised products are available to insulate existing walls. Check with your local building information centre. External insulation or (if local building regulations permit) cavity fill are often appropriate solutions for double brick walls.

RETROFITS AND RENOVATIONS

Adding (or 'retrofitting') insulation to existing buildings provides a major opportunity to increase comfort and reduce energy costs and greenhouse gas emissions. An ideal time for doing this is during renovations.

This section explains how to retrofit insulation to various construction types. Refer to the previous sections of this sheet to determine the appropriate type and level of insulation for your climate.

Walls

Most walls will benefit from added insulation, and it is possible to add insulation to most construction types used in Australia. Autoclaved aerated concrete (AAC) already has a reasonable degree of insulation built into the blocks themselves, and straw bale is an extremely highly insulated system.

Apart from these exceptions, added wall insulation is essential in all climates. If it is not already fitted, or if existing insulation levels are not high enough, there are ways of installing it as a retrofit.

Cavity Brick Walls

Cavity brick walls have high thermal mass, but without insulation are usually too cold in winter, and often too hot in summer if exposed to prolonged heat wave conditions. If the cavity is insulated, the internal thermal mass (ie. the internal brick skin) is protected from external temperature changes, and becomes highly effective at regulating temperatures within the home.

Insulate existing cavities by sealing the bottom of the cavity if it is open to the subfloor, and pumping in loose bulk material to a measured density. This has been common practice in the UK and Europe for many years, and is becoming available in Australia, usually in one of the following forms:

> Small polystyrene balls (produced with CO_2) coated in a non-toxic bonding agent are pumped in at regular points around the building. The bonding agent solidifies and locks all the balls in place.

> Mineral fibres can be blown into the cavity either through a series of small holes as above, or into the top of the cavity if it is accessible. This material is mineral wool. It is treated with a moisture repellent to keep the insulation and cavity dry.

It is important that such materials are installed by reputable manufacturers whose products meet either the Australian, UK or European standards.

Brick veneer, reverse brick veneer and timber framed walls

Brick veneer walls have the brick skin on the outside, which is not the ideal location for thermal mass. The bricks heat up in summer and radiate heat late into the evening, while in winter they stay cold and absorb heat from the house. Insulation is essential to protect the occupants from external temperature extremes that are exacerbated by the external brick skin.

Reverse brick veneer is much more thermally efficient because the thermal mass is on the inside, however good insulation is still important to maintain thermal comfort.
[See: 4.9 Thermal Mass]

Timber framed walls are low mass construction, and rely entirely upon insulation to maintain thermal comfort.

The two cavity fill methods previously described (polystyrene balls or mineral fibres) can be used to insulate these wall types if the lining or cladding is not being removed. More material may be required, as it will fill up not only the cavity but the width of the wall frame (brick veneer and reverse brick veneer). Note that the effectiveness of existing reflective insulation is greatly diminished by replacing the airspace with fill material. For timber frame walls, insulation is pumped into the voids between studs and noggings, but this can be labour intensive.

The ideal option, if the scope of the renovation permits, is to remove the internal plasterboard linings or external cladding and fit insulation into the stud frame.

Either bulk or reflective insulation can be retro-fitted to existing wall frames by either cutting up a roll and fitting the pieces between each wall stud, or by using a factory prepared product like bulk batts, concertina foil batts or multi-cell foil batts, which are easy to install and expand or fold into place. Reflective foil-backed plasterboard is also a useful material.

There is usually sufficient depth in a wall frame to add more than one layer of reflective insulation, including the necessary air gap of 25mm between layers. When installing from the room side, the foil should not have an antiglare coating on it.

R 2.0 (70mm) or R 2.5 (90mm) bulk insulation can be fitted between studs. It is important to choose the correct thickness of insulation to suit the thickness of the cavity.

Bulk insulation can be fitted between studs in the conventional manner and, depending on the thickness of the studs and the selected R-value, may or may not fill the entire wall frame width. Do not compress bulk insulation.

When used in conjunction with a layer of wall wrap foil, ensure there is an air space of at least 25mm between the batt and the wall wrap foil.
[See: 4.8 Insulation Installation]

Other wall types

Single skin high mass walls, such as, concrete block, rammed earth or mud brick can have their thermal performance radically improved by installing insulation on the wall exterior. The simplest method is to use polystyrene board with an external render, or batts fixed between battens at around 600mm centres, covered with a waterproof cladding.
[See: 4.8 Insulation Installation; 4.9 Thermal Mass]

Ceilings and roofs

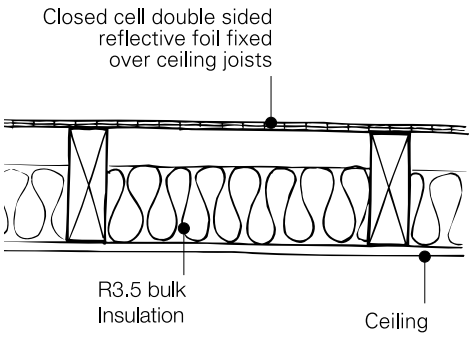
It is possible to add insulation to all roof types common in Australia, and even if some effort is required to lift roofing, the benefit is well worth it.

Ceiling fires have increased significantly with the more common use of downlights that penetrate the ceiling. Care must be taken to ensure that minimum clearances around downlights are maintained and that transformers are not underneath the insulation. Wherever possible avoid recessed light fittings as these are a major source of heat loss.

Tiled roofs without foil insulation can have it added easily if the roof is being re-tiled. If the tiles are to remain in place and access is available to the roofspace, double sided foil or foil batts can be added between the rafters or trusses, directly under the tile battens.

Metal roofs need a condensation barrier directly beneath them: a layer of reflective foil insulation is an effective membrane and barrier to radiant heat, thus doing two jobs at once. It is usually necessary to remove the roofing to install this, but most metal roofing can be removed and reinstalled easily, without damage.

If foil insulation has been fitted it may still be necessary to fit extra layer/s of foil beneath it. A minimum air gap of 25mm should always be maintained between layers. If the roof is being painted to restore colour, select the lightest permissible colour (heat-reflective roof paints are also an option), and then match the remaining colour scheme to it.



Ceiling insulation is simple to fit if the roof space is accessible. If the house has a flat roof or raked ceilings, there will be no access into the space except by removing and reinstalling the roofing or the ceiling lining. If the ceiling is being replaced, it's a simple job to install insulation from below. Reflective foil backed plasterboard is a useful material in this situation, but may not provide sufficient insulation if used on its own.
[See: 4.8 Insulation Installation]

Floors

Floors do not always require insulation. Refer to the previous sections of this sheet to determine whether floor insulation is required for your situation.

Raised timber floors should have subfloor access, with soil clearance of around 400mm below the lowest timbers. This provides sufficient access to install insulation. Foil or bulk insulation will work well, but in either case care must be taken to ensure it is well supported and will not sag or fall down in time. Vermin also need to be accounted for. Insulation board can be laid beneath floor finishes if there is no subfloor access.

Concrete slabs are either suspended or slab on ground. Suspended slabs can be insulated in a similar way to raised timber floors.

A suspended concrete slab with an in-slab heating or cooling system installed must be insulated around the vertical edge of its parameter and underneath the slab with insulation having R-value of not less than 1.0.

A concrete slab-on-ground with an in-slab heating or cooling system must have insulation installed around the vertical edge of its perimeter. The insulation must achieve a minimum R value of 1.0 in zones 1 to 7 and a minimum R value of 2.0 in zone 8. The insulation must be water resistant and be continuous from the adjacent finished ground level to a depth of 300mm or for at least the full depth of the vertical edge of the concrete slab-on-ground.

To install slab-on-ground edge insulation you can excavate a shallow trench around the slab edge, but you should avoid excavating right down to the bottom of the slab, as destabilisation of the foundation may occur.

Install a 40mm closed cell polystyrene board and fibre cement cover board around the entire slab edge, up to the height of the wall cladding. Ensure the termite barrier remains intact. For more effective performance (if needed) an additional fin of closed cell polystyrene board can be laid horizontally from the slab edge underneath paving, extending about 1-1.5m.
[See: 4.8 Insulation Installation]

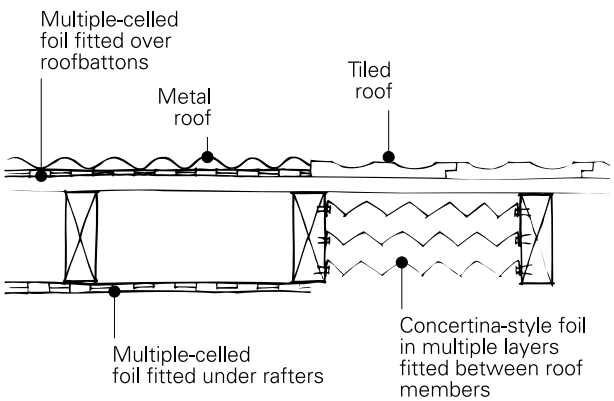
Air Leakage

Householders can improve the energy efficiency of most existing and new homes by weathersealing. Overseas standards and research recognise that the weather proofing or draught sealing of houses is the most effective method of achieving direct energy savings, whilst maintaining healthy indoor air quality. It is estimated that Australian buildings leak 2-4 times as much air as Northern American or European buildings, suggesting a tremendous opportunity for energy savings in Australia.

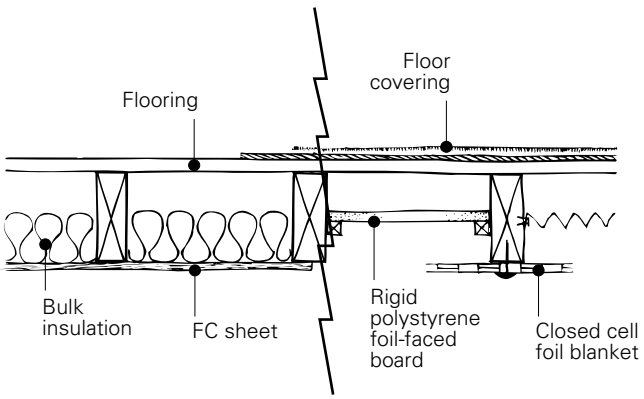
In Australia, households produce around 20 per cent of our total annual greenhouse gas emissions, of which heating and air-conditioning account for around 38 per cent. Draughts can account for up to 25 per cent of heat loss from a home.

According to the Mobile Architecture and Built Environment Laboratory there are currently no scientific programs on air leakage performance for Australian residential construction and the challenge is to identify where weather sealing can be improved and to develop appropriate methods of construction, repair and detailing.

Roof



Floor



Exposed subfloor (Pole home).

Enclosed or ventilated subfloor (brick, brick veneer, timber frame).

PROPERTIES AND USES OF COMMON INSULATION TYPES

Common types of reflective insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched Roof	Cathedral or raked ceilings	Timber floors	Framed walls
Reflective Foil Laminate [RFL] insulation	> Aluminium foil laminated with glasswool reinforcement > Requires a sealed air space of at least 25mm between foil and solid surface to provide full insulation > Useful as a barrier against moisture > Dust build up on foil reduces performance > Available in rolls, often with one side painted with anti-glare paint	✓	✓	✓	✓
Multi-cell Foil Batts	> Batts made from layers of RFL with enclosed air cavities between the layers > Other characteristics identical to RFL insulation > Double or triple cell batts available > 25mm air space to be maintained between product and other material	✓	✓	✓	✓
Concertina – type Foil Batts	> Concertina-folded foil/ paper laminate > Expandable, and can be adjusted to suit varying gaps > Other characteristics identical to RFL	✓	✓	✓	✓

Common types of bulk insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched Roof	Cathedral or raked ceilings	Timber floors	Suspended slabs	Slab edges	Full masonry walls	Framed walls
Glasswool Batts	> Made from melted glass spun into a mat of fine fibres > Easy to cut and install, commonly sold in DIY packs as rolls or batts > Should not be compressed or moistened > Can cause irritation, wear protective clothing during installation	✓	✓	✓				✓
Rockwool Batts	> Made from melted volcanic rock spun into a mat of fine fibres > Higher R-values than glasswool per unit thickness > Good sound absorption properties > Other characteristics- see glasswool	✓	✓	✓				✓
Rockwool Loose-fill	> Supplied as granules, properties as for Rockwool batts > Can be difficult to install in weatherboard walls > Treat with water repellent and install evenly > Should not be compressed or moistened	✓	✓*					✓
Polyester	> Made from polyester threads spun into a mat, produced in rolls and batts > Similar physical properties to fibreglass and rockwool > Should not be compressed or moistened > Protecive clothing is not required during installation	✓	✓	✓				✓
Wool Batts	> Made from spun sheep's wool, treated against vermin and rot > Available with polyester blend to reduce settling and compression > Check the quality and fire resistance of the product	✓	✓	✓				✓
Wool Loose-fill	> Properties as for wool batts, but quality and density can vary and affect the R-value	✓	✓*					
Cellulose Fibre Loose-fill	> Made from pulverised recycled paper > Borax and boracic acid are added as fire retardant and to deter vermin > Usually pumped into ceiling, must be a consistent density and thickness > Should not be compressed or exposed to moisture > Some settling may occur, decreasing performance	✓	✓*					
Extruded polystyrene [styrofoam]	> Rigid boards that retain air but exclude water > High R-value per unit thickness, suitable where space is limited > Easy to cut and install and can be rendered > Greater structural strength and moisture resistance than EPS		✓	✓	✓	✓	✓	✓
Expanded polystyrene [EPS]	> Semi-rigid boards of polystyrene beads > Easy to cut and install and can be rendered > Available as pre-clad panels		✓	✓	✓	✓	✓	✓

*Consult manufacturers for maximum roof slope to which loose fill insulation can be installed

Composite insulation combines the benefits of bulk and reflective insulation

MATERIAL	DESCRIPTION	Flat ceilings Pitched Roof	Cathedral or raked ceilings	Timber floors	Suspended slabs	Slab edges	Full masonry walls	Framed walls
Glasswool or Rockwool Batts and blankets with RFL	> Reflective foil is bonded to one side of the batt > Characteristics as for batts, plus: > Higher 'down' R-values due to foil > Increased moisture resistance due to foil	✓	✓	✓	✓			
Expanded polystyrene with foil	> Expanded polystyrene boards sandwiched between reflective foil > Characteristics as for EPS, plus: higher 'down' R-values due to foil		✓	✓	✓			✓

ADDITIONAL READING

Contact your State / Territory government or local council for further information on insulation considerations for your climate.
www.gov.au

Australian Bureau of Statistics (March 2008), *Environmental Issues: Energy Use and Conversation*, Catalogue no. 4602.0.55.001

BEDP *Environment Design Guide*
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www.renew.org.au

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