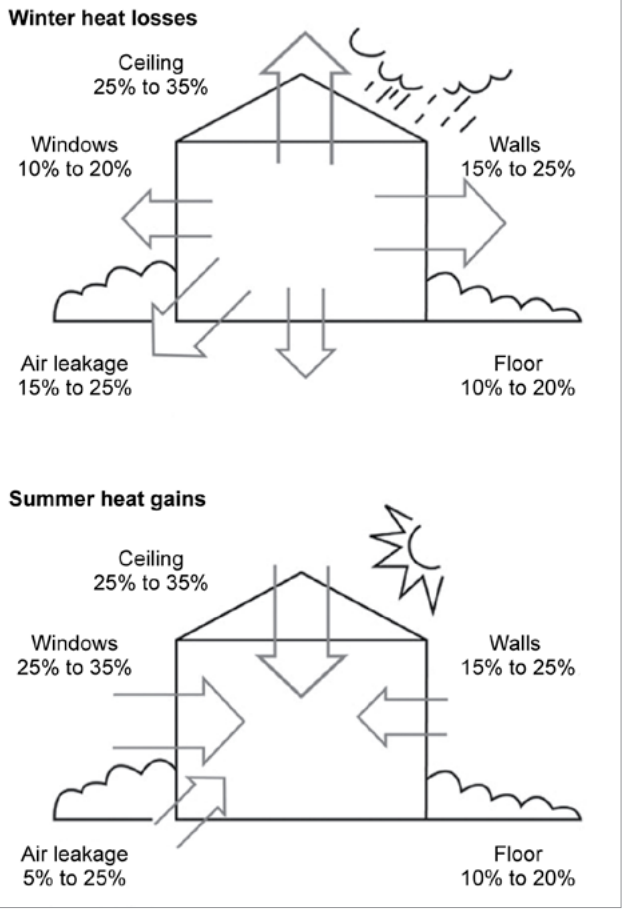
Insulation

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

Climatic conditions influence the appropriate level and type of insulation. Establish whether the insulation is 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' below*)



Source: SEAV 2002

Typical heat losses and gains without insulation in a temperate climate.

Use passive design techniques 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 also important, as draughts can account for up to 25% of heat loss from a home in winter. (see *Passive solar heating*; *Passive cooling*; *Sealing your home*)

Insulation can help 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 retrofitting insulation, see 'Adding insulation to existing buildings' below.

Most common construction materials have a low insulating value, but some require little or no additional insulation. Such 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.

Under the Building Code of Australia (BCA), the required total R-values for the building fabric vary depending on climate zone (see *Design for climate*) and the building site's height above the Australian Height Datum. Ensure you comply with the BCA requirements for energy efficiency of building fabric.

Choosing insulation

Insulation products come in two main categories — bulk and reflective — which are sometimes combined into a composite material. For the many different products available see 'Insulation types and their applications' below.

To compare the insulating ability of the products available, we need to 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 have 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 fits within the space available. Ask if performance guarantees or test certificates are available.

All insulation materials that are sold in Australia must meet Australian Standard AS/NZS 4859, materials for the thermal insulation of buildings, even if they are imported.

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 glass wool, polyester and cellulose fibre insulation contain significant amounts of recycled material. Contact the manufacturer or industry association to find out more.

The appropriate degree of insulation depends on climate, building construction type, and whether auxiliary heating and/or cooling is to be used (*see 'Insulation levels for your climate' below*).

The BCA sets out minimum requirements for the R-values of materials used in the construction of buildings. For reference, see BCA 2013, 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.

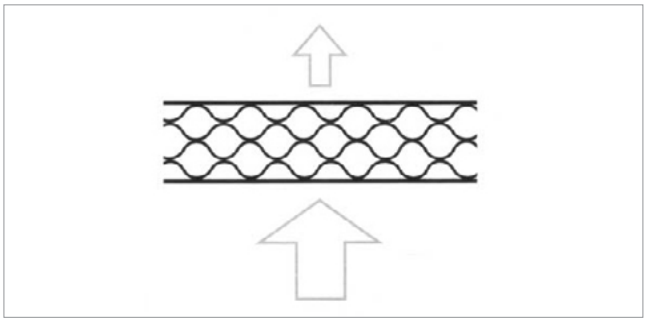
- 'Up' R-values describe resistance to heat flow upwards (sometimes known as 'winter' R-values).
- 'Down' R-values describe resistance to heat flow downwards (sometimes known as 'summer' R-values).

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

Insulation types and their applications

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 glass wool, wool, cellulose fibre, polyester and polystyrene. All bulk insulation products come with one material R-value for a given thickness.



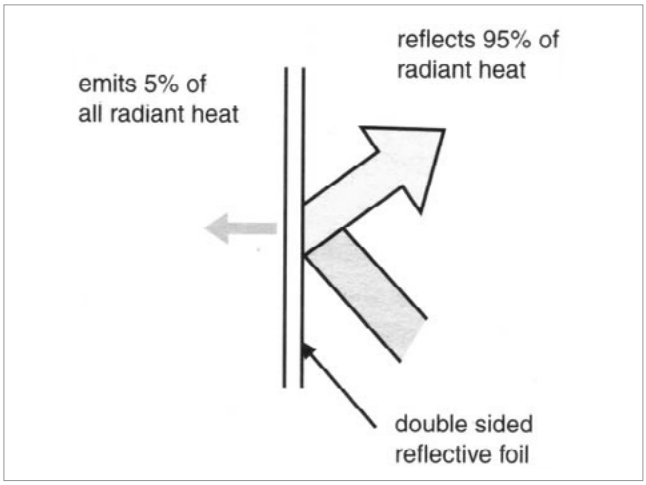
Source: SEAV 2002

Bulk insulation traps air in still layers.

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 greatly reduces performance. Face reflective surfaces downwards or keep them vertical. The anti-glare surface of single sided foil sarking should always face upwards or outwards.



Source: SEAV 2002

Reflective insulation and heat flow.

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 summarised at the end of this article.

Insulation levels for your climate

The following table gives the minimum insulation levels required by the BCA for a range of locations. Some experts believe that additional insulation can further improve building performance.

The table does not distinguish between directional R-values for roofs and ceilings. 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 level (Total R-value)	
	Roof/Ceiling*	Wall
Cool temperate; 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
Hot humid; Hot dry		
Reducing heat gain is the top 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 temperate; Mild temperate; 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

*These minimum insulation levels are higher if your roof has an upper surface absorbance value of more than 0.4.
Source: ABCB 2012

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 *Insulation installation*)

To reduce the risk of electrical short circuiting, electrically conductive insulation must not be laid across ceiling surfaces or ceiling joists, or under subfloors. Electrically conductive insulation must also be secured with non-conductive staples.

Veranda roofs should be insulated in hot climates where outdoor living spaces are used extensively, to reduce radiant heat gain. Heat build-up under verandas 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.

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.

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 subfloor spaces in mixed climates may be sufficient to reduce heat transfer.

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 after construction, as the internal or external lining must be removed. A good time to insulate walls is during recladding or replastering. 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 cavity brick walls.

Adding insulation to existing buildings can greatly increase comfort and reduce energy costs and greenhouse gas emissions. An ideal time for doing this is during renovations. Insulation can be retrofitted to various construction types.

Walls

Most walls 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 (i.e. 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 carbon dioxide) 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 are blown into the cavity either through a series of small holes, as above, or into the top of the cavity if it is accessible. Known as mineral wool, this material is treated with a moisture repellent to keep the insulation and cavity dry.

Ensure that such materials are installed by reputable insulation installers.

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 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 *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 fills up not only the cavity but the width of the wall frame (brick veneer and reverse brick veneer). However, the effectiveness of existing reflective sarking 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 retrofitted 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 such as 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.

Bulk insulation rated R2.0 (70mm) or R2.5 (90mm) 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. It is important to choose the correct thickness of insulation to suit the thickness of the cavity. 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 reflective surface of the wall wrap foil. (see *Insulation installation*)

Other wall types

Single skin high mass walls such as concrete block, rammed earth or mud brick can have their thermal performance significantly 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 *Insulation installation*; *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 benefits make it well worthwhile.

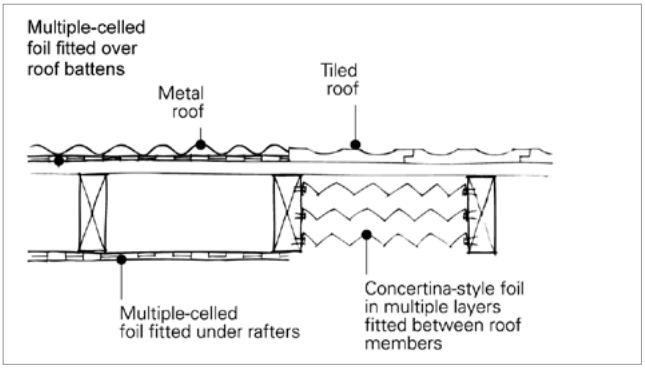
Ceiling fires have increased significantly with the more common use of downlights that penetrate the ceiling. Take care to ensure that minimum clearances around downlights are maintained and that transformers are not covered by the insulation. Wherever possible avoid recessed light fittings as these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

Tiled roofs without sarking can have it added easily if the roof is being re-tiled. If the tiles are to remain in place and the roof space is accessible, you can add double sided foil or foil batts between the rafters or trusses, directly under the tile battens.

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

If sarking has been fitted it may still be necessary to fit extra layer/s of foil beneath it. Always maintain a minimum air gap of 25mm between layers. If the roof is being painted to restore colour, select the lightest colour permissible (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 could be used in this situation, but may not provide sufficient insulation if used on its own (see *Insulation installation*); it will also gather dust on any upward-facing reflective surface and rapidly become ineffective.



Roof insulation.

Floors

Floors do not always require insulation.

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 works well, but in either case care must be taken to ensure it is well supported and will not sag or fall down in time. Access by vermin also needs to be considered. Insulation board can be laid beneath floor finishes if there is no subfloor access.

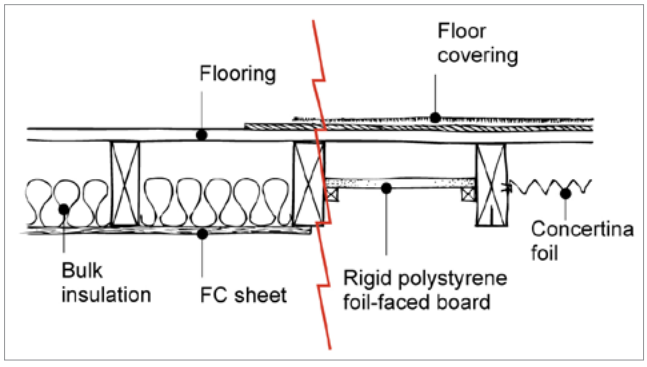
Concrete slabs are either suspended or slab-on-ground. Suspended slabs can be insulated in a similar way to raised timber floors.

A suspended concrete slab with an in-slab heating or cooling system must be insulated underneath and around the vertical edge of its perimeter with insulation having an 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, excavate a shallow trench around the slab edge but avoid excavating right down to the bottom of the slab as the foundation may destabilised. 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 *Insulation installation*)



Exposed subfloor (pole home) (left) and enclosed or ventilated subfloor (brick, brick veneer, timber frame) (right).

Air leakage

Householders can improve the energy efficiency of most existing and new homes by weather sealing. Overseas standards and research recognise that the weatherproofing or draught sealing of houses is the most effective way to achieve direct energy savings while maintaining healthy indoor air quality. It is estimated that Australian buildings leak two to four times as much air as North American or European buildings (Luther 2007), suggesting a tremendous opportunity for energy savings in Australia.

In Australia, households produce around 20% of total annual greenhouse gas emissions (AGO 2005), of which heating and air conditioning account for around 40%. Draughts can account for up to 25% of heat loss from a home (DEWHA 2008).

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

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) sarking	Aluminium foil laminated with glass wool 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 (mainly on upward facing foil) reduces performance. For inclined and horizontal locations, best performance is achieved with the shiny surface facing down. Do not use electrically conductive insulation under subfloors or across ceiling and ceiling joists. 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 Best to install between the ceiling rafters or between the floor joists Other characteristics identical to RFL sarking 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. Best to install between the ceiling rafters or between the floor joists 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
Glass wool 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 glass wool per unit thickness Good sound absorption properties Other characteristics: see glass wool	✓	✓	✓				✓

continued

Common types of bulk insulation (continued)

Material	Description	Flat ceilings, pitched roof	Cathedral or raked ceilings	Timber floors	Suspended slabs	Slab edges	Full masonry walls	Framed walls
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 Protective 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 vermin deterrent 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; can be rendered Greater structural strength and moisture resistance than expanded polystyrene		✓	✓	✓	✓	✓	✓
Expanded polystyrene (EPS)	Semi-rigid boards of polystyrene beads Easy to cut and install; can be rendered Available as pre-clad panels		✓	✓	✓	✓	✓	✓

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

Composite insulation (combining 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
Glass wool or rockwool batts and blankets with reflective foil laminate (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 (EPS) with foil	EPS boards sandwiched between reflective foil Characteristics as for EPS, plus higher 'down' R-values due to foil		✓		✓			✓

* Take care when placing foil surfaces as they can cause condensation problems: the foil surface acts as a vapour barrier, and for condensation control it should always be located on the warm side of the bulk insulation. In cold climates the foil surface should be on the inside (room side) of the bulk insulation, so that condensation does not occur within the bulk insulation. In hot climates, especially where the house is air conditioned, the foil surface should be on the outside of the bulk insulation, thus preventing the humid air from condensing within the bulk insulation.

References and additional reading

Contact your state, territory or local government for further information on insulation considerations for your climate: www.gov.au

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