

Shading

Direct sun can generate the same heat as a single bar radiator over each square metre of a surface, but effective shading can block up to 90% of this heat. By shading a building and its outdoor spaces we can reduce summer temperatures, improve comfort and save energy. A variety of shading techniques can help, from fixed or adjustable shades to trees and vegetation, depending on the building's orientation as well as climate and latitude.



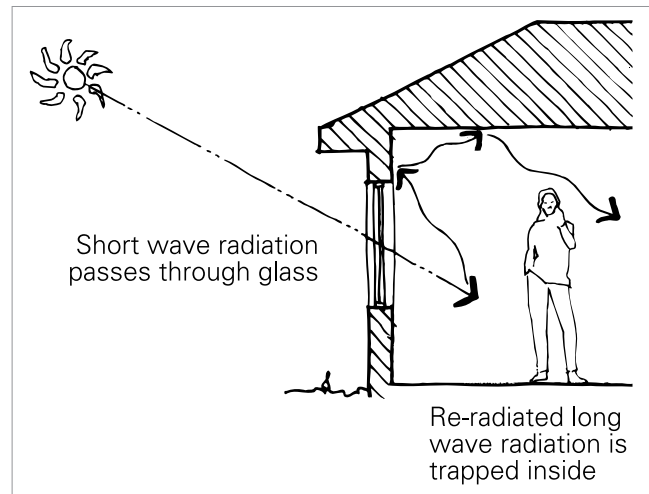
Photo: Architect Brian Meyerson

Shading glass reduces unwanted heat gain.

Shading glass is the best way to reduce unwanted heat gain, as unprotected glass is often the greatest source of heat entering a home. However, fixed shading that is inappropriately designed can block winter sun, while extensive summer shading can reduce incoming daylight, increasing the use of artificial lighting. Shading uninsulated and dark coloured walls can also reduce the heat load on a building.

Radiant heat from the sun passes through glass and is absorbed by building elements and furnishings, which then re-radiate it inside the dwelling. Re-radiated heat has a longer wavelength and cannot pass back out through the glass as easily. In most climates, 'trapping' radiant heat is desirable for winter heating but must be avoided in summer.

Shading of wall and roof surfaces is therefore important to reduce summer heat gain, particularly if they are dark coloured or heavyweight. Light coloured roofs can reflect up to 70% of summer heat gain.



Solar radiation is re-radiated inside.

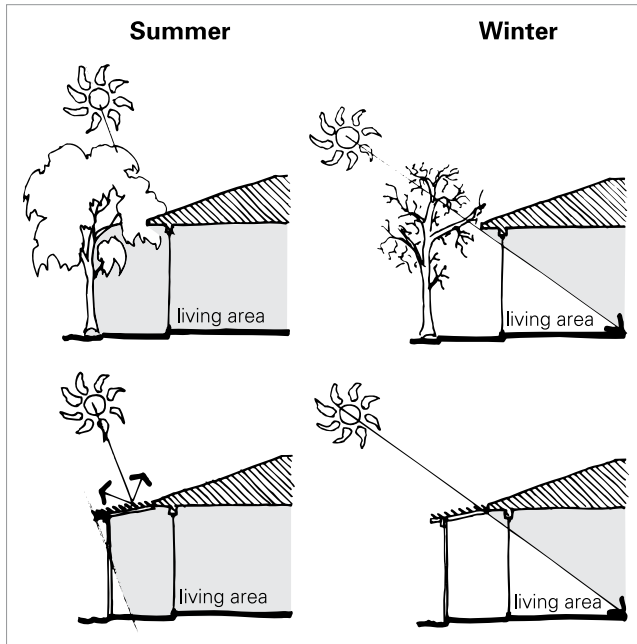
Shading requirements vary according to climate and house orientation, as shown below.

Orientation	Suggested shading type
North	Fixed or adjustable horizontal shading above window and extending past it each side
East and west	Fixed or adjustable vertical louvres or blades; deep verandas or pergolas with deciduous vines
NE and NW	Adjustable shading or pergolas with deciduous vines to allow solar heating or verandas to exclude it
SE and SW	Planting: deciduous in cool climates, evergreen in hot climates

General guidelines for all climates

Use external shading devices over openings, such as wider eaves, window awnings and deep verandas or pergolas. Lighter-coloured shading devices reflect more heat, and those with light coloured undersides make better use of daylight than dark coloured. Internal shading does not prevent heat gain unless it is reflective: only shiny surfaces can reflect short wave radiation back through the glass without absorbing it.

To reduce unwanted glare and heat gain, use plants to shade the building, particularly windows. Evergreen plants are recommended for hot humid and some hot dry climates. For all other climates use deciduous vines or trees to the north, and deciduous or evergreen trees to the east and west.



External shading devices.

Within the range of north orientation that allows good passive sun control (20°W and 30°E of solar north) sun can be excluded in summer and admitted in winter using simple horizontal devices, including eaves and awnings. For situations where a good northerly orientation cannot be achieved (e.g. existing house, challenging site) it is still possible to find effective shading solutions. (see *Orientation and Passive solar heating*)

North-facing openings (and south-facing ones above the tropic of Capricorn) receive higher angle sun in summer and therefore require narrower overhead shading devices than east or west-facing openings. Fixed horizontal shading above north-facing glazing is all that is required. Examples include eaves, awnings, and pergolas with louvres set to the correct angle (see *'Fixed shading' below*).

East and west-facing openings require a different approach, as low angle morning and afternoon summer sun from these directions is more difficult to shade. Keep the area of glazing on the east and west orientations to a minimum where possible, still allowing for good cross-ventilation (see *Passive cooling*), or use appropriate shading devices. Adjustable shading, such as external blinds, is the optimum solution for these elevations.



This deep veranda provides welcome shade but can admit very low angle sun.

Deep verandas, balconies or pergolas can be used to shade the eastern and western sides of the home, but may still admit very low angle summer sun. Use in combination with planting to filter unwanted sun. Wide verandas can reduce daylight unless carefully designed.



Plantings, deciduous vines, shade cloth and screens can all be used in conjunction with pergolas to provide seasonal shading.

Pergolas covered with deciduous vines provide self-adjusting seasonal shading. A gap between the wall and planted screens should be left for ventilation and cooling. Vines on walls or a trellis (where appropriate) can also provide summer insulation to all orientations. As evergreen vines block winter sun, they should only be used in tropical climates or on problematic west façades.

Use drought tolerant ground cover plants instead of paving where possible, to keep the temperature of the ground and surrounding surfaces lower in summer.

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Protect skylights and roof glazing with external blinds or louvres. This is crucial as roof glazing receives almost twice as much heat as an unprotected west-facing window of the same area. Quite small skylights can deliver a lot of light, so be conservative when sizing them.

Position openable clerestory windows to face north, with overhanging eaves to exclude summer sun. Double glaze clerestory windows and skylights in cooler climates to prevent excessive heat loss.

Advanced glazing solutions can exclude up to 60% of heat compared to clear glass.

Advanced glazing solutions can exclude up to 60% of heat compared to clear glass, and are a useful secondary measure on east and west elevations. They should not be used as a substitute for shading in hotter climates because only effective shading can exclude 100% of direct solar heat gain. Insulative glazing (e.g. double glazing) reduces ambient (conducted) heat gains.

Measurements of heat gains in building elements such as walls, floors or roofs are expressed as U-values. U-values and solar heat gain coefficients (SHGC) are available for all glazing products and require careful selection (see *Glazing*). Use high SHGC glass on north-facing windows when you want to let in winter sun and low SHGC when you want to exclude it.

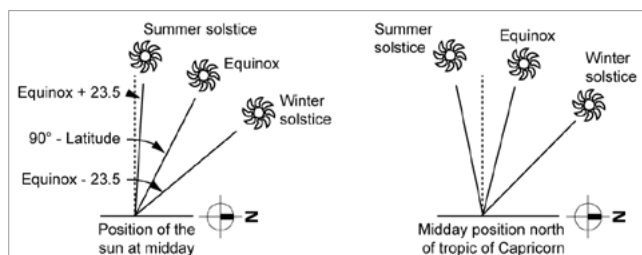
Low U-values (best performance) are desirable in cooler climates and hot climates where windows are kept closed, e.g. because of air conditioning or high external air temperatures. (see *Design for climate; Glazing*)

Calculating sun angles

The angle of the sun in the sky at noon can be easily calculated for the solstices and equinoxes as follows:

- Equinox = $90^\circ - \text{latitude}$
- Summer solstice = Equinox + 23.5°
- Winter solstice = Equinox - 23.5°

The diagram for Darwin below shows why southern façades must be shaded in tropical locations to keep out the summer sun — buildings need to be able to be shaded all year round.



Calculating sun angles.

Many designers have computer aided drafting programs that calculate sun angles and shadows for various locations and topographies based on a digital site survey.

The Geoscience Australia website (www.ga.gov.au) allows you to find the latitude of more than 250,000 place names in Australia and calculate the sun angle at any time of the day, on any day of the year.

City	Latitude
Darwin	12°S
Cairns	16.9°S
Broome	18°S
Townsville	19.25°S
Rockhampton	23.4°S
Geraldton	28.8°S
Perth	32°S
Sydney	34°S
Adelaide, Canberra	35°S
Melbourne	37°S
Hobart	48°S

Fixed shading

Fixed shading devices (eaves, awnings, pergolas and louvres) can regulate solar access on northern elevations throughout the year, without requiring any user effort.

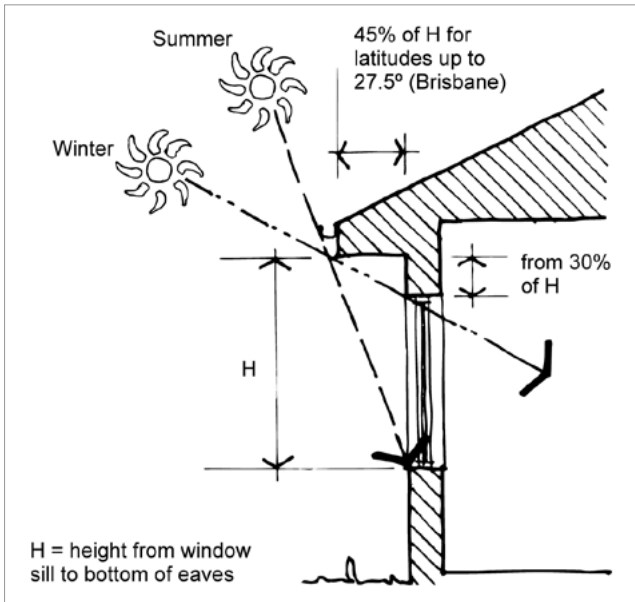
Summer sun from the north is at a high angle and is easily excluded by fixed horizontal devices over openings. Winter sun from the north is at a lower angle and penetrates beneath these devices if correctly designed.

Eaves

Correctly designed eaves are generally the simplest and least expensive shading method for northern elevations and are all that is required on most single-storey houses. Some designers may avoid sizing eaves properly in the mistaken belief that the process is complex.

Precise angles for each latitude can be calculated using the simple process above. They only vary the day and month that sun begins to strike the glass in autumn and shade it in spring because the movement of the sun is most noticeable to us around the spring and autumn equinoxes. This is due to the 'apparent' movement of the sun slowing as it changes direction at each solstice due to the earth's tilted axis as it orbits around the sun.

The following simple rules of thumb ensure that north-facing glass is fully shaded for a month either side of the summer solstice and receives full solar access for a month either side of the winter solstice.



45% rule of thumb for latitudes south of and including 27.5°S.

As a rule of thumb, eaves width should be 45% of the height from the window sill to the bottom of the eaves. Aim for consistent sill heights where possible and consider extending the eaves overhang over full height doors or windows. This allows the 45% rule to be simply met with the following standard eaves overhangs:

- 450mm where height is 900–1200mm
- 600mm for a height of 1200–1350mm
- 900mm for a height of 1350–2100mm
- 1200mm for a height of 2100–2700mm.

Where sill heights vary on a single north façade, set your eaves overhang to the average sill height of larger glass areas. In warmer climates go up to the nearest size and in cooler climates go down to the nearest size. Think about how climate change and warming might affect the heating requirements of the home.

To avoid having permanently shaded glass at the top of the window, ensure that distances between the top of glazing and the eaves underside are at least 30% of the height — a more important component of eaves design than width of overhang, especially in cool and cold climates where it is a significant source of heat loss at night with no compensating daytime solar gains. It is not always achievable with standard eaves detailing which is flush with the 2100mm head (i.e. height of the top of the window).



The top 20% of this window is in permanent shade.

In the image below, standard 2100mm high doors are shaded by 1000mm eaves (including gutter) set 300mm above the head. Note the sun angle at midday in mid-winter is above the glass line. This configuration provides full shading to the glass from late October to late February at latitude 35°S (near Canberra) and is appropriate for a higher altitude cool climate winter.



Photo: Suntech Design

Eaves can be sized to allow shading in summer and solar access in winter.

North-facing upward raked eaves allow full exposure of glass to winter sun and shade larger areas in summer, without compromising the solar access of neighbours to the south. A separate horizontal projection of louvres shades lower glazing. This allows 100% winter solar access and excludes all sun between the spring and autumn equinoxes.



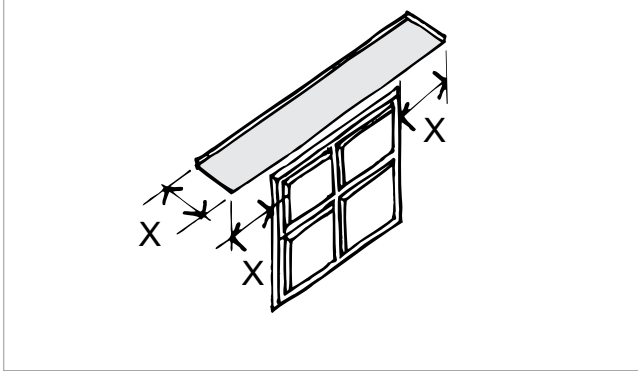
Photo: Architects: Enviro Studio, Photo: SIMART

North-facing upward raked eaves.

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Horizontal shading devices must extend beyond the width of the north-facing opening by the same distance as their outward projection to shade the glass before and after noon.



Source: SEAV

Extend shading beyond the window edges.

Varying the rule of thumb

Variations to the 45% rule of thumb are beneficial for fine-tuning your passive shading to suit varying heating and cooling requirements determined by regional climate, topography and house design. For example, reduce the overhang by decreasing the percentage of the height by up to 3% to extend the heating season:

- at higher altitudes (e.g. eastern highlands, tablelands and alpine regions)
- where cold winds or ocean currents are prevalent (e.g. southern WA and SA)
- in inland areas with hot dry summers and cold winters (e.g. Alice Springs)
- in cold, high latitude areas (e.g. Tasmania and southern Victoria).

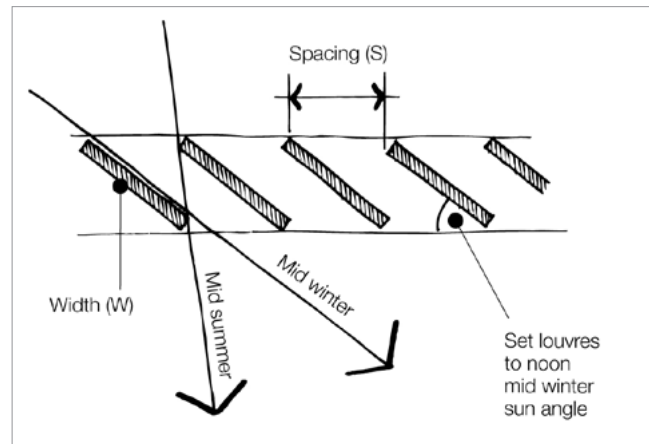
Gradually increase the percentage of height as heating requirements decrease in latitudes north of 27.5°S (Brisbane), to decrease or eliminate the amount of sun reaching glass areas either side of the equinox:

- For hot dry climates with some heating requirements, gradually increase the overhang up to 50% of height (full shading).
- For hot humid climates and hot dry climates with no heating requirements, shade the whole building at all times with eaves overhangs of 50% of height from floor level to both north and south where possible, and use planting or adjoining buildings where it is not possible. East and west elevations require different solutions.

(see *Design for climate; Passive solar heating; Passive cooling*)

Louvres

Fixed horizontal louvres set to the noon mid-winter sun angle and spaced correctly allow winter heating and summer shading in locations with cooler winters. As a rule of thumb, the spacing (S) between fixed horizontal louvres should be 75% of their width (W). The louvres should be as thin as possible to avoid blocking out the winter sun.

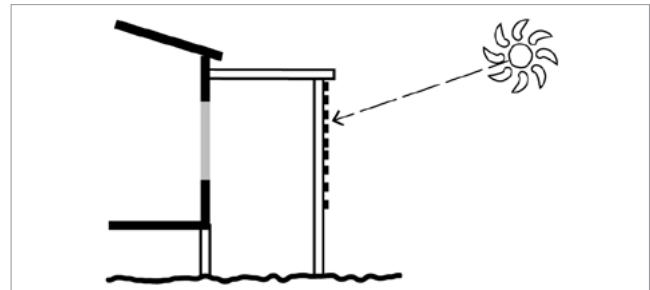


Spacing for fixed louvres.

Fixed shading for east and west

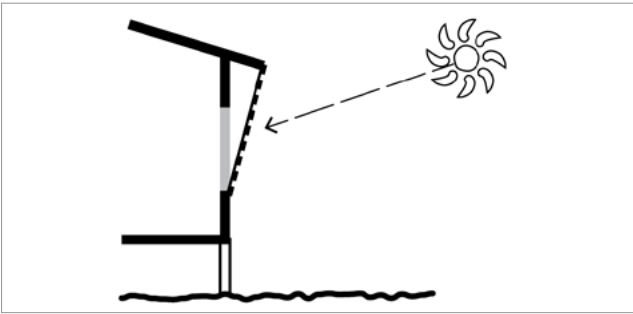
West-facing glass and walls are a significant source of heat gain in hotter climates. East-facing glass can be equally problematic because, while the home is cooler in the morning and heat gains do not cause noticeable discomfort, it is the start of a cumulative process that causes thermal discomfort in the afternoon and early evening. Both east and west require shading in hotter climates. In cooler climates, east shading is a lower priority.

Because east and west sun angles are low, vertical shading structures are useful in allowing light, views and ventilation while excluding sun. Roof overhangs, pergolas and verandas that incorporate vertical structures such as screens, climber covered lattice and vertical awnings are also effective.



Source: Townsville City Council

Pergola with vertical screen to block low-angle sun.



Source: Townsville City Council

Vertical timber batten screen attached to the house.

Adjustable shading

Adjustable shading allows the user to choose the desired level of shade. This is particularly useful in spring and autumn when heating and cooling needs are variable. (NOTE: Active systems require active users.)

Climate change

Climate change does not affect sun angles, but the desirability of shade or solar heat gain may change, thus affecting the overall design strategy. Adjustable shading (mechanical or seasonal vegetation) facilitates adaptation to changing climatic conditions.



Photo: Envirova Studio

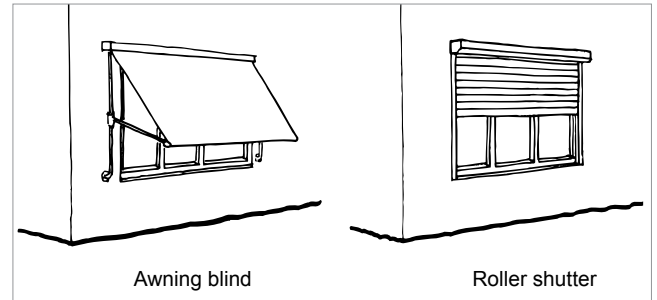
Adjustable louvers can adapt to changing climate conditions.

Northern elevations

Adjustable shading appropriate for northern elevations includes adjustable awnings or horizontal louvre systems and removable shade cloth over pergolas or sails. Shade cloth is a particularly flexible and low cost solution.

Eastern and western elevations

Adjustable shading is especially useful for eastern and western elevations, as the low angle of the sun makes it difficult to get adequate protection from fixed shading. Adjustable shading gives greater control while enabling daylight levels and views to be manipulated. Appropriate adjustable systems include sliding screens, louvre screens, shutters, retractable awnings and adjustable external blinds.



Awnings and roller shutters provide adjustable shading on eastern and western elevations.

North-east and north-west elevations

Adjustable shading is recommended for these elevations as they receive a combination of high and low angle sun throughout the day. Typical responses for northern and eastern or western elevations need to be integrated. Select systems that allow the user to exclude all sun in summer, gain full sun in winter, and manipulate sun levels at other times.



Shade cloth is flexible and low cost.

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Climate specific responses

In high humidity climates and hot dry climates with warm winters, shade the building and outdoor living spaces throughout the year. For all other climates, use appropriate passive solar design principles.

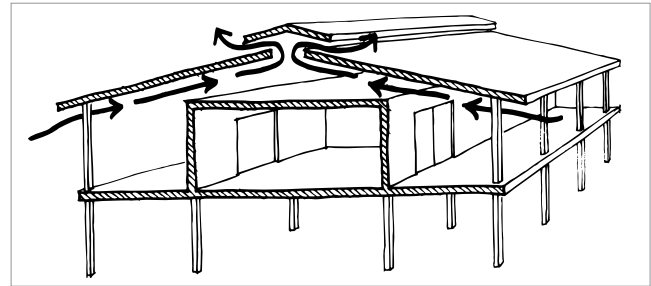
(see *Passive design; Orientation; Passive solar heating; Passive cooling*)

Hot humid climates

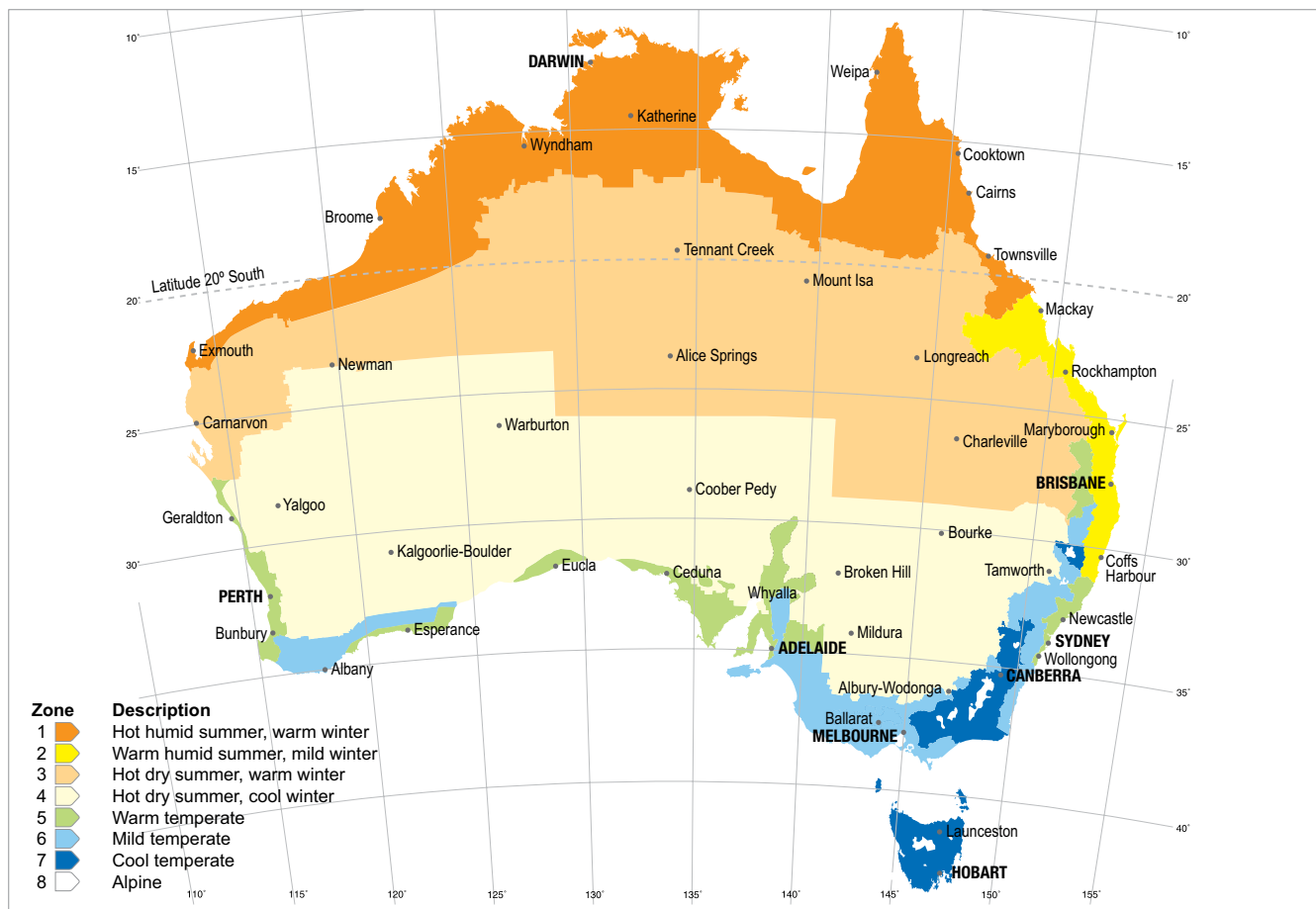
In hot humid climates, it is essential to shade the walls year round and highly advantageous to shade the whole roof.

- Shade all external openings and walls including those facing south.
- Use covered outdoor living areas such as verandas and deep balconies to shade and cool incoming air.
- Use shaded skylights to compensate for any resultant loss of natural daylight.

- Choose and position landscaping to provide adequate shade without blocking access to cooling breezes.
- Use plantings instead of paving to reduce ground temperature and the amount of reflected heat.
- A 'fly roof' can be used to shade the entire building. It protects the core building from radiant heat and allows cooling breezes to flow beneath it.



A fly roof protects a building from radiant heat and encourages cooling breezes.

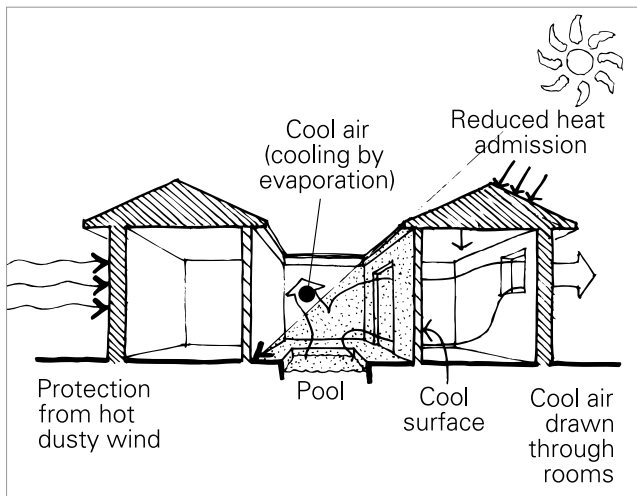


Source: Australian Building Codes Board (ABCB)

Climate zones of Australia.

Hot dry climates

- Shade all external openings in regions where no winter heating is required.
- Provide passive solar shading to north-facing openings in regions where winter heating is required.
- Avoid shading any portion of the glass in winter when winter heating is required — use upward raked eaves to allow full winter solar access, or increase the distance between the window head and the underside of the eaves.
- Use adjustable shade screens or deep overhangs (or a combination of both) to the east and west. Deep covered balconies or verandas shade and cool incoming air and provide pleasant outdoor living spaces.
- Place a shaded courtyard next to the main living areas to act as a cool air well. Tall, narrow, generously planted courtyards are most effective when positioned so that they are shaded by the house.
- Use plantings instead of paving to reduce ground temperature and the amount of reflected heat.



Courtyard pools cool through evaporation.

Warm humid and warm/mild temperate climates

- Provide passive solar shading to all north-facing openings, using shade structures or correctly sized eaves.
- Use adjustable shade screens or deep overhangs to the east and west. Adjustable shade screens exclude low angle sun the most effectively.



This adjustable shade screen can exclude low angle sun.

Cool temperate climates

- Do not place deep covered balconies to the north as they obstruct winter sun. Balconies to the east or west can also obstruct winter sun to a lesser extent.



Covered balconies should allow winter sun access.

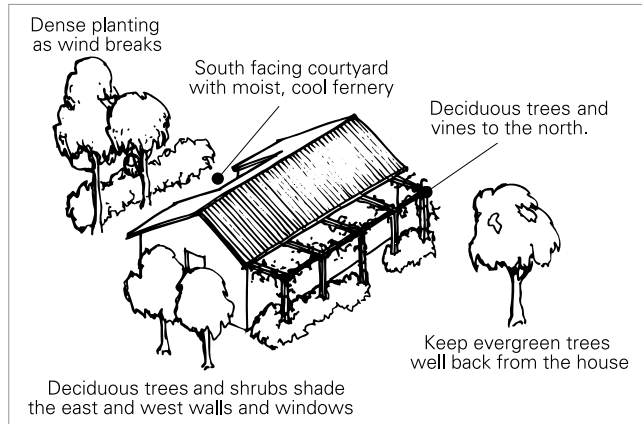
- Avoid shading any portion of the north-facing glass in winter — use upward raked eaves to allow full winter solar access, or increase the distance between the window head and the underside of the eaves.
- Use deciduous planting to the east and west. Avoid plantings to the north that would obstruct solar access.

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Using plants for shading

Match plant characteristics (such as foliage density, canopy height and spread) to shading requirements. Choose local native species with low water requirements wherever possible.



Plants can provide shade and act as windbreaks.

In addition to providing shade, plants can assist cooling by transpiration. Plants also enhance the visual environment and create pleasant filtered light. (see the appendix *Landscaping and garden design*)

- Deciduous plants allow winter sun through their bare branches and exclude summer sun with their leaves.
- Trees with high canopies are useful for shading roofs and large portions of the building structure.
- Shrubs are appropriate for more localised shading of windows.
- Wall vines and ground cover insulate against summer heat and reduce reflected radiation.

Shading for a healthier environment

Appropriate shading practices reduce the chance of exposure to harmful ultraviolet rays. Planting is a low cost, low energy provider of shade that improves air quality by filtering pollutants.

Shading and daylight

Choose shading methods that allow adequate amounts of daylight into the building while preventing unwanted heat gain.

- Select plants that allow filtered light into the building. (see the appendix *Landscaping and garden design*)
- Design glazing to admit maximum light for minimum heat gain. Clear sections in veranda roofs can be useful. (see *Glazing*)
- Light coloured external surfaces or shading devices reflect more sunlight into the building. Depending on the situation this can be beneficial, or it can create unwanted glare. (see *Lighting*)

References and additional reading

Contact your state, territory or local government for further information on passive design considerations for your climate.

For sun paths (including best orientation for Queensland locations) see: www.works.qld.gov.au

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Authors

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Updated by Chris Reardon, 2013