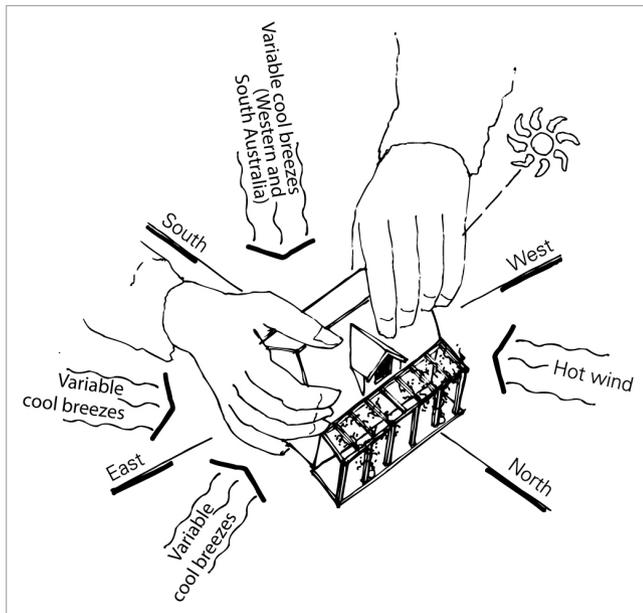


Orientation

Orientation is the positioning of a building in relation to seasonal variations in the sun's path as well as prevailing wind patterns. Good orientation can increase the energy efficiency of your home, making it more comfortable to live in and cheaper to run.

Read about the principles of good orientation in this article in conjunction with *Passive solar heating*, *Passive cooling* and *Shading*. Identify your climate zone and develop an understanding of appropriate design responses by referring to *Design for climate*.



Orientate your home to make best use of sunlight and winds.

When deciding the best orientation for your home, bear in mind that the climate is warming, and hotter summers with more extreme heat waves will become the norm during its life span. While passive solar heating is still very desirable in climates that require heating, the priority will gradually shift from heating to cooling. Additional attention to shading of windows and walls (particularly west facing) and exposure to cool breezes and other forms of natural cooling is required in all climate zones.

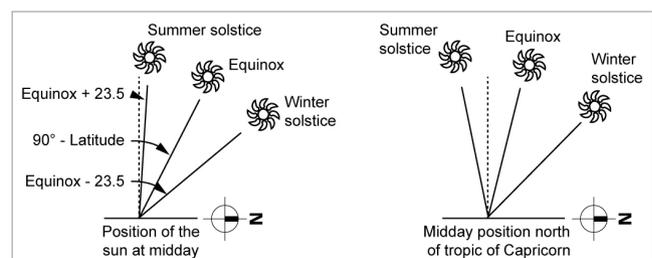
Principles of good orientation

Good orientation, combined with other energy efficiency features, can reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort. It takes account of summer and winter variations in the sun's path as well as the direction and type of winds, such as cooling breezes.

Good orientation can help reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort.

Ideally, choose a site or home with good orientation for your climatic and regional conditions and build or renovate to maximise the site's potential for passive heating and passive cooling, adjusting the focus on each to suit the climate. For those sites that are not ideally orientated, there are strategies for overcoming some of the challenges.

In hot humid climates and hot dry climates with no winter heating requirements, aim to exclude direct sun by using trees and adjoining buildings to shade every façade year round while capturing and funnelling cooling breezes.

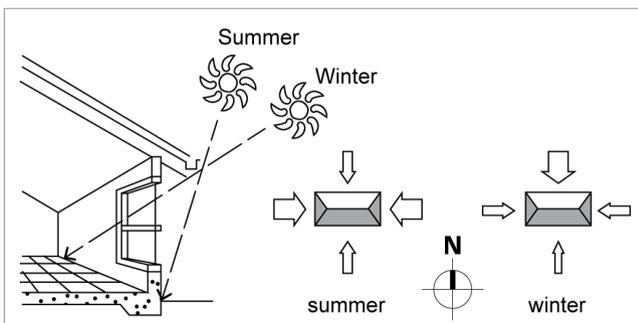


Left: How to calculate sun angles. (See *Shading* for a table of latitudes from which to calculate sun angles for Australian cities.) Right: Midday sun position north of the tropic of Capricorn.

In all other climates a combination of passive solar heating and passive cooling is desirable. The optimum balance between capturing sunlight (solar access) and capturing cooling breezes is determined by heating and cooling needs.

North orientation is generally desirable in climates requiring winter heating, because the position of the sun in the sky allows you to easily shade northern façades and the ground near them in summertime with simple horizontal devices such as eaves, while allowing full sun penetration in winter.

North-facing walls and windows receive more solar radiation in winter than in summer. As shown in the diagram, the opposite is true for other directions — and why, in mixed or heating climates, it is beneficial to have the longer walls of a house facing north to minimise exposure to the sun in summer and maximise it in winter.



Average daily solar radiation on vertical surfaces.

Choosing the best orientation

Prioritise your heating and cooling needs. Are you in a climate that requires mainly passive heating, passive cooling, or a combination of both?

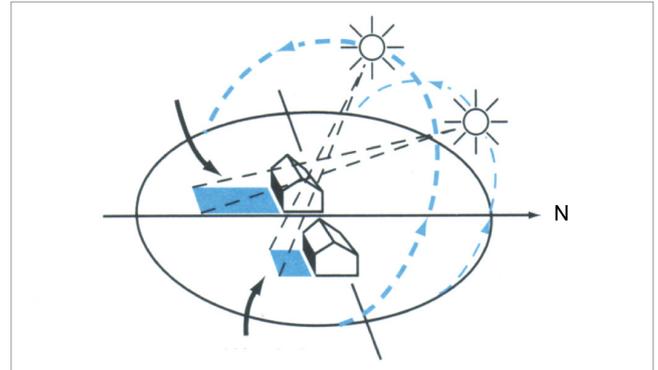
Compare your summer and winter energy bills, consult an architect or designer, ask your local energy authority or refer to local meteorological records.

Your local climate research should study:

- temperature ranges, both seasonal and diurnal (day–night)
- humidity ranges
- direction of cooling breezes, hot winds, cold winds, wet winds
- seasonal characteristics, including extremes
- impact of local geographic features on climatic conditions (see *Choosing a site*)
- impact of adjacent buildings and existing landscape.

The Australian Bureau of Meteorology (www.bom.gov.au) provides wind roses for each region in Australia. They are based on daytime data and don't address evening and night breezes that are often the main source of cooling.

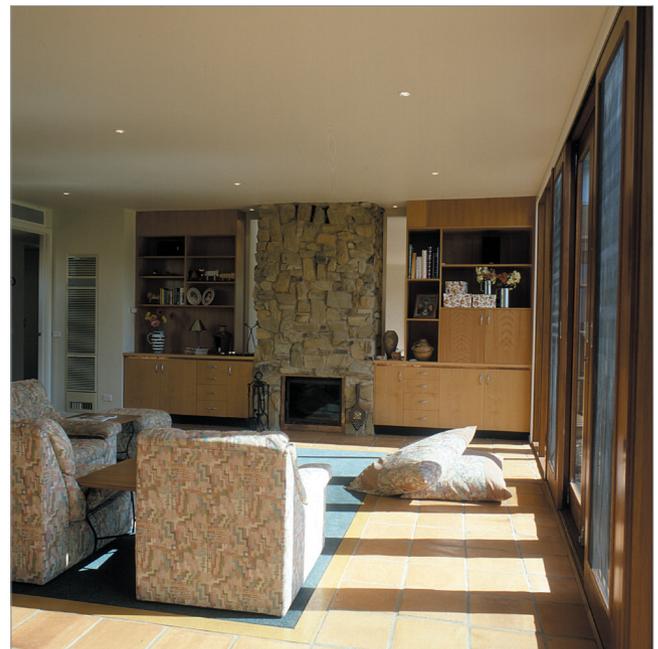
Orientation for passive heating



Sun movement from high angle in summer to low angle in winter.

Orientation for passive heating is about using the sun as a source of free home heating by letting winter sun in and keeping unwanted summer sun out — desirable in the majority of Australian homes. It can be done with relative ease on northern elevations by using horizontal shading devices to exclude high angle summer sun and admit low angle winter sun.

'Solar access' is the term used to describe the amount of useful sunshine striking glass in the living spaces of a home. The desired amount of solar access varies with climate.

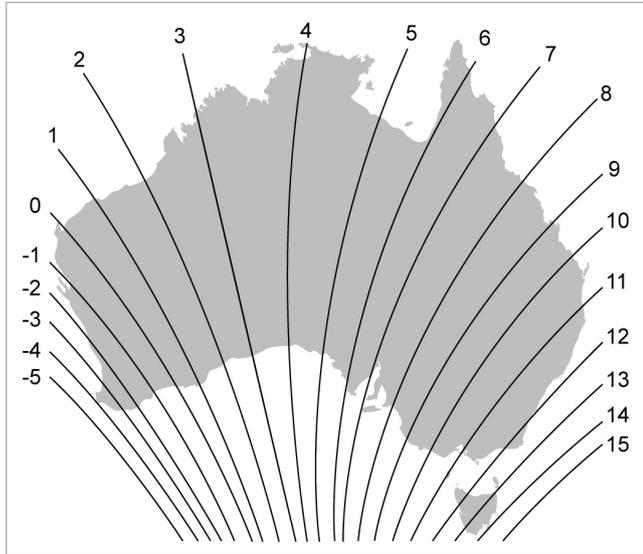


The sun is a source of free home heating.

Passive design

Orientation

First, establish true or solar north for your region. This is useful in all climates whether you are encouraging or excluding solar access. Just use maps and street directories, or use a compass to establish magnetic north and then find true or solar north by adding or subtracting the 'magnetic variation' for your area using the map below.



Source: Dr Holger Willrath, Solar Logic

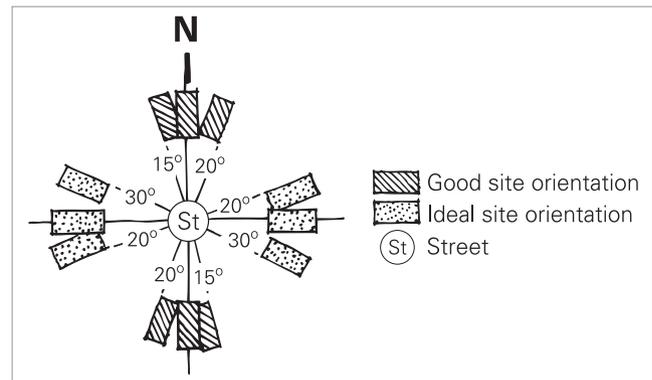
True north as degrees west of magnetic north.

Solar north deviates significantly from magnetic north throughout Australia. Take this into account when orienting a home. All references to north in this guide are to solar north, not magnetic north.

Precise orientation is not as critical as many people think. While ideal orientation (in most climates) is solar north, orientations of up to 20° west of north and 30° east of north still allow good passive sun control. As can be seen from the diagram below, good solar orientation is possible on most sites.

Variations in orientation towards east and west can have advantages in some climates and for some activities. For example, in cold climates, orientations west of north increase solar gains in the afternoon when they are most desirable for evening comfort, but east of north can warm the house more in the mornings, improving daytime comfort for those who are at home then. In warmer climates, orientations east of north can allow better capture of cooling breezes.

Poor orientation and lack of appropriate shading can exclude winter sun and cause overheating in summer by allowing low angle east or west sun to strike glass surfaces at more direct angles, reducing reflection and increasing solar gains.



Orientation does not have to be precise: there is a degree of flexibility.

A range of methods is available for measuring and assessing the amount of solar access required when designing a new home, renovating an existing home or buying a unit. The most thorough (and commonly used) method is to have an accredited thermal performance assessor simulate the home's thermal performance using house energy rating software such as AccuRate, BERS Pro and First Rate. This will identify both problems and opportunities. Accredited assessors can be contacted through the Association of Building Sustainability Assessors or the Building Designers Association of Victoria.

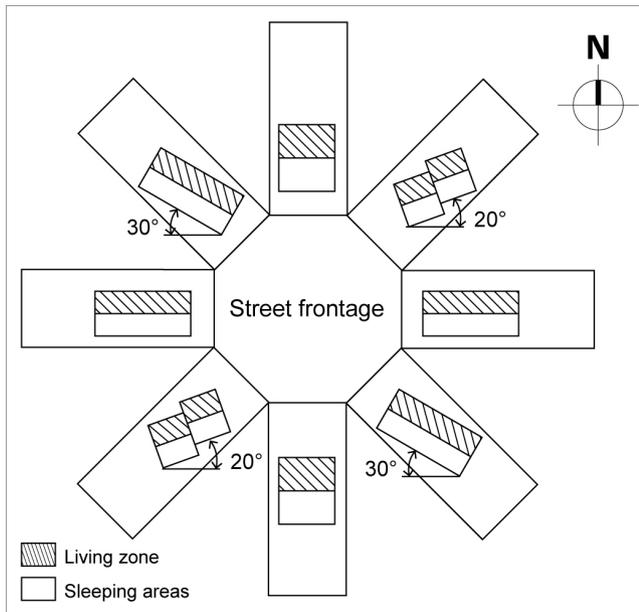
Traditional methods using charts and formulas are rarely used these days because they are unable to model the complex interaction of the multiple variables that determine how a house will perform. These variables are addressed in detail in the *Passive design* articles that follow and include *Shading, Insulation, Glazing and Thermal mass*.

The site

You can achieve good passive solar performance at minimal cost if your site has the right characteristics. Where possible, choose a site that can accommodate north-facing daytime living areas that flow to outdoor spaces with similar orientation. In tropical areas, northerly solar access is not desirable: sites that allow maximum exposure to cooling breezes and designs that draw or funnel them through the building are preferable. (see *Choosing a site*)

On smaller sites achieving permanent solar access is more likely on north-south blocks because they receive good access to northern sun with minimum potential for overshadowing by neighbouring houses. In summer, neighbouring houses can provide protection from low east and west sun.

However, on narrow blocks, careful design is required to ensure sufficient north-facing glass is included for adequate passive solar heating.

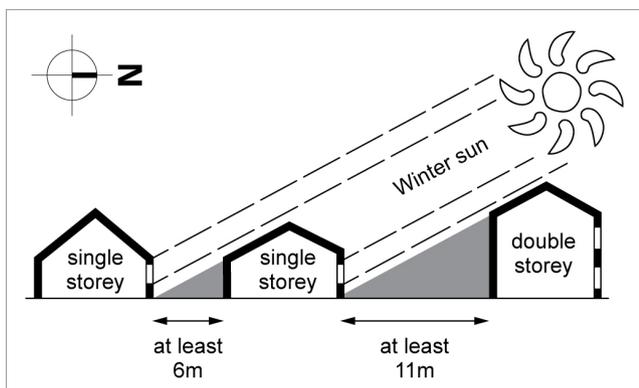


Source: AMCORD

Orientation possibilities on a cul-de-sac.

North-south sites on the north side of the street allow north-facing living areas and gardens to be located at the rear of the house for privacy.

North-south sites on the south side of the street should be wide enough to accommodate an entry at the front as well as private north-facing living areas. Set the house back to accommodate a north-facing garden and consider creating a private outdoor living courtyard with plantings or even a garage on the northern boundary where planning permits.



The lower angle of winter sun can limit solar access.

Sites running east-west should be wide enough to accommodate north-facing outdoor space. Overshadowing by neighbouring houses is more likely on these sites — particularly if multi-level housing is permitted, as winter sun is lower in the sky, particularly in southern latitudes.



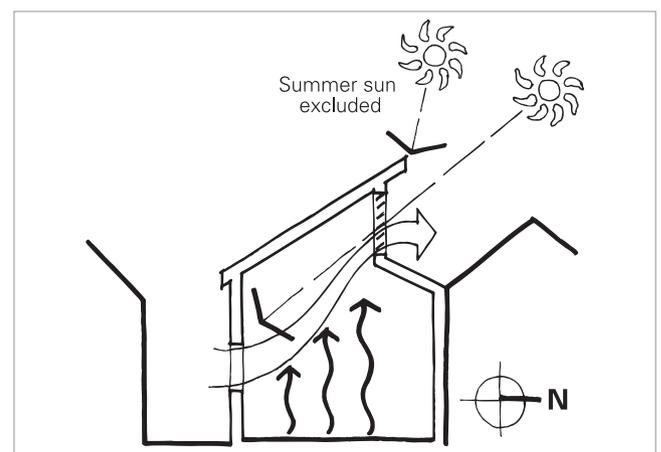
Source: AMCORD

Orientation on slopes.

A north-facing slope increases the potential for access to northern sun and is ideal for higher housing densities. A south-facing slope increases the potential for overshadowing. Your design for solar access should not compromise that of your neighbours.

At subdivision level, smaller individual lots are ideally located on north-facing slopes where they still receive solar access at increased densities.

South-facing slopes are often better suited to medium density where party walls can be designed to provide thermal buffers and smaller floor areas can be solar heated with carefully designed and shaded east or west-facing windows using advanced glazing.



High level openable windows capture winter sun and create cooling currents in summer.

Passive design

Orientation

Views to the north are an advantage, as north is the preferable direction to position windows and living areas. If the view is to the south, avoid using large areas of glass in order to minimise winter heat loss or use mirrors to reflect north sun onto the glass (Wrigley 2012).

Clerestory (high level) windows can be used to capture winter sun and create stack ventilation (rising hot air) in summer. Sunlight entering through clerestory windows should strike thermal mass at lower levels so that heat is stored for later release. Failure to do this can produce pockets of heat in high level, uninhabited spaces that is quickly lost through the glass at night.

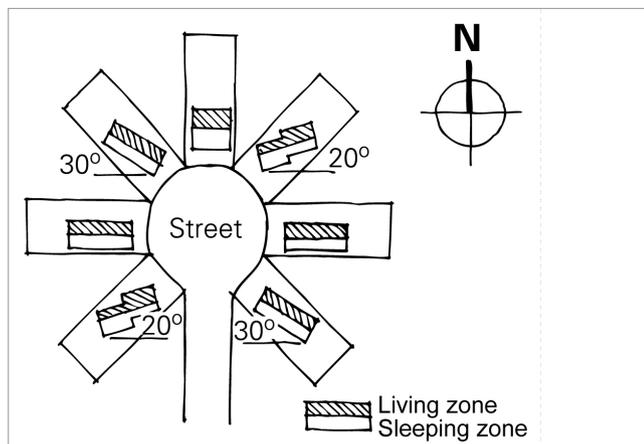
Clerestory windows should not be used in cold climates unless carefully designed, as daytime heat gains rarely offset night-time heat losses and cold draughts are unavoidable.

The house

The ideal orientation for living areas is within the range 15°W–20°E of true or 'solar' north (although 20°W–30°E of true north is considered acceptable). It allows standard eaves overhangs to admit winter sun to heat the building and exclude summer sun with no effort from the occupants and no additional cost.

Poor orientation can exclude winter sun as well as cause overheating in summer by allowing low angle east or west sun to strike glass surfaces, creating a greenhouse effect where it's not required. Choose a house that has good orientation or can be easily adapted for better orientation.

Build close to the south boundary to maximise sunny, north-facing outdoor living areas and protect solar access but avoid compromising the solar access of neighbours. Choose a home with living spaces that have good access to winter sun.

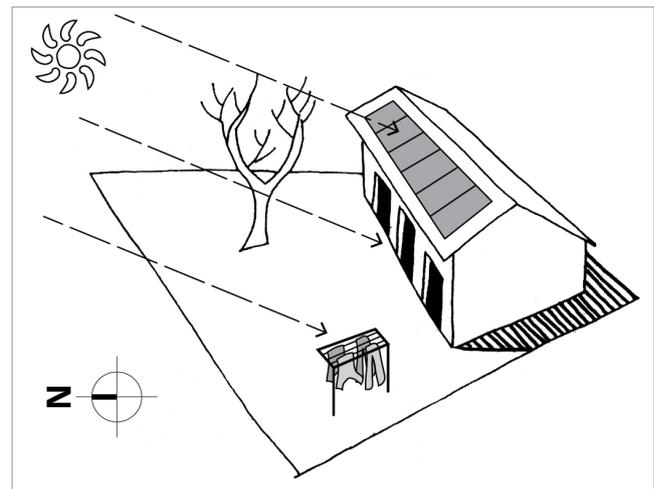


Daytime living areas shown shaded.

Look for a suitable area of glass on north-facing walls with access to winter sun. As a general guide this should be 10–25% of the exposed thermal mass floor area of the room. This rule can vary considerably depending on design, glazing type and exposed thermal mass. (see *Thermal mass*)

Check that west-facing glazing is not excessive in area and is properly shaded to prevent overheating. West-facing walls receive the strongest sun at the hottest part of the day.

Check that there is no significant detrimental overshadowing (of both windows and roof where photovoltaics and solar hot water may be located) by adjacent buildings and trees.

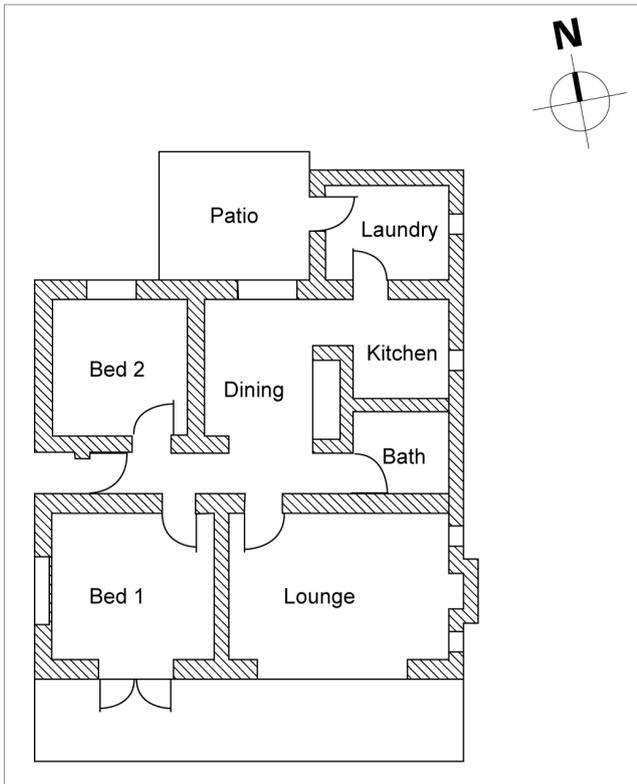


Source: SEAV

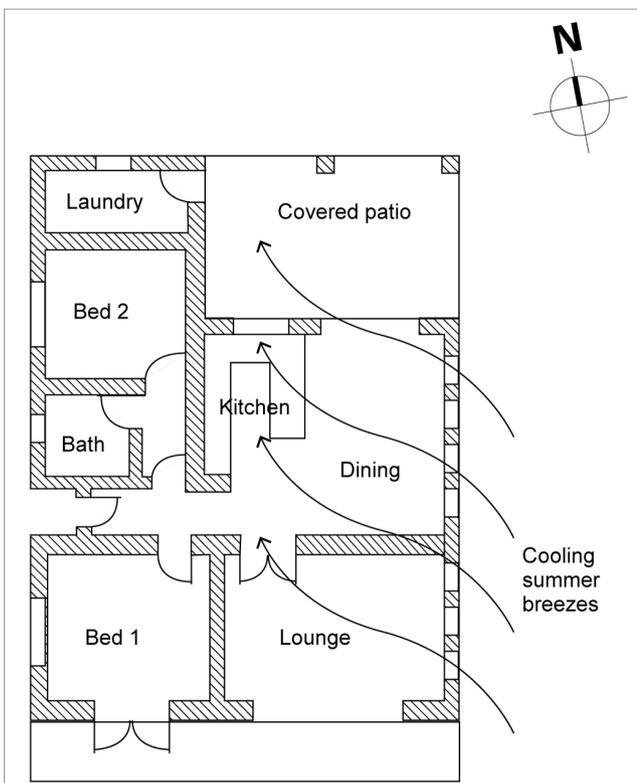
Northern side of the house is free from major obstructions.

Ensure year-round solar access for clothes drying and solar collectors.

When renovating, adjust floor plan and orientation to trap the winter sun and encourage summer breeze flow by adding new windows, changing openings and relocating rooms that block breezes and sun.



Original floor plan.



New floor plan.

Checklist for designing a new home or renovating

When you build, buy or renovate, there are things you can do or features to look for to achieve the best thermal comfort your site or home can offer. The following points are a brief overview: for more detailed information see *Buying an existing home*.

- Relocate living areas to take advantage of winter sun and cooling summer breezes.
- Maximise north-facing daytime living areas where passive solar access is available.
- Use smaller, well shaded windows to increase cross-ventilation to the south, east and west.
- Avoid west-facing bedrooms to maintain sleeping comfort.
- Locate utility areas (laundries, bathrooms and garages) on the south or west where possible.
- Avoid placing obstructions such as carports or sheds to the north.
- Plant shade trees in appropriate locations; landscape to funnel cool breezes and block or filter harsh winds.
- Prune vegetation that blocks winter sun; alternatively plant deciduous vegetation that allows winter sun in but provides summer shade.

Checklist for choosing a project home

For more detailed information than the following brief overview, read *Buying a home off the plan*.

- Select a design that allows daytime living areas to face between 15° west of north and 30° east of north on your site. Most project home companies will mirror or flip a design to suit your needs at no extra cost. East is best in warmer climates and west in cooler climates.
- Turn north-facing verandas into pergolas (including those with adjustable blades) by replacing roofing material such as tiles or metal with slats or louvres, particularly over window areas.
- Shade east and west-facing glass by adding or relocating shade structures including verandas and deep covered balconies.
- Reduce the amount of south, east and especially west-facing glazing, or relocate some to north-facing walls.
- Select smaller windows on south, east and west-facing walls to aid cross-ventilation.

Most project home companies will mirror or flip a design to suit your needs at no extra cost.

Passive design

Orientation

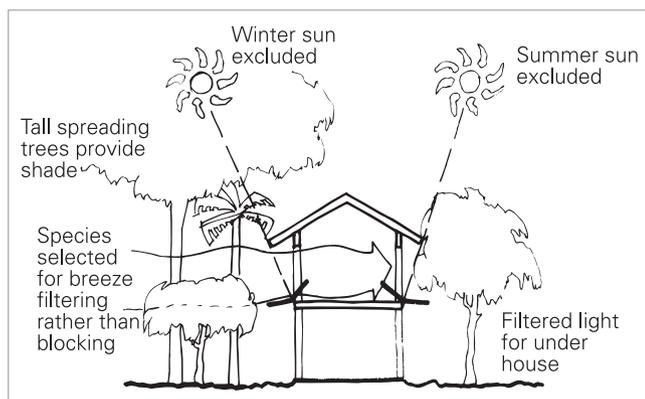
Checklist for choosing a unit

Orientation is particularly important when buying a unit because external modifications such as shading are often prohibited by body corporate rules intended to preserve the visual amenity of the building. For more detailed information than the following brief summary, see *Buying and renovating an apartment*.

- Solar access to living areas is highly desirable (except in the tropics).
- Good exposure to cooling breezes is essential in hotter climates.
- Look for well-designed cross-ventilation to distribute cooling breezes through the unit.
- North-east corner units, north-south cross-over (split level) or cross-through (one side to the other) are ideal.
- North-facing living areas and balconies or outdoor spaces are ideal.
- Look for passive shading to north glass and well-designed adjustable shading to east and west.
- Avoid units facing west only.
- Look for sheltered balconies or courtyards with winter solar access.
- Sunny, sheltered spaces and facilities for community interaction are a desirable feature.

Orientation for cooling dominated climates

Good orientation for passive cooling keeps out unwanted sun and hot winds while ensuring access to cooling breezes. A degree of passive cooling is required in most Australian climates but in hot humid climates, orientation should aim to exclude direct sunlight and radiant heat (from nearby structures) at all times of the year while maximising access to cooling breezes.



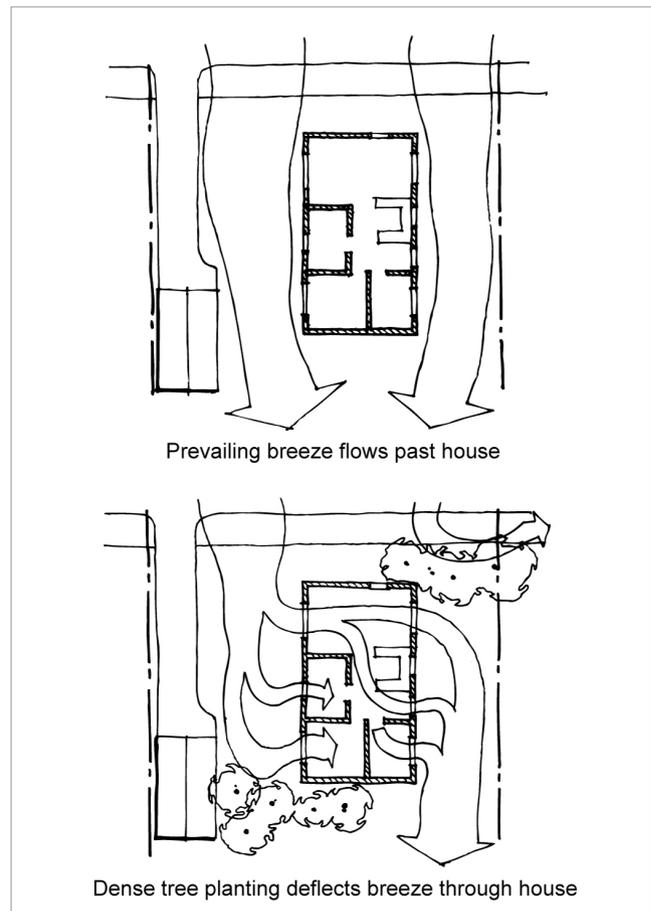
Orientation for an elevated tropical house.

What is good cool breeze access?

Cool breezes can come from a range of directions but near the coast are generally onshore. On the east coast of Australia, they are generally north-easterly to south-easterly whereas on the west and southern coasts, they are commonly south-westerly. The predominant cooling breezes in Darwin are from the north-west in the wet season and the south-east in the dry season.

Breeze direction can vary within a few hundred metres due to landforms, vegetation or other buildings. Talk to your neighbours or spend time on your site in hotter seasons to establish the direction of your most reliable cooling breezes.

While many inland areas often receive no regular breezes, cool air currents form as cooling night air flows down slopes and valleys (just as water would), and in flat inland regions, thermal currents created by diurnal temperature differences also provide useful cooling. These are often of short duration and occur later at night or in early morning and need to be trapped and stored as 'coolth' for the following day. (see *Thermal mass*)



Cool breeze diversion.

Unlike sunlight, breezes can be diverted, so find a way to divert them through your home using fences, outbuildings, plantings and windows that open widely.

What other passive cooling options are there?

Night purging of heat from the building to cooler night air is critical for thermal comfort. Because breezes are often unreliable, alternative means of purging are recommended. Among the most effective means is a whole-of-house fan that creates breezes.

One way roof insulation uses low emissivity reflective insulation to reduce daytime heat gains while allowing conduction and convection to allow upward flow of heat at night. This is only useful in climates with low or no heating needs. (see *Insulation*)

Radiant cooling to clear night skies is also effective but difficult to achieve. Clear night skies provide a limitless source of radiant cooling for areas and surfaces that can be exposed to it. Outdoor living areas and sleep-outs are the most effective but large openings with exposure to night skies are also able to shed heat. Design and orientation of glazing for passive solar heating requires unobstructed sky exposure and this can be very useful for radiant summer cooling.

Active cooling systems use roof mounted solar panels that heat the home in winter to cool it in summer by running in reverse – drawing heat out of the building and radiating it to clear night skies and cool night air. Parts of the roof must have unobstructed solar access for this to work.

The site

Look for a site with good access to cooling breezes. Ensure that landscape and adjacent buildings funnel rather than block beneficial breezes and provide shade to all walls.

Land with a south-facing slope provides increased shade. South is ideal for views because south-facing windows require minimal shading. In regions with cooler winters, however, glass areas should be small to limit heat loss. The overhang of eaves should be broader above the tropic of Capricorn because of increased southern solar exposure.

Solar access to some part of the site between 9am and 3pm is beneficial for clothes drying and vegetable gardens in all climates, and uninterrupted solar access to roof areas is highly desirable for solar collectors. Passive solar access becomes increasingly important as heating needs increase.

Innovative design and fans can achieve thermal cooling comfort on sites with limited access to cooling breezes. Use high level windows and vents to create convection currents for cooling in the absence of breezes. Use low mass construction except for regions where earth temperatures maintain earth coupled slab temperatures below 19°C. (see *Thermal mass*)

The house

Choose or design a house with maximum exposure to cooling breezes and limited or no exposure to direct sun, depending on climate. Use careful design to improve performance in the case of poorly oriented sites or existing homes.

- Narrow, elongated or articulated buildings facilitate passive cooling. Ideally the long elevation should open up to cooling breezes.
- Avoid or shade west-facing walls and windows if possible as they receive the strongest radiation at the hottest part of the day.
- Open plan internal layouts facilitate ventilation. Houses of one-room depth are ideal.
- 100% openable windows or openable insulated panels located on more than one side of a room improve ventilation.
- Outdoor living areas (courtyards, verandas and balconies) should be shaded at all times and fitted with ceiling fans.
- Use security screens over openings to allow safe, effective ventilation.
- Alternatively, highly insulated and shaded rooms can be efficiently cooled by the highest energy rated air conditioning and the energy used offset with rooftop photovoltaics. This may provide the 'least cost' solution.

Checklist for designing a new home or renovating

When you build or renovate, maximise what your site has to offer according to this brief overview or see *Buying an existing home* for more detailed information.

- Configure or reconfigure rooms to capture and encourage the flow-through of cooling breezes, and position door and window openings to improve cross-ventilation paths.
- In climates with low or no heating needs, develop the site so that existing buildings and trees shade all walls and deflect cooling breezes into the interior.
- Provide as much roof shading as possible but leave enough solar exposed areas for solar hot water or photovoltaic collectors.

Passive design

Orientation

- Design narrow building forms with long walls orientated to cooling breezes.
- Design open plan interiors and one-room depth buildings with 100% openable windows (casement or louvre) either side to improve cross-ventilation.
- Allow for bedrooms to be closed and well insulated if using air conditioning in the hot humid ('build-up') season.
- Elevate the house to allow air to circulate beneath it in hot humid climates.
- Minimise east and west-facing openings because they receive the strongest sun and are the most difficult to shade; however, if they are needed for ventilation, ensure they are well shaded.
- Add small windows to rooms with only one or include vents above internal doors to improve cross-ventilation.
- Consider using high level solid louvre panels in internal walls in hot humid climates where privacy is not an issue.
- Use generous, climate appropriate eaves overhangs (including on the south above the tropic of Capricorn).
- Use clerestory windows or solar chimneys to create convection currents to cool the house in the absence of breezes.
- Use roof ventilators or ridge and eaves vents to cool roof spaces.
- Include shaded, rain-protected outdoor living areas with ceiling fans.

Checklist for choosing a project home

For more detailed information than this brief overview, read *Buying a home off the plan*.

- Choose a project home designed and built from materials that suit your climate.
- Consider using lightweight construction – often the best option, particularly where walls are exposed to hot summer sun or the home is designed to be air conditioned.
- Avoid inappropriate styles borrowed from different climate zones to yours.
- Make sure your design can be positioned on your site to capture cooling breezes and has a minimal area of west-facing windows.
- Mirror or flip the design to suit your site and breeze paths.
- Move windows or doors from one elevation to another to capture cooling breezes.
- Make sure windows have significant openable area for ventilation (casement or louvre).

- Ensure all openings are shaded by appropriate width eaves or devices.
- Include south eaves in tropical climates.
- Use open carports (not closed garages) to allow for breezes.

Checklist for choosing a unit

For more detailed information than this brief checklist of important orientation related features, read *Buying and renovating an apartment*.

Choose a unit with good orientation because external modifications such as shading are often prohibited by body corporate rules intended to preserve the visual amenity of the building.

- Units generally use high mass construction, which can be problematic if orientation is not adequately addressed.
- Poorly orientated or inadequately shaded glazing heats thermal mass and makes summer living conditions unbearable.
- Consider a unit with low thermal mass such as MRTFC (multi-residential timber framed construction).
- Well-designed cross-ventilation to distribute cooling breezes through the unit is essential in any warm climate unit.
- North-east corner units, north-south cross-over (split level) or cross-through (one side to the other) are ideal.
- Solar access to living areas and good exposure to cooling breezes are important in climates requiring both heating and cooling.
- North-facing living areas and balconies or outdoor spaces are desirable in climates with winter heating needs, but south-facing or well-shaded orientation to cooling breezes is preferable in tropical climates.
- Passive shading to north glass or well-designed adjustable shading to east and west is essential.
- Avoid units facing west only.
- Shady, sheltered spaces and facilities with winter sun are highly desirable for community interaction.
- In hot humid climates, landscaping that provides shade to building and paved surfaces is highly desirable.

Orientation for challenging sites

Limited or no solar or cool breeze access

On sites with poor orientation or limited solar access due to other constraints, high levels of thermal performance are still achievable through careful design.

Low mass construction: Consider low mass construction systems with smaller windows, high insulation levels, and active solar or high efficiency heating and cooling systems.

- In hotter climates low mass does not store daytime heat gains and cools quickly when night-time temperatures drop. It also responds more rapidly and efficiently to cooling breezes when available and to active heating or cooling at times when they are not.
- In cooler climates low mass is more responsive to heating input, allowing the use of heating to suit lifestyle patterns. For example, if your house is unoccupied all day and frequently on weekends, heating can be switched off in the knowledge that the home can be warmed quickly on your return.
- In changing climates low mass construction will allow more flexible responses to rising temperatures and more variable weather patterns.

Active solar space heating and cooling can also be useful, especially if controlled by 'smart' technologies.

A combination of high thermal performance, photovoltaics and high efficiency space conditioning can deliver 'beyond zero emission' comfort year round.

Advanced glazing and shading systems can achieve net winter solar gains from windows facing almost any direction while limiting summer heat gains to a manageable level. A larger budget may be required but long term benefits can be gained. (see *Shading; Glazing*).

These solutions require active users or expensive automated shading systems that draw down screens or shades when they sense solar radiation in summer. Active, roof mounted solar heating systems are a viable alternative where the roof has solar access. They can also provide summer cooling if run in reverse to radiate heat to clear night skies.

Manually adjusted shading and active heating systems should also be considered in cooler climates where cold spells can be unpredictable in spring and autumn.

Small lot housing

The ideal orientation for living areas is within the range 15°W–20°E of true or 'solar' north (20°W–30°E of true north is considered acceptable). This allows standard eaves overhangs to admit winter sun through north-facing glass to heat the building but exclude summer sun, with no effort from the occupants and no additional cost.

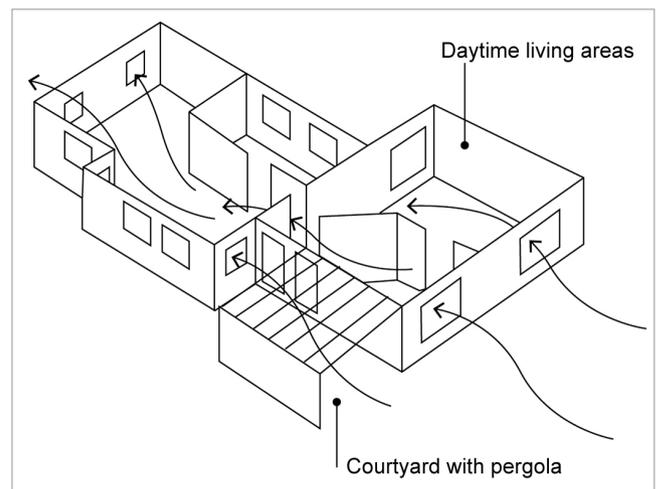
Smaller lots limit urban sprawl over productive land and reduce infrastructure costs – but may make it harder to achieve ideal orientation.

Smaller lots limit urban sprawl and reduce infrastructure costs – but may make it harder to achieve ideal orientation.

The simplest and most cost effective solution is to build smaller, better designed homes. The alternative – squeezing oversized homes onto tiny sites – leads to poor orientation and loss of privacy and outdoor living space. It also adds to energy bills through loss of solar access while increasing the amount of floor area to heat and cool.

There are signs that market demand for smaller, better designed homes is growing rapidly, driven largely by affordability and rising energy costs.

Articulated floor plans allow for better placement of smaller windows to increase cross-ventilation and night purging in summer. They also offer the opportunity to create private, sunny courtyards and utilise natural daylight that can be either direct or reflected off light coloured walls and buildings on narrow sites. (see *Lighting*)



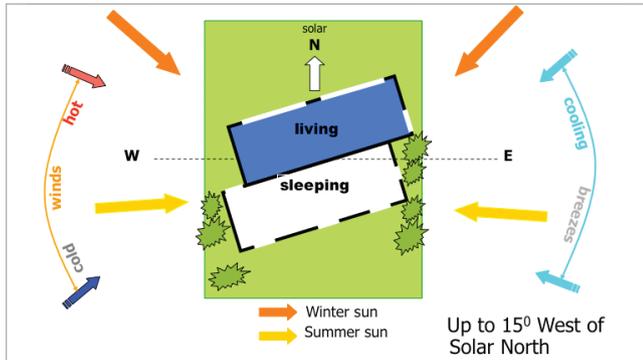
Source: SEAV

Articulated floor plan.

Passive design

Orientation

The diagrams below indicate how these principles might be applied on small lots in eastern Australia. Breeze and wind directions should be reversed for Western Australia and adapted to suit local conditions in other regions. The passive heating principles remain the same.



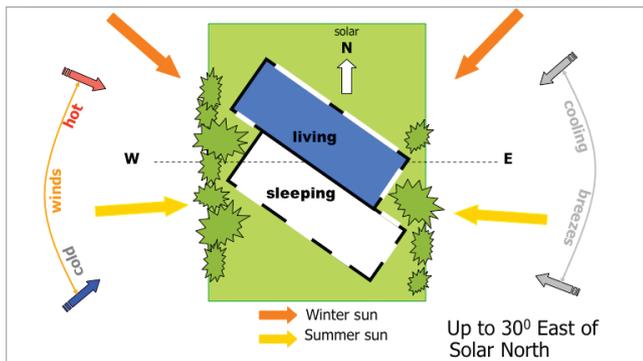
Source: Suntech Design

Cool or cold climate orientation – heating dominant.

This orientation maximises late afternoon solar gains and allows morning sun in winter. It excludes summer sun from west and south-facing windows and minimises exposure to westerly winds while allowing reasonable breeze access.

Dense planting to the west shades walls from summer sun and protects them from cold winter winds.

This configuration is also useful in warmer climates where cooling breezes are from the south-east. Slightly increased overhangs for north eaves reduce solar gains in spring and autumn in these climates, and breeze filtering plantings to the east provide shade from morning sun in summer.

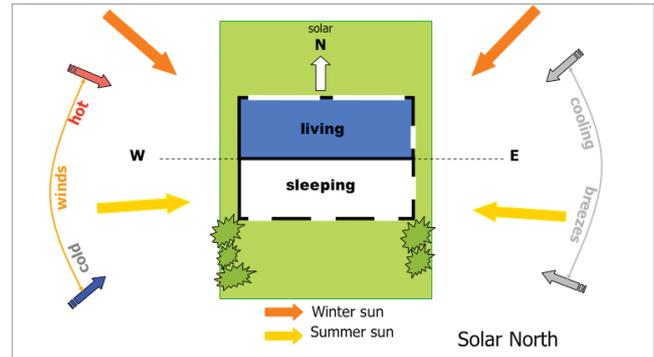


Source: Suntech Design

Mixed climate orientation – cooling dominant.

This orientation maximises exposure to cooling breezes but reduces passive solar heat gains. It requires shade plantings to the west to eliminate solar gains through south-facing windows in summer and protect the house from westerly winds.

In warmer climates, shade plantings on the east are also required but should not block breezes. Clerestory windows along the spine can increase solar and breeze access to sleeping areas.



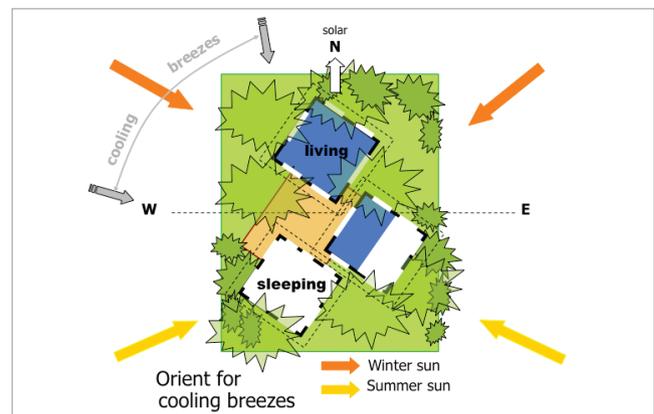
Source: Suntech Design

Temperate climate orientation – daytime heating and cool sleeping required.

This simple configuration allows for passive heating of living areas during the day and cooler, southerly sleeping areas.

In cooler climates, a thermal mass wall separating these zones would transfer solar warmth to sleeping areas.

In warmer regions, passively shaded clerestory windows along the spine would allow hot air to escape from bedrooms in summer while allowing in a small amount of winter sun.



Source: Suntech Design

Hot humid orientation (Darwin).

Although this orientation suits Darwin where cool breezes come predominantly from the north-west, it can be simply reconfigured for east or west coast tropical sites.

It divides the home into separate pavilions to maximise the cross-flow of breezes. Canopy trees partially overhang the roof and shade all walls without blocking breezes. Where such shading can't be achieved, an elongated east-west floor plan will limit low solar access to east and west walls.

Both the building form and understorey plantings are designed to funnel breezes into the building and allow them to escape.

A pavilion design allows hybrid cooling, where two pavilions might be free-running and the third designed and insulated for conditioning. Installing a thermal mass dividing wall in the third pavilion with non-conditioned sleeping spaces behind it would help create night-time sleeping comfort after the early evening conditioning is switched off.

References and additional reading

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

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Authors

Principal author: Caitlin McGee

Contributing authors: Chris Reardon, Dick Clarke

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