Heating and cooling

Very little energy is needed to make a well-designed house comfortable. Appropriate insulation, which is essential for a comfortable house, combined with passive solar design and a draught-proofed building, can create low or even no energy requirements for heating and cooling (see *Passive solar heating*; *Insulation*). Highly efficient homes with no heating or cooling input are possible across much of Australia.

Even for existing homes there are many ways to reduce energy bills, improve comfort and help the environment. The principles of thermal comfort and the importance of air movement, humidity and radiant heat are explained in the section *Passive design*.

Projected average home energy use in 2012 — actual energy use varies from state to state (particularly with climate) and from home to home depending on the heating and cooling systems in the home and how they are used.

Household energy use	%
Heating and cooling	**40**
Water heating	21
Appliances and equipment including refrigeration and cooking	33
Lighting	6

Source: DEWHA. 2008

Never use mechanical heating and cooling as a substitute for good design. However, for existing homes, installation of high efficiency heating and cooling technologies, with modest building improvements and behaviour change, may be cheaper options to reduce energy bills and greenhouse gas emissions than major home renovations.

Your money is better invested in an energy efficient building than spent on heating and cooling.

At 40% of household energy use, heating and cooling are together the largest energy user in the average Australian home (DEWHA 2008). However, since most home heating uses gas, heating is responsible for a lower proportion of energy bills and greenhouse gas emissions than its share of energy use suggests.

Heating

Use passive design principles to increase comfort and reduce the need for heating. Insulate the roof, walls and floor, seal off draughts, let in winter sun and draw curtains at night. Zone your existing or new home and only heat the rooms you are using; use doors to prevent heat escaping into unused rooms. (see the section *Passive design*)

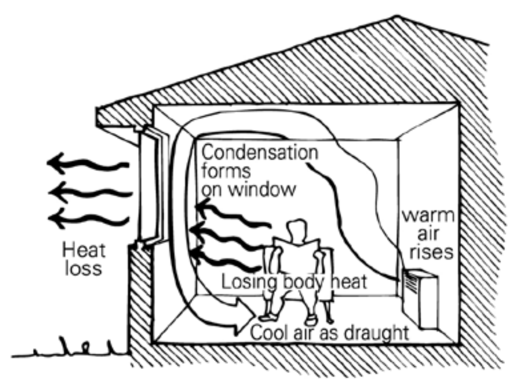
The two main types of heating are radiant and convective.

Radiant heaters predominantly heat people and objects by direct radiation of heat. Convective heaters warm and circulate the air in a room.

Other forms of heating, such as heated floors, also heat by conduction through direct contact.

Different forms of heating are best in different circumstances:

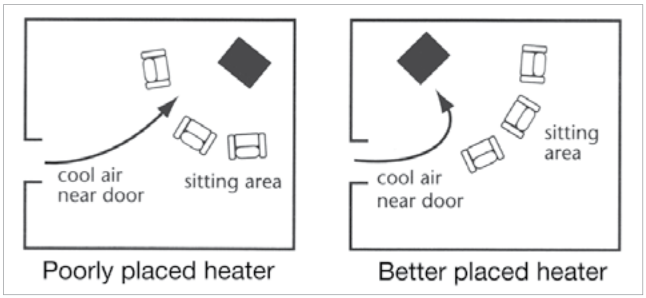
- In larger rooms with high ceilings, a combination of radiant and convective heating is best.
- In small rooms, space convective heating is effective.
- In larger draughty rooms or bathrooms, radiant heating works best.



Heaters produce air movement as hot air rises and then falls as it cools.

All heaters produce air movement as the hot air rises from the heater to the ceiling. Air is cooled when in contact with windows and poorly insulated walls and ceilings. The cooled air falls and is drawn back along the floor to the heater.

Sitting in draughts created by air movement can make you feel much colder. Minimise draughts from windows and use heavy curtains with snug pelmets or other ways of preventing air flow through gaps at the top and sides of window coverings to stop convection and radiant heat loss. Always consider appropriate clothing to stay warm and reduce the effects of draughts. Position your furniture to deflect or avoid draughts.



Position your heater and furniture to deflect and avoid draughts.

Choosing a correctly sized heater (and cooler) is very important. Do not install an oversized heater, as you will be wasting money on buying a bigger heater than you need and wasting energy/money in operating it. Expert advice helps make sure you are choosing a correctly sized heater.

An oversized heater wastes money and energy.

Energy choices

Gas heaters and efficient reverse cycle air conditioners (or heat pumps) produce only one-third the greenhouse gas emissions of standard electric heaters. The most efficient 5–6 star reverse cycle units actually produce less than one-fifth of the emissions of conventional electric heaters.

Gas heaters and reverse cycle air conditioners have Energy Rating Labels to help you choose the most efficient model.

Wood can be an excellent fuel because it is a renewable resource if sustainably harvested. However, do not use wood fired heaters in urban areas because of the air pollution they create, and the emissions associated with transporting firewood to urban areas.

About 10% of homes use wood for heating but the wood is often obtained from unsustainable sources. Use only sustainably harvested wood to avoid habitat destruction and rare species extinction.

Do not use treated timbers, which may give off toxic pollutants when burned.

Burn wood only in airtight, slow combustion heaters. They have the highest energy efficiency of wood heaters, and use the least wood and cost the least to run. Careful operation of wood heaters is also critical to limiting air pollution. Use seasoned wood and don't add large loads of wood just before turning the heater right down. Do not use illegally modified heaters, adjusted to burn overnight.

Central vs space heating

Choosing whether to heat your whole house or only the required rooms or spaces has a major influence on the greenhouse impact of your home. In a house with central heating, the greenhouse emissions and costs of running it are usually higher than running efficient space heating.

Central heating can often heat a whole house whether individual rooms are occupied or not. Space heaters usually only heat the room or area where the heater is installed.

For an energy efficient house, use space heating only in rooms that require heating or use a zoned central heater to reduce running costs.

Heat only the rooms that are being used.

Answer the following questions before buying a heater:

- Does the room need to be heated or will eliminating cold draughts and improving insulation be enough?
- How many rooms need to be heated?
- How big are they?
- How often and for how long will heating be required?

The Choice online calculator (www.choice.com.au) helps estimate heater size. Seek expert advice to find a system most suited for your application.

Central heating

Central heating usually uses more energy than space heating as more of the house tends to be heated. However, an energy efficient house with central heating may use less energy than an inefficient house with space heating. Several types of central heating are available.

Many central heaters have high energy losses from the heat distribution systems, usually through ducts or hot water pipes. They should be as short as possible and well-insulated (at least R1.5 for ducts and 25mm of pipe insulation). Fans and pumps can also be costly to run. When heating requirements are low, distribution losses can be the main contributor to heating costs.

In well-insulated houses with solar gain to some rooms, a central thermostat may not provide comfort throughout: some rooms may have higher heat losses and cool down faster than the rest of the house.

Ducted air

In ducted systems, hot air is circulated through roof or underfloor ducts, supplying convective heat. Gas or a reverse cycle air conditioner can be the heat source.

Design the system so that the extent of the area heated can be controlled and include zoning to allow for shutting off heating to unoccupied areas. Ducted systems should be designed and installed by accredited experts.

Ensure the ducted system is sized for the house. New, energy efficient houses that meet the requirements of the Building Code of Australia (BCA) require less heating and smaller capacity heating equipment.

Ducts should be the correct size and have adjustable outlets (registers). Ducts need to be larger if also used for cooling.

Insulate ducts to at least R1.5 and make sure all joints are well sealed. (see *Insulation*)

Floor outlets are often better than ceiling outlets for heating, as warm air naturally rises and they deliver heat to where it is most needed. Well-designed ceiling outlets can work well particularly when rooms are sealed from draughts to the outdoors. Cold air entering under outside-facing doors can form a layer above the floor and stop the less dense warm air from ceiling vents heating the air near the floor, creating a 'cold feet–warm head' problem.

A return air path from every outlet back to the central system is very important. Without it the warm air escapes and the system sucks cold air in, dramatically reducing its effectiveness. In each room that has a duct outlet installed, a gap under the door between the room and the central return air inlet creates a return path.

In ducted gas systems, a fan moves the air around the home, using electricity as well as gas. High efficiency ducted gas systems use more efficient motors/fans, and control the fan speed, to reduce electric running costs.

Hydronic systems

Hydronic systems circulate hot water or coolant through radiator panels in rooms, supplying a mix of convective and radiant heat.

Hydronic systems are usually gas fired but can be heated by a wood fired heater, solar system or heat pump. Solar systems can use gas or wood heating as a back-up. These systems have the advantage of adaptability to energy sources as energy markets change.

Each panel or room should have its own control.

Low water content systems are best as they reduce energy use. Ensure water circulation pipes are well insulated, and smart controls manage pump usage. Higher running costs are usually caused by unnecessary water circulation or poor pipe insulation.

Exterior walls behind panels must also be insulated to prevent heat loss to the outside. Use wall cavity insulation or a layer of installed reflective foil on the internal wall behind the panel. Ideally all exterior walls should be insulated to maximise comfort from the heating system, especially in a new home or major renovation.

In-slab floor heating

Concrete floors can be used to store heat from off-peak electric cables or hydronic pipes set into the slab. They are installed during building construction or renovation. (see *Concrete slab floors*)

Slab insulation is very important, so that heat from the slab does not leak into nearby cold, wet earth. Insulate slab edges, and ideally the entire slab, from the ground to minimise heat loss. Insulate walls from the slab to reduce heat loss.

Electric in-slab heating generally has the highest greenhouse gas emissions of any heating system. As electricity prices have increased, in-slab heating costs have also increased.

The best in-floor system for minimising greenhouse gas emissions is a hydronic system using one of the following:

- solar with gas back-up
- efficient slow combustion wood heater that heats water (wetback)
- geothermal or water-sourced heat pumps.

In-slab systems provide a combination of radiant, convective and conductive heat. They are slow to warm and cool due to the high thermal mass of the slab and are therefore unsuitable for houses where heating is only needed occasionally and in changeable weather. They are ideal as back-up for passive solar heating of thermal mass on cloudy or extremely cold days but use caution — if you heat the slab then the ability to store heat from passive solar gain is reduced.

Avoid heating areas of the slab exposed to the sun in winter.

Heating zones and thermostats are essential to reduce energy use. Slab heating running costs are particularly sensitive to air leakage through gaps.

Central heating systems compared

The central heating comparison table assumes well designed and efficiently operated systems and gives general running costs and greenhouse gas emissions. Obtain expert advice before making decisions on the type best for you.

Central heating systems comparison

System type	Running cost	Greenhouse gas emissions
High efficiency ducted natural gas	Low	Low
Hydronic zoned natural gas or heat pump	Low	Low
Ducted reverse cycle or heat pump	Medium	Medium (low with green/renewable electricity source)
Hydronic zoned with wood/solar heat source	Low	Very low (if from a renewable resource and seasoned wood)
In-slab high off-peak electric	Medium–high	Very high (low with green/renewable electricity source)

Space heating

Electric heaters

These devices heat a smaller area — one or perhaps two rooms — and come in a wide range of types.

Electric portable heaters

Electric portable heaters can be cheap to buy but are expensive to run and sometimes ineffective.

- Radiant heaters, such as bar heaters, are good for bathrooms as they give almost instant heat direct to your body and do not directly heat air. Less warm air is lost than with other heater types and they heat your body even when an exhaust fan is used. No thermostat is fitted so use a timer or switch. Turn off radiant heaters when leaving the room for any length of time.
- Fan heaters heat the air and provide convective heat. Larger upright models are more effective. They can warm smaller rooms quickly and some have thermostats to help reduce energy use.
- Convector heaters heat the air, which then rises naturally. They are not recommended for rooms with high ceilings or poor insulation levels or where there is a high ventilation rate.
- Combined convector/radiant heaters are larger than fan convector units (but may have a small fan to increase heat output). They have a large surface that becomes hot and radiates heat, as well as slots to allow heated air to rise into the room.
- Oil-filled column heaters supply a mix of convective and radiant heat but are slow to respond. Some have thermostats, timers and fans.

Heaters that don't rely on fans and do not reach high temperatures are more suited to bedrooms, as they are less likely to overheat and cause fires if clothes are accidentally placed on them. All electric heaters should have a safety cut-out to avoid overheating.

Electric systems may produce high greenhouse gas emissions — up to six times as much as an efficient gas heater. However, using a small electric heater for local heating may be cheaper and have lower emissions than heating a much larger area with gas. Offset electricity greenhouse emissions by using 100% GreenPower.

Offset electricity greenhouse emissions by using 100% GreenPower.

Electric fixed heaters

Reverse cycle air conditioning (or heat pumps) provides convective heat and is the most energy efficient electric heater. The most efficient 5–6 star units may be cheaper to run and generate lower greenhouse gas emissions than gas heaters. Visit the Equipment Energy Efficiency website (www.energyrating.gov.au) to find the most efficient reverse cycle air conditioners.

Wall panel convectors use peak electricity and are expensive to run, like portable electric heaters.

Off-peak electric storage heaters provide a mix of radiant and convective heat. They use bricks to store heat produced overnight using off-peak electricity. Unless carefully controlled they can lead to overheating in milder weather, and they continuously 'leak' heat, so their overall efficiency in intermittently used spaces is low.

Gas heaters

Gas portable heaters

Unflued portable heaters can provide either convective or radiant heat and run on natural gas or LPG.

Adequate ventilation is needed to maintain good air quality, which can significantly reduce efficiency. An efficient externally flued heater is usually preferable but may not always be an option, particularly for tenants. In these cases units are available that burn more cleanly, producing lower combustion emissions and requiring less ventilation.

Unflued gas heaters often create condensation problems — usually at the opposite (coolest) end of the house. Take care to ensure they don't lead to mould growth.

The use of unflued heaters is restricted in some states because of their associated indoor air pollution hazard, which can cause health problems. Check your state or territory regulations for details.

Gas fixed heaters

Wall units and floor consoles can provide convective and/or radiant heat, and usually have fans to circulate hot air. Most are flued, requiring less ventilation and producing fewer condensation problems.

Gas fixed heaters usually have fans to circulate hot air.

Some fixed gas heaters use fan-powered flues or 'balanced' flues: they draw in outdoor air, heat it, then return it outdoors. Other gas heaters use indoor air for combustion, and rely on flues to remove the waste gases from the house. In well-sealed houses, there is a risk that exhaust gases can be drawn back into the house through exhaust fans, such as kitchen range hoods or bathroom exhaust fans, creating health and safety risks.

In low humidity climates, humidity trays may be required to maintain room humidity levels. They need to be topped up with water regularly.

Gas pot-belly stoves and fireplace inserts supply mostly radiant heat. High mass structures nearby can store and convert this to convective heat.

Some flame effect heaters, both free standing and fireplace inserts, operate as radiant and convection heaters. These vary greatly in their efficiency so look for models which are star-rated as highly efficient. Avoid unrated models, which may be just gas decorative appliances.

Gas decorative appliances

Some log or flame effect fires are actually decorative appliances and are not designed to provide space heating. They can use up to 75MJ of gas per hour (two to four times as much as a gas space heater) without giving effective heating. Check carefully before you install a gas log or flame effect fire to ensure it is certified under AS 4553-2008, Gas space heating appliances. Decorative appliances are certified under AS 4558-2011, Decorative gas log and other fuel effect appliances, for safety registration and are not required to carry an Energy Rating Label.

If you have a decorative appliance, use it only occasionally.

> *Gas decorative appliances use more gas than a space heater but don't heat areas effectively.*

Wood and other solid fuels

Open fireplaces

Open fireplaces give radiant heat but are highly inefficient. Up to 90% of the heat energy goes up the chimney and large volumes of cold air are drawn into the room to replace it, creating cold draughts or removing heated air from nearby spaces where other heating is running. They are the least efficient wood heating method and produce the highest levels of air pollution. Open fires are better at producing ambience than heat.

To comply with the BCA, fireplaces are meant to have closable dampers (flaps that, when closed, stop air escaping up the flue). Many older units do not have dampers, although they can be retrofitted. Seal fireplaces when they are not in use to prevent large amounts of heated (or cooled) air escaping from the room.

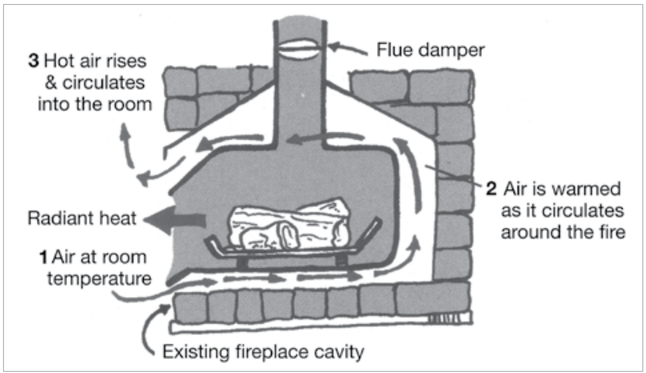
Inserts

Fireplace inserts provide a combination of convective and radiant heat and are available as:

- steel framed open fire
- efficient slow combustion heater.

Open fire inserts are marginally more efficient than open fires as they draw more heat from the firebox through convection. They can also reduce problems with smoking chimneys.

However, inserts are still only about 30% efficient and should only be used occasionally. Dampers are very important and must be closed when the fireplace is not in use to prevent heat loss.



Slow combustion inserts are up to 60% efficient if they are installed correctly.

Slow combustion inserts are up to 60% efficient if they are installed correctly, as they seal the chimney at ceiling level and provide vents back into the room to reclaim heat from the flue and case. If the wall behind the fireplace is external it should be insulated.

Non-airtight potbelly stoves provide mainly radiant heat and are only about 40% efficient. They also create higher air pollution.

Slow combustion stoves and heaters supply convective and radiant heat and can be up to 70% efficient. They are most suitable for large spaces that need heating for long periods — they can take a long time to heat up and cool down. Many can be fitted with a wetback to heat water.

All slow combustion stoves must comply with AS/NZS 2918:2001, Domestic solid fuel burning appliances — installation, for flue gas emissions. Only approved slow combustion stoves should be installed.

Operating tips for wood heaters

Get a good fire going as quickly as possible to allow the heater to draw air and function properly, with little smoke production.

Allow a hot fire to burn for at least one hour before turning it down for overnight burning.

Avoid unnecessarily running your heater on low overnight to save a lot of wood and reduce creosote formation. Operating wood heaters with the air supply closed off usually causes high pollutant emissions.

Load firewood with approximately 25mm gaps between the logs to let in adequate air and help to develop pockets of glowing coals. Use only dry, untreated wood from sustainable sources.

Check the seals around heater doors and ash-removal trays.

Inspect your flue or chimney once a year for blockages such as bird nests or creosote build-up. Have it swept if necessary. Close off chimneys when they are not being used to prevent major heat losses through the chimney cavity.

Space heating systems compared

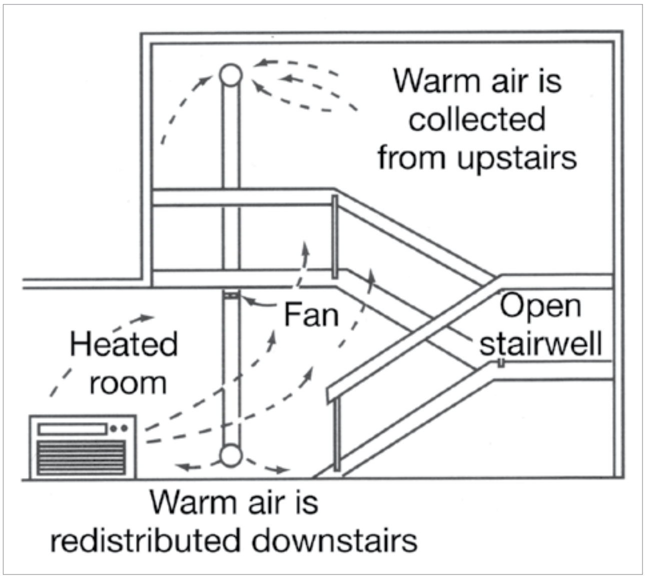
The space heating comparison table assumes well designed and efficiently operated systems, and general running costs and greenhouse gas emission. Obtain expert advice before making decisions on the type best for you.

Space heating systems comparison

System type	Running cost per unit of heat produced	Greenhouse emissions per unit of heat produced
High efficiency natural gas	Low	Low
Slow combustion wood heater (standards compliant, well managed)	Low	Low (if from a renewable resource and seasoned wood)
Reverse cycle air conditioner (or heat pumps)	Medium	Medium
Off-peak electric storage	Medium	High
Electric portable heaters and panel	High	High

Heat shifters

Heat shifters consist of a fan and ducting, and cost little to run and install. They move air from warm areas to cooler areas.

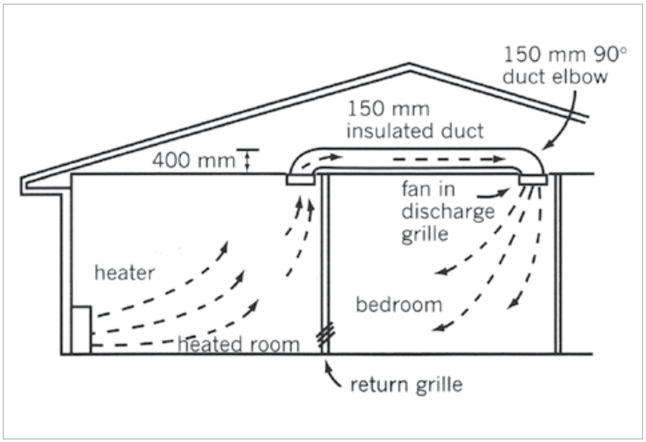


Heat shifters redistribute warm air downwards.

Heat shifters redistribute warm air that collects upstairs back downstairs, or warm air from the ceiling back down to floor level.

They can also supply heat for rooms that only require low levels of heating, such as bedrooms.

Make sure the fan isn't left running when not needed, and that there is a return air path back to the heat source.



Heat shifters can distribute heat to other rooms.

Solar air heaters and heat recovery

Solar air heating or heat recovery is an energy efficient heating method that can boost indoor temperature and lower heating energy inputs. How efficient the solar air heating is depends on the system's design and the location of the house. In cooler parts of Australia, solar air heating can assist with heating during mild weather periods, such as autumn and spring.

The systems take the warm air from inside the roof space, filter it and push it into the living space below. Thermostats can control the required indoor temperature. Additional benefits include creating a positive pressure in the house which can reduce draughts and increase the comfort. They rely on efficient electric fans with relatively low running costs; some models use solar powered fans, which may deliver limited air flow.

Solar air heaters reduce drafts and increase comfort.

Heat recovery systems act as a heat exchanger. They recover waste heat from exhaust air vented from the house and use it to warm fresh input air. The systems do not necessarily add heat to the house but recover the energy lost by venting warmed air.

Micro-cogeneration systems

Cogeneration is the simultaneous production of electricity and useful thermal energy from a single fuel source, typically natural gas. Although still in the early developmental stages, micro-cogeneration systems are available that produce electricity from gas and provide hot water. The electricity can be exported to the electricity grid when not used in the house and the hot water used for heating or domestic use. These systems are usually over 70% efficient as they use the wasted heat from the cogeneration plant to heat the water.

Cooling

Use passive design principles to increase comfort and reduce the need for cooling. Insulate your home and shade windows from summer sun. Never use mechanical cooling as a substitute for good design (see *Passive cooling*). However, many existing homes do not include good design features, and climate change is bringing higher night-time temperatures, so cooling equipment may be needed at times.

The better insulated, shaded and draught-proofed a house is, the smaller (and cheaper to buy and run) the cooling unit needed, and the less often it needs to run. See www.fairair.com.au for a useful air conditioner sizing calculator.

Mechanical cooling devices

Consider these questions when choosing cooling systems:

- Does the air require cooling or will creating a cooling breeze be enough?
- How big an area needs to be cooled? A single living area is often sufficient to survive a few days of a summer heat wave in many climates.
- How often and for how long is cooling needed?
- Is space cooling or a whole house ducted system required? Whole house systems are more expensive to buy and generally more costly to run.

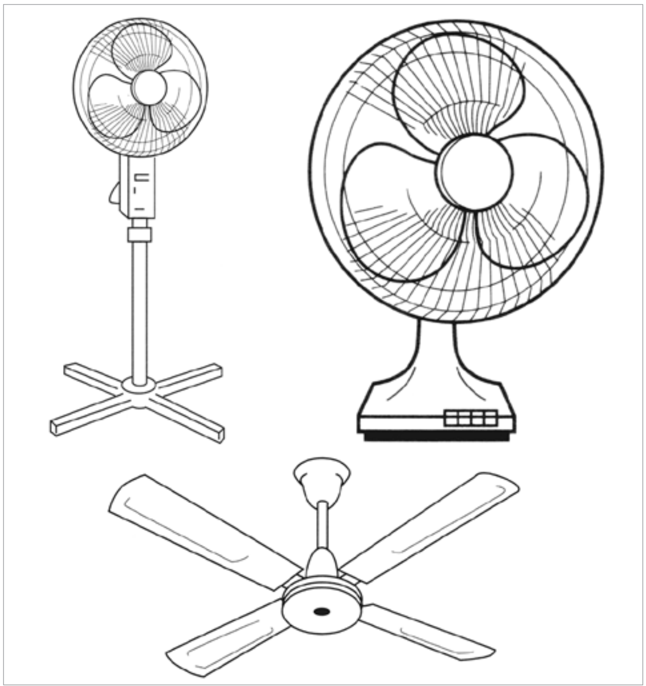
There are many variables to consider. Seek expert advice before proceeding with the design or purchase of a mechanical cooling system.

The three major methods of mechanical cooling are fans, evaporative coolers and air conditioners.

Fans

Fans should be the first choice for mechanical cooling.

With good design and insulation, fans can often supply adequate cooling for acclimatised residents in all Australian climates. They circulate air but do not reduce temperature or humidity. Typically, the air flow created by a fan provides a similar improvement to comfort as reducing the temperature by around 3°C.



Fans can be portable (table or floor) or fixed (ceiling or wall)

Fans are the cheapest cooling option to run and have the lowest greenhouse impact; air conditioners are expensive to run and produce more greenhouse gas.

Make fans your first choice for mechanical cooling — they are the cheapest to run and have the lowest greenhouse impact.

Portable table and floor fans or fixed ceiling and wall models are available.

Fans have a wide variation in efficiency: a Choice test showed ceiling fans used from 54W to over 100W. Check power consumption before buying and make significant savings in long periods of operation.

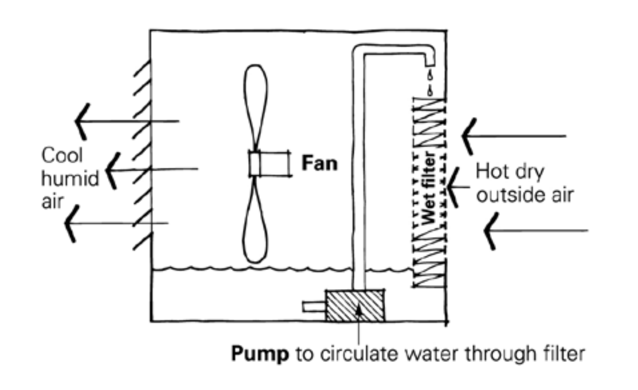
Combine fans with an air cooling system for comfort at higher thermostat settings from the extra air movement. The reduced air conditioner running costs more than offset the fan energy use.

Evaporative coolers

Your second choice for mechanical cooling should be evaporative coolers, except in humid regions.

Evaporative coolers work best in climates with low humidity as the air has greater potential to absorb water vapour. They are significantly less effective in climates with high humidity.

They cool the air to just above the 'wet bulb' temperature. Check to see if the wet bulb temperature is at a comfortable level for you in summer by searching on the Bureau of Meteorology website (www.bom.gov.au) for wet bulb temperatures in your local area.



Evaporative coolers work best in climates with low humidity

Some doors and windows must be open for evaporative cooling to allow hot air to escape from the house. Smaller and older units do not use a thermostat, just a fan speed control. Newer, whole-house systems can be fitted with electronic thermostats and timers.

Operating costs can be low as only the fan and a small water pump use energy. However, many units have inefficient fans and fan motors that consume more energy than necessary. Some modern evaporative coolers use far less energy than older models: check with manufacturers.

Purchase costs are moderate.

Evaporative coolers use evaporation of water as the cooling mechanism. Check with your council to see if there are any restrictions on using water for evaporative cooling.

Take care when using portable units not to place them next to open windows and doors that can let in a lot of heat on a windy day.

Portable units have to be topped up with water at a rate of about 4L/hr. For central systems, water use can be 25L or more per hour on hot, dry days and may have implications in water restricted situations. Make sure the bleed-off rate isn't excessive — ask the installer to set it to the recommended minimum.

Systems can also be mounted in windows and doors.

Evaporative coolers can increase heating bills and allow a house to heat up faster when not operating, because large volumes of air can be sucked out of the house through the evaporative unit. Many modern units have automatic seals when not in use. Otherwise, close off ducts and cover the roof unit in winter to reduce heat losses.

An indirect benefit of an evaporative cooler is that it tends to pressurise the house, keeping out bugs and dust.

Air conditioners/refrigerated coolers

If thermal comfort cannot be achieved with passive design, fans or evaporative cooling, consider air conditioning.

Air conditioning can give a higher degree of comfort in any climate. However, it consumes more energy and creates more greenhouse gases than fans and efficient evaporative cooling systems unless the building and air conditioner are *very* energy efficient.

For efficient air conditioning, the house or room should be sealed and highly insulated with bulk and reflective insulation. Windows must also be shaded from the summer sun. (see *Shading; Insulation*)

Purchase costs vary depending on the size and type of air conditioner, and efficiency varies widely between units and models.

Choose the most efficient model of the correct size for air conditioning.

Systems using inverter technology and advanced design can show energy savings of up to 40% over standard units. The Equipment Energy Efficiency website (www.energyrating.gov.au) lists the products regulated by energy labelling programs and Minimum Energy Performance Standards.

Always choose the most efficient model for your application.

Air conditioners are available as portable, wall, window, split and ducted systems. Fixed systems need to be installed by a licensed refrigeration mechanic/electrician.

Ensure your air conditioner is correctly sized by having an expert calculate the cooling load before purchasing. Use the Australian Institute of Refrigeration, Air Conditioning and Heating's online calculator (www.fairair.com.au) for cooling requirements based on specific room characteristics.

Portable air conditioner units

Portable split units consist of separate indoor and outdoor components connected by a flexible hose passed through a partially open window or door. They plug into a standard power outlet and are generally not as efficient as other types of air conditioners but suitable for small rooms up to about 20m^2. Always check the Energy Rating Label.

Portable single duct units consist of a single indoor unit which can be on rollers and a duct to exhaust the condenser air outside, usually through a window. These types of portable air conditioners are less effective than portable split units and currently are not required to carry an Energy Rating Label.


Photo: Paul Ryan

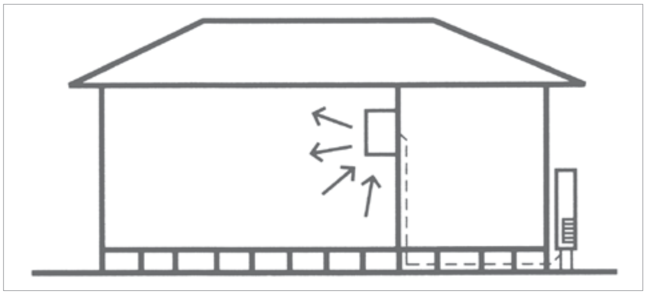
Portable air conditioners are not as efficient as modern fixed systems.

Portable single duct units draw the air from the room and exhaust the hot air out the window. The outlet often doesn't seal tightly and heat can enter the room. The units draw air from other rooms in the house as they vent air, typically heating them up, and they do not work well in large rooms. Take care to empty the water that condenses or they do not work effectively.

Through wall/window units

Through wall/window units are placed in an existing external window or a hole made in an external wall. Smaller units can use a standard power outlet but larger ones may need a dedicated electrical circuit installed.

They are suitable for single rooms up to about 50m^2 but are generally less efficient than fixed split systems.



A split system unit can be away from the outdoor compressor.

Fixed split systems

Fixed split systems, especially those using inverter technology, are generally the most efficient domestic air conditioners. The indoor wall or floor mounted unit can be up to 15m from the outdoor compressor.

Multi-split systems have more than one indoor unit running off the outdoor compressor.

Ducted units

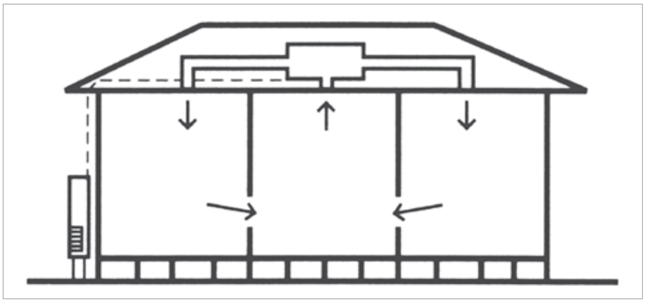
Ducted air conditioning units cool large areas or an entire house.

Ducts must be well insulated, to at least R1.5, and joints sealed to prevent condensation and leakage. The roof should have reflective foil insulation installed and be vented to dispel hot air.

Zone systems to cool only occupied areas and allow different conditioning in living and sleeping areas.

Alternative heat exchangers

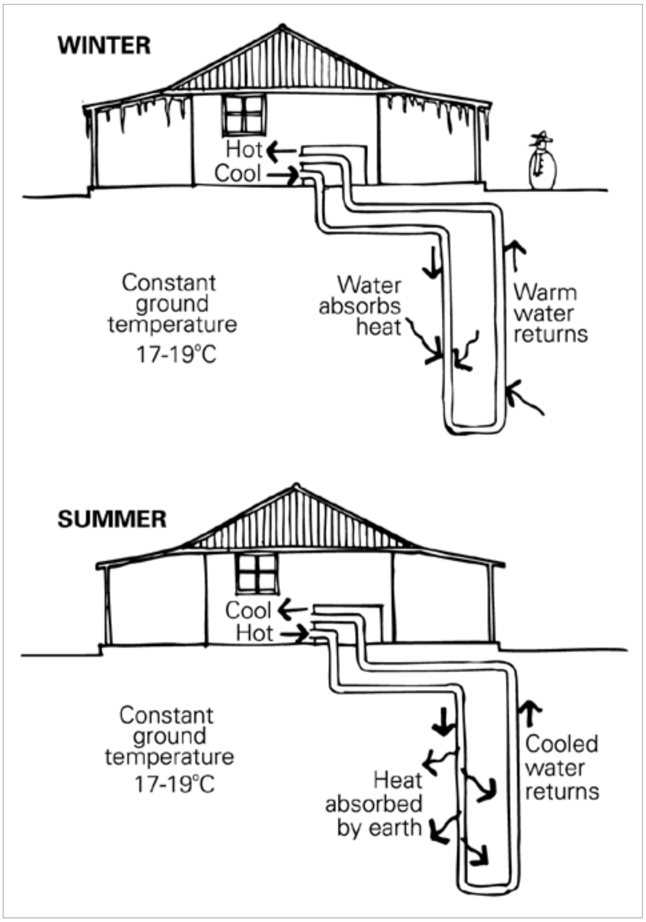
Reverse cycle air conditioners, in both cooling and heating modes, mostly use an air-to-air heat exchanger, like a refrigerator. They dissipate heat extracted from the room to the outside when cooling or from the outside air into the room when heating.



Ducted units can cool an entire house.

In colder climates, heating and cooling modes must be appropriately selected, as some units may ice up, reducing both efficiency and heating capacity in cold conditions.

Air-to-water or air-to-ground (also called geothermal) exchangers are far more efficient. Heat exchange pipes are run through a body of water or deep into the ground where the temperature is relatively stable all year round.



Geothermal systems are very efficient heat exchangers.

Geothermal systems are highly efficient, producing up to four units of heat output for each unit of electricity input, a performance comparable to the most efficient conventional air conditioners. However, their main benefit is that they can continue to operate efficiently in extremely hot or cold conditions, where peak capacity and efficiency of air-to-air units can be significantly affected. They can also be used to run hot water services.

Geothermal systems are highly efficient, even in extremely hot or cold conditions, and can run hot water services.

They are expensive to install and so are more suitable for housing in extremely hot or cold conditions and with large heating and/or cooling loads, e.g. multi-housing developments.

Solar air cooling

Solar air cooling systems use a fan or ventilator to extract hot air out of the roof space for tile/metal roofs or the gap between the sarking and metal roof sheets. They work by extracting hot air from the roof space and replacing it with ambient air, to minimise heat transfer to the ceiling space below. The effectiveness of removing hot air from the roof space is very sensitive to roof colour and presence of reflective foil under the roofing. A dark (or unpainted steel) roof absorbs an enormous amount of heat. The temperature in the roof cavity is significantly reduced only by a very large air flow, well beyond the capacity of most fans and vents. A light roof or reflective foil (see *Insulation*) under the roofing dramatically reduces heat gain, so ventilation systems are more likely to make a noticeable difference.

Systems using a solar panel as the only source of electricity have no running costs but work only in sunny conditions. Some systems combine daytime and night-time cooling. The advantage of a system using grid electricity to power the fan is that night-time cooling can flush heat out of the building overnight.

These types of systems are many and varied. Some also draw cool/warm air into the building when required.

Cooling systems compared

The cooling comparison table assumes well designed and efficiently operated systems and gives general running costs and greenhouse gas emissions. Obtain expert advice before making decisions on the type best for you.

Cooling systems comparison

System type	Running cost	Greenhouse gas emissions*
Fan	Low	Low
Evaporative cooler	Low	Low
Refrigerated cooler	Medium	Medium
Geothermal	Low–medium	Low–medium
Solar air cooler (using electricity to power fan)	Low	Low

* Using GreenPower can reduce emissions from all systems but increases running costs.

Cooling system operating tips

Shade outdoor components of air conditioners from direct sun — but don't limit air flow around them.

Some units are noisy in operation. Split systems (where the compressor is outside) are quieter inside but consider your neighbours when selecting and locating external components.

Reverse cycle models can also be used for heating and can provide low cost, low emission heating (*see 'Heating' above*). Units that use electric heating elements cost more to run and produce more greenhouse gases.

For ducted systems, install a zoning system so only rooms requiring air conditioning are cooled. Ensure that ducts are well insulated and consider installing reflective foil or painting the roof a light colour and ventilating it to reduce the roof space temperature.

Purchase a system that has controls such as a timer to schedule activation and shut-off.

Set the thermostat as high as possible on your cooling system.

Never set the thermostat at a temperature below what you require — that does not make the unit cool faster.

Always aim to set the thermostat as high as possible.

Avoid leaving air conditioning running when no-one is home. It is cheaper to cool the house down when you arrive home, or to set a timer so that the house begins cooling shortly before people return home.

Practical tips for heating and cooling

Do not leave heating and cooling appliances on overnight or when you are out, although slow combustion stoves can be left on in very cold weather. If you must have the house comfortable when you arrive home, install a timer and turn your system on about 15 minutes before your return.

Locate thermostats in the most used rooms and away from sources of heat and cold.

Each degree of extra heating in winter or cooling in summer increases energy consumption by about 5–10%. Set the thermostat to 18–20°C in winter and 25–27°C in summer.

Dress appropriately for the weather. Putting on a jumper is better than turning the heater up.

Maintain your heater. Keep reflectors shiny and free of dust. Clean air filters regularly.

Service all heaters and coolers according to the manufacturer's instructions. Pay special attention to air filters.

Close windows and doors in areas where a heater or air conditioner is on unless ventilation is required for unflued gas appliances.

Close drapes or blinds, especially in the evening when you are heating.

References and additional reading

Contact your state, territory or local government for further information on energy efficiency: www.gov.au

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