Heating and Cooling

Very little energy is required to make a well designed house comfortable. A highly efficient house may need no non-renewable energy inputs for heating and cooling. Such homes are possible across much of Australia.

Even for existing homes there are many ways to reduce energy bills, improve comfort and help the environment.

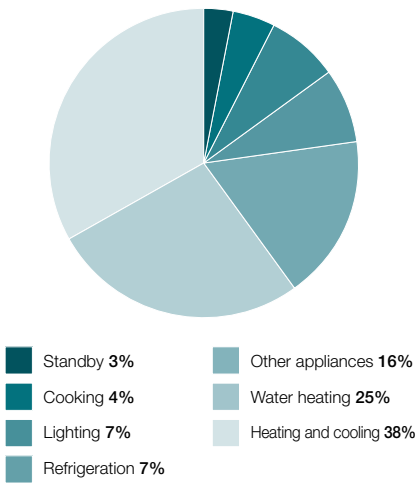
Mechanical heating and cooling should never be used as a substitute for good design.

It is better to invest more money in an energy efficient building than spend it on heating and cooling.

The principles of thermal comfort and the importance of air movement, humidity and radiant heat are explained in the passive design section. [See: 4.1 Passive Design]

Heating and cooling account for 38 per cent of household energy use making it the largest energy user in the average home.

Home energy use
(Baseline Energy Estimates, 2008)



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. This applies to existing homes as well as new homes. [See: 4.1 Passive Design]

There are two main types of heating – 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.

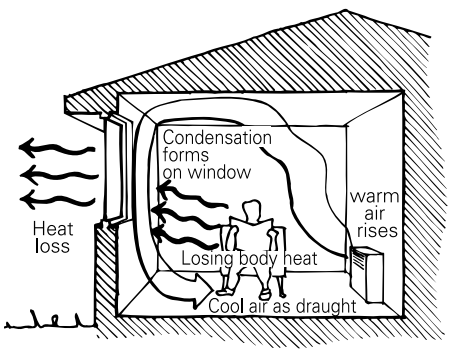
Other forms of heating, such as heated floors, also heat by conduction through direct contact.

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.

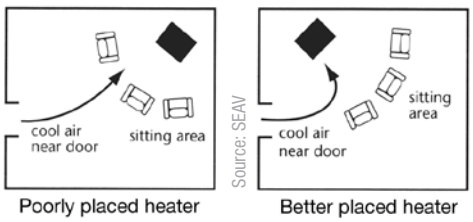
> In larger draughty rooms or bathrooms, radiant heating works best.



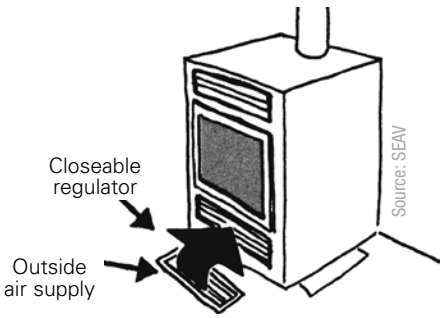
All heaters produce air movement as the hot air rises from the heater to the ceiling. Air is cooled when in contact with windows and poorly insulated walls. The cooled air falls and is drawn back along the floor to the heater.

Sitting in draughts created by air movement can make you feel much colder. Your body radiates heat through exposed windows making you feel cold. minimise draughts from windows and use heavy curtains with snug pelmets 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.



If you have a suspended floor, you can reduce the flow of air through the living space by putting a vent in the floor in front of the heater to supply air. But make sure it can be closed off when not being used.



Ask 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 Australian Consumers' Association provides an on line calculator to help you estimate what size heater you might need.

See: www.aca.com.au/cp/energy/quizheatingcalc.cfm, then talk to an expert who can give you appropriate advice.

Energy choices

Gas heaters and efficient reverse cycle heat pumps produce only one third the amount of greenhouse gas emissions of standard electric heaters.

Gas heaters and reverse cycle heat pumps have energy labels to help you choose the most efficient model. It should be noted that there are indoor air quality issues surrounding the use of unflued gas heaters.

Wood can be an excellent fuel because it is a renewable energy source, if sustainably harvested. However, air pollution from wood fires and the transport of firewood to urban areas are environmentally detrimental.

About 20 per cent 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 that may give off toxic pollutants when burned.

Burn wood only in high efficiency, low emission heaters.

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.

Central heating can often heat a whole house, whether individual rooms are occupied or not. Space heating heats the one or two rooms that are in use.

Ducted air

Hot air is circulated through roof or underfloor ducts, providing convective heat. Gas or a reverse cycle heat pump can be the heat source.

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

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: 4.7 Insulation]

Floor outlets are often better than ceiling outlets for heating as they deliver heat to where it is most needed, but well designed ceiling outlets can work well.

A return air path from every outlet back to the central system is very important. Without it the warm air will escape and the system will suck cold air in, dramatically reducing the effectiveness of the system.

Hydronic systems

Hot water or coolant is circulated through radiator panels in rooms, providing a mix of convective and radiant heat.

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

It is very important that the water circulation pipes are well insulated.

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.

In-slab floor heating

Concrete floors can be used to store heat from off-peak electric cables or hydronic pipes set into the slab. These are insulated during building construction or renovation.

Electric in-slab heating generally has the highest greenhouse gas emissions of any heating system.

The best system for minimising greenhouse gas emissions is hydronic pipes using:

> Solar with gas back-up.

> Efficient slow combustion wood heater with a wetback.

> Geothermal or water-body heat pumps.

In-slab systems provide a combination of radiant, convective and conductive heat.

In-slab systems 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. They are ideal as back-up for passive solar heating of thermal mass on cloudy or extremely cold days.

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

Slab edges must be insulated. Ideally the entire slab should be insulated from the ground to minimise heat loss. Walls should be insulated from the slab to reduce heat loss.

Heating zones and thermostats are essential to reduce energy use.

The table below assumes well designed and efficiently operated systems. Running costs and greenhouse gas emissions are general and you should obtain expert advice before making decisions on which type is best for you.

Comparison of central heating system

SYSTEM TYPE	RUNNING COST	GREENHOUSE GAS EMISSIONS
Hydronic zoned with wood / solar heat source	low	very low
High efficiency ducted natural gas	low	low
Hydronic zoned natural gas or heat pump	low	low
Ducted reverse cycle heat pump	medium	medium
In-slab high off-peak electric	medium	high

SPACE HEATING

Electric heaters

These devices heat a smaller area – one or perhaps two rooms. There is a wide range available.

Electric portable heaters

Electric portable heaters can be cheap to buy but are expensive to run and sometimes ineffective. They include the following:

> Radiant heaters, such as bar heaters, are good for bathrooms as they provide almost instant heat direct to your body and do not directly heat air. Less warm air is lost when an exhaust fan is used compared to other heater types. No thermostat is fitted so a timer or switch should be used. 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. 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.

> Oil filled column heaters provide a mix of convective and radiant heat but are slow to respond. Some have thermostats, timers and fans. They are more suitable for larger rooms with high ceilings.

Electric systems may produce high greenhouse gas emissions – up to six times as much as an efficient gas central heating system.

Electric fixed heaters

Reverse cycle heat pumps provide convective heat and are the most energy efficient electric heater.

Wall panel convectors use peak electricity and are expensive to run.

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 periods of milder weather.

Gas heaters

Gas portable heaters

Unflued portables 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 which burn cleaner, producing lower combustion emissions, requiring less ventilation.

Unflued gas heaters often create condensation problems – usually at the opposite (coolest) end of the house. Care is needed to ensure they don't lead to mould growth.

The use of unflued heaters is restricted in some states.

Gas fixed heaters

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

In low humid climates, humidity trays may be required to maintain room humidity levels. These need to be topped up regularly.

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

Wood and other solid fuels

Open fireplaces

Open fireplaces provide radiant heat, but are highly inefficient, with up to 90 per cent of the heat energy going up the chimney. Large amounts of cold air are drawn into the room to replace air lost up the chimney. They are the least efficient of all wood heating methods and produce the highest levels of air pollution. Open fires are better at producing ambience than heat.

Fireplace inserts are available in two forms:

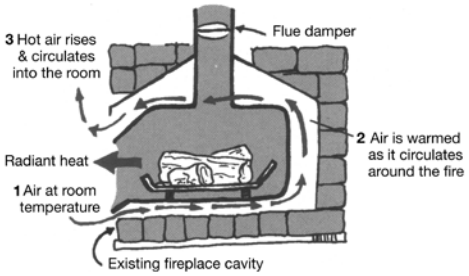
> Efficient slow combustion heater.

> Steel framed open fire.

They provide a combination of convective and radiant heat.

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 per cent 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 per cent efficient if they are installed correctly by sealing the chimney at ceiling level and providing 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 per cent efficient.

Slow combustion stoves and heaters provide convective and radiant heat and can be up to 70 per cent 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 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. This will 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 burn.

Avoid unnecessarily running your heater on low overnight. This will save a lot of wood and reduce creosote formation. High pollutant emissions are usually caused by operating wood heaters with the air supply closed off.

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.

Inspect your flue or chimney once a year for blockages such as bird's nests or creosote build up. Have it swept if necessary.

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

Close off chimneys when they are not being used, to prevent major heat losses through the chimney cavity.

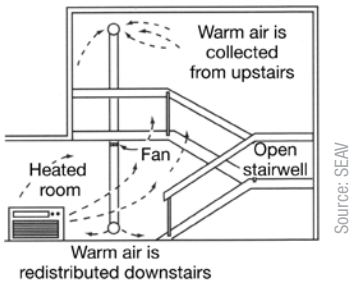
The table below assumes well designed and efficiently operated systems. Running costs and greenhouse gas emissions are general and you should obtain expert advice before making decisions on which type is best for you.

Comparison of space heating systems

SYSTEM TYPE	RUNNING COST	GREENHOUSE EMISSIONS
High efficiency natural gas	low	low
Slow combustion wood heater	low	low
Reverse cycle heat pump	medium	medium
Off-peak electric storage	low	high
Electric portable heaters and panel	high	high

Heat shifters

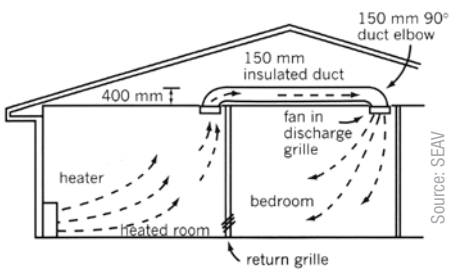
Heat shifters consist of a fan and ducting and cost little to run and install. They move air from warm areas to cooler areas.



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

They can also provide 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.



COOLING

Use passive design principles to increase comfort and reduce the need for cooling. Insulate your home and shade windows from summer sun. Mechanical cooling should never be used as a substitute for good design. [See: 4.6 Passive Cooling]

Mechanical cooling devices

Points to consider 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 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 cost more to run.

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

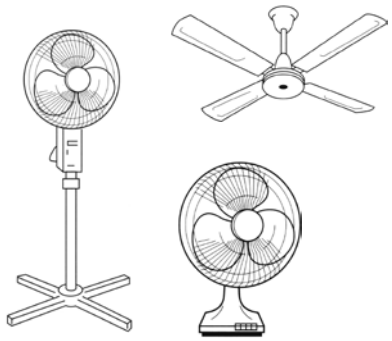
Fans

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

Fans should be the first choice for mechanical cooling.

With good design and insulation, fans can often provide adequate cooling for acclimatised residents in all Australian climates. They save money and the environment.

Fans are the cheapest to run and have the least greenhouse impact, while air conditioners are expensive to run and produce more greenhouse gas.



Fans cost little to buy and run. They circulate air but do not reduce temperature or humidity.

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

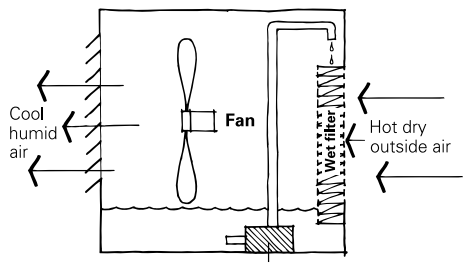
Fans are useful in combination with an air cooling system as the extra air movement provides comfort at higher thermostat settings.

Evaporative coolers

Your second choice for mechanical cooling should be evaporative coolers.

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

They will cool the air to just above the 'wet bulb' temperature. You can check with your local bureau of meteorology to see if the 'wet bulb' temperature is at a comfortable level for you in summer.



Some doors and windows must be open for evaporative cooling to allow the 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 uses energy. Evaporation provides the cooling energy. However, many units have inefficient fans that consume more energy than necessary.

Evaporative coolers use water on the cooling medium. You should check with your council to see if there are ant restrictions on using water for evaporative cooling.

Purchase costs are moderate.

Care is needed 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 regularly, about four litres per hour. For central systems water use can be 25L or more per hour on hot, dry days and this needs to be considered in water restricted situations. Make sure the bleed-off rate isn't excessive – ask the installer to set it to the recommended minimum.

Window and door mounted systems also exist.

Close off ducts and cover the roof unit in winter to reduce heat losses.

Refrigerated coolers (air conditioners)

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

While normally giving a higher degree of comfort, air conditioning consumes more energy and creates more greenhouse gases than fans and efficient evaporative cooling systems.

Air conditioning can provide comfort in any climate.

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: 4.4 Shading; 4.7 Insulation]

Purchase costs are higher than evaporative coolers.

Efficiency varies between units and models.

Systems using inverter technology can show energy savings of up to 30 per cent vs standard units, however, are more expensive. The Australian Greenhouse Office lists which products are regulated by Energy Labelling Programs and Minimum Energy Performance Standards. See www.energyrating.gov.au

Always choose the most efficient model for your application.

Air conditioners are available as portable, wall, window, split and ducted systems.

Correct sizing of air conditioners is very important. Always have a cooling load calculation done by an expert before purchasing. The Australian Consumers' Association has an on-line calculator as a guide to the size system you might need. See www.choice.com.au/calculators/quizcoolingcalc.asp

The Australian Institute of Refrigeration Air Conditioning and Heating (AIRAH) has a website that can assist you in selecting the appropriate cooling options. See www.fairair.com.au

Operating tips

Shade outdoor components from direct sun.

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

Reverse cycle models can also be used for heating. Units that use electric heating elements cost more to run and produce more greenhouse gases.

Adjust louvres to point cold air towards the ceiling if possible because cool air falls.

For ducted systems, install a zoning system so only rooms requiring air conditioning are cooled.

Purchase systems that have controls such as timers to schedule activation and shut off.

Never set the thermostat at a temperature below what you require. Setting it lower does not make the unit cool faster.

Always aim to set the thermostat as high as possible.

Types of air conditioners

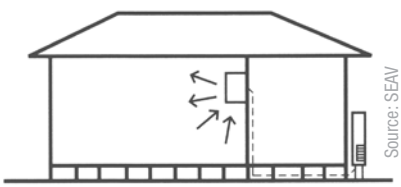
Portable split units

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

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 special wiring.

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



Split system unit.

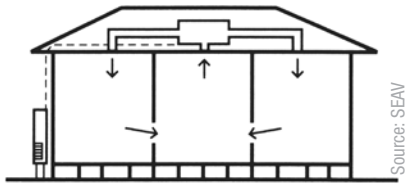
Fixed split systems

Fixed split systems 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 units are used to cool large areas or an entire house.



Ducted unit.

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.

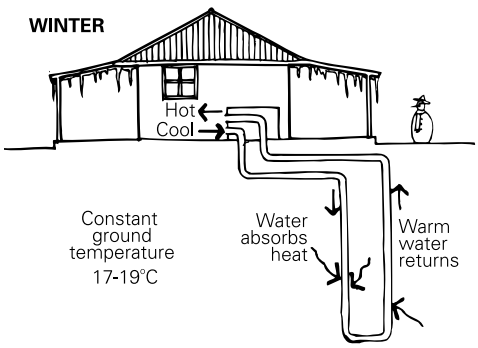
Systems should be zoned to cool only those areas occupied and to allow different conditioning in living and sleeping areas.

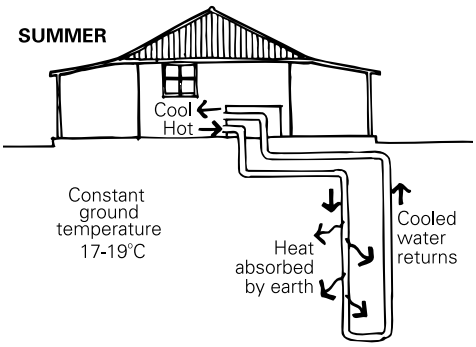
Alternative heat exchangers

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

In colder climates, it is important to ensure the unit is properly selected in the heating and cooling modes.

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 highly efficient, producing up to four units of heat output for each unit of electricity input. They can also be used to run the hot water service.

Although expensive to install, depending on whether a bore or shallow trench is used, they have very low running costs.

They are ideal where there are large heating and/or cooling loads, and are most suitable for multi-housing developments.

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, ensure you have a timer and turn your system on about 15 minutes prior to 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 will increase energy consumption by about 5 to 10 per cent. Set the thermostat to 18° to 20°C in winter and 25° to 27°C in summer.

Dress appropriately for the weather. Putting on a sweater 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 un-flued gas appliances.

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

ADDITIONAL READING

Contact your State / Territory government or local council for further information on energy efficiency.
www.gov.au

Australian Consumer Association
www.choice.com.au

Australian Institute of Refrigeration, Air Conditioning and Heating
www.airah.org.au

Department of the Environment, Water, Heritage and the Arts (2008), *Australian Residential Sector Baseline Energy Estimates 1990 – 2020.*

Energy Rating
www.energyrating.gov.au

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