Thermal Comfort at Home

A guide for older South Australians

Also useful for architects and building designers

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Thermal Comfort at Home

A guide for older South Australians

This guide is based on research funded by the Australian Research Council, ARC DP180102019 "'Improving thermal environment of housing for older Australians" (2018-2021) and in consultation with the research participants.

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What is thermal comfort?

'Thermal comfort' is the contentment you feel by a combination of temperature, humidity and air movement in your environment. What you're wearing and doing also matter.

In science, thermal comfort is defined as the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.*

This is not just about how you feel. Thermal comfort can also affect health and wellbeing. Cold weather results in more cases of cardiovascular diseases, influenza, pneumonia, arthritis and mood disorders such as depression. Hot weather leads to more heat strokes, lethargy, headaches, and again, mood disorders. For older people in particular, the World Health Organization warns that extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory diseases.

The potential for health problems increases as we age, because:

- Metabolic rate reduces
- Muscle strength wanes
- Vascular reactivity slows down.

These changes affect our body's ability to stay healthy and feel good even on really hot or cold days.

Getting older doesn't mean we have to suffer. This guide explains the things you can do to make your home thermally comfortable.

Life is better when thermal comfort in your home is just right.

*ASHRAE 2020. ANSI/ASHRAE Standard 55-2020. Thermal Environmental Conditions for Human Occupancy. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA.

Contents

1. About this guide

This guide is based on scientific research from a project called 'Improving thermal environment of housing for older Australians' (DP180102019). Funded by the Australian Research Council (ARC), the project analysed the housing of people aged 65 and over in South Australia in 2018-2021.

The project was developed by a team of researchers at The University of Adelaide with backgrounds in architecture, built environments, building engineering, gerontology and public health. They worked in collaboration with the Urban Ageing research group at The Hague University of Applied Sciences in the Netherlands, and in consultation with older people from across South Australia.

This consultation involved more than 300 older people from various regions representing 3 climate zones in South Australia:

- Whyalla, Port Pirie, Port Augusta (hot dry summer, cool winter)
- Greater Adelaide Metropolitan (warm temperate)
- Adelaide Hills and Fleurieu (mild temperate).

These zones are shown in the map on page 6.

You can read more about the research project on page 40.

Get informed to get comfortable

This guide will help you achieve thermal comfort at home by asking you to consider your:

- specific thermal comfort goals
- needs and constraints
- local climate
- housing type and location.

This guide will help you learn aspects that affect your thermal comfort and what you can do to achieve it.

Designers, architects and builders will also find this guide useful to understand how to include thermal comfort principles into their projects.

Note that this guide is intended for people who live at home or can make some changes to their living environment.

2. Why thermal comfort matters

The thermal condition of your home is important to your comfort, health and wellbeing.

Most vulnerable

Older people – especially those with pre-existing medical conditions, who live alone, or in poorly constructed housing.

[van Hoof J, Schellen L, Soebarto V, Wong JKW, Kazak JK 2017 Ten questions concerning thermal comfort and ageing, Build and Env 120 123-133] and [O'Neill MS, Ebi KL 2009 Temperature extremes and health: impacts of climate variability and change in the United States, J Occup Environ 51 1 13-25]

75 - 80%

Proportion of time people aged 60+ spend inside their own home.

[ABS 2008 How Australians Use Their Time, 2006, Cat. No. 4153.0 Canberra, Australian Bureau of Statistics] and [Matz CJ, Stieb DM, Davis K, Egyed M, et al 2014 Effects of age, season, sex and urban-rural status on time-activity: Canadian Human Activity Pattern Survey 2 (CHAPS 2), Int J Environ Res Public Health 11 2108–2124]

Risk of illness and death

Cold conditions can fuel risk of hypothermia, strokes, cardiac conditions related to changes in blood pressure, and illnesses such as arthritis, influenza, pneumonia and asthma.

Hot conditions can elevate risk of cardiovascular diseases, hyperthermia and heat stroke.

[Havenith G 2001 Temperature regulation and technology, Gerontechnology 1: 41–49] [Vassallo SU, Delaney KA 1989 Pharmacologic effects on thermoregulation: mechanisms of drug-related heatstroke, J Toxicol Clin Toxicol 27 4-5 199-224] and [Donaldson GC, Keatinge WR, Saunders RD 2003 Cardiovascular responses to heat stress and their adverse consequences in healthy and vulnerable human populations, Int J Hyperthermia 19 3 225-235]

More than 80%

Proportion of older South Australians who used air-conditioning to cope in a severe heat wave in 2008.

[Hansen A, Nitschke M, Bi P, Pisaniello D, et al. 2014 Heat-health behaviours of older people in 2 Australian states, Austr J Ageing 34 1 19–25]

21 - 24°C

Indoor temperature range in which participants in another study with older people in South Australia reported experiencing fewest health symptoms.

[Bills R 2018 Creating comfort and cultivating good health: The links between indoor temperature, thermal comfort and health, Proc 10th Windsor Conference - Rethinking Comfort 886-900]

15 - 28°C

Indoor temperature range considered satisfactory by older South Australians in this project, due to improved wellbeing.

Outside this range the influence of temperature on wellbeing became more pronounced, adversely.

[Williamson T, Soebarto V, Bennetts H, Arakawa Martins L, Pisaniello D, Hansen A, Visvanathan R, Carre A, van Hoof J 2022 Assessing human resilience: A study of thermal comfort, wellbeing and health of older people (Chapter 7). In Nicol, Roaf, Rijal (Eds) The Handbook of Resilient Thermal Comfort, Routledge, UK.]

3. Key factors that influence thermal comfort

Thermal comfort is achievable when your environment is just right: not too hot, not too cold; comfortable and pleasant. But this can feel different for each of us. Understanding what works for you will help you maintain comfortable conditions in your home.

Personal preferences

Some people like warm conditions all the time, others prefer to feel cool regardless of the weather. Some prefer dry air, while others like humidity or rain.

Health

The frequency and intensity of some illnesses are largely related to weather. Examples are the common cold, flu and the winter blues in cold weather, and nausea and heat stress in hot weather.

Costs

Ageing can mean living with a reduced income. Heating and cooling can be expensive – not only for the equipment but also the ongoing energy bills.

Environmental concerns

If you are concerned about the environment, you won't like knowing that home energy use is a major source of greenhouse gas emissions – a contributor to climate change.

Environmental concern leads some people to limit the use of heating and cooling. Some choose not to install any heating and cooling equipment at all.

Access to equipment

Heaters, coolers and fans help control indoor conditions.

Technology works best if you understand what is available, which ones most suit your needs, and how best to operate them to reach thermal comfort within a budget.

Climate/location

South Australia generally has a Mediterranean climate with mild winters and warm to hot summers. But this varies considerably across the state, with implications for house design and thermal comfort.

According to the Australian Building Codes Board, South Australia has 3 main climate zones, as shown on page 6. Within these zones, micro-climates with features such as gully winds, sea breezes, and heat radiated by buildings, roads and paving, exist.

South Australia's climate zones

Hot dry summer, cool winter

- Dominated by the need for cooling in summer
- Less heating is required during the day in winter
- Cold winter nights

Warm temperate

- Both heating and cooling may be needed
- In summer, cooling is required on very hot days and nights
- In winter and beyond (May to October) heating is required

Mild temperate

- Cooler than metropolitan Adelaide
- In summer, cooling is required less often
- In winter (often with frosty mornings), heating is needed more often

4. Find your comfort profile

Before you read the rest of this guide, it's a good idea to think about your preferences. The following questions will help build your thermal comfort profile. It's not a test – just an activity to help you think about the impact of indoor and outdoor weather on your comfort, wellbeing and energy bills.

a) In which climate zone in South Australia do you live? Check the map on page 6.	☐ Hot dry summer, cool winter ☐ Warm temperate ☐ Mild temperature
b) Do you feel your health or wellbeing is adversely affected by the temperature or weather?	☐ Never/rarely ☐ Sometimes ☐ Often ☐ Most of the time/always *If you ticked 'Often' or 'Most of the time/always', talk to your doctor to understand how weather and indoor temperatures can affect your health. Ask if your medications can affect your thermal sensitivity.*
c) What sort of conditions in your home do you like?	☐ Lots of sun ☐ No direct sunlight ☐ Lots of fresh air ☐ No breezes Do the people you live with (if any) like similar conditions? ☐ Yes ☐ No
d) If you wanted to, are you able to make changes to your home such as adding shading to windows?	☐ No – I live in an apartment, rental accommodation or retirement village ☐ Yes, it is possible to make changes
e) What is the first thing you do when you feel too hot or too cold at home?	☐ Change clothing or activity ☐ Open or close windows, curtains ☐ Turn on heater or cooler
f) Do your energy bills change between summer and winter?	☐ Yes, more expensive in winter ☐ Yes, more expensive in summer ☐ No, about the same all year round
g) If you have heating and or cooling do you sometimes choose not to use it?	☐ Yes - for financial reasons ☐ Yes - due to environmental concerns ☐ Yes - because I don't like the type of heating or cooling (e.g. too noisy, too breezy). ☐ No – no concerns

Summarise your comfort profile here:

How to use this guideline

Now that you have described your comfort profile, you can:

- continue by reviewing your space (page 9) then reading through the general suggestions on how to improve thermal comfort (from page 10), or
- go directly to the scenarios (from page 27) to see which of these examples depicts your comfort profile and which suggestions are relevant to improve your thermal comfort.

5. Review your space

To really understand your situation, do an energy review of your home or ask someone to do this for you.

Most libraries have a Home Energy Toolkit that you can borrow. The toolkit will help you identify things such as:

- what direction your windows face
- where hot and cold spots are in a room
- how much energy your appliances use.

Armed with this information, you can decide whether you need to make changes to improve your thermal comfort. Turn to the next section to find out how.

You can also download the toolkit from: **www.sa.gov.au/topics/energy-and-environment/using-saving-energy/home-energy-audits/home-energy-toolkits**

6. How to improve thermal comfort

This section explains the changes you can make in and around your home in 4 ways:

A. Personal activities
This is the best place to start – simple changes you can make yourself. See page 11.

B. Around the house
Things you can do in and around your house at little or no cost. See page 14.

C. Equipment and technology
The type of heaters, coolers or fans you can install depends on your budget, location and preferences. See page 16.

D. House design, renovation and construction
Design principles and building specifications that can affect the thermal performance and energy use of a house. Useful for renovating your current house, downsizing, or looking for another house. See page 23.

A. Personal activities

In cold weather

- If you can, keep active to maintain circulation, increase metabolic rate and produce body heat.
- Dress warmly. Layers are good. Keep hands, feet and head warm.
- Eat warming food like soups and stews or take a warming drink.
- When sitting (for example watching TV or reading) use knee rugs or blankets and place a mat under your feet.
- If your room gets sunshine during the day, keep the curtains open. Once the sun goes down, close the curtains to reduce heat loss through the windows.

In hot weather

- Reduce activity.
- Wear light clothing, ideally of natural fibres that 'breathe' such as cotton and linen.
- Avoid going out in the heat of the day. Arrange outdoor activities for early morning or after the sun goes down.
- Drink plenty of water. Even if you're not thirsty, maintaining fluid intake is important for a healthy body and mind.
- Eat light and cold foods that can be easier to digest and don't need the stove or oven.
- Refresh with cool showers or a damp flannel placed behind your neck.
- Keep blinds and curtains shut to reduce the heat coming through the window.
- When the temperature drops, open windows or doors to cool the house down.

TIPS from the our research study participants

- 'I change our diet slightly for more warming food. My husband makes the soup and we have soup for lunch. I usually will do a casserole or two warmer food, but salads in the summer.'
- 'I rely a lot on my bath, a hot bath in winter and a cold bath in summer before going to bed, and during the day in the summertime, if I feel I'm getting hotter I get into the bath. I keep the water in there.'
- 'For me, I've always hated the cold, all my life, so it's always been dress more, dress more and dress more.'
- 'Yes, I think exercise is the main thing in winter. If I exercise first thing in the morning, I find that that helps me right through the day because then your body is already warm.'
- 'Go outside, do something outside. Come back inside and you'll feel warm, work in the garden.'
- 'Sit with feet and ankles in cold water to cool down'.

- ‘I’ve got a shelf in the freezer to keep 2 dresses during the summer. One stays in the freezer and one of them I put on. After an hour or so I’ll change them. I know that I’ve always got something cold. When my air-conditioner broke down that was a godsend.’
- ‘Because of daylight saving and because of the climate, you can do your gardening at 6 in the morning or 7:30 at night.’
- ‘I get up early, do what I need to, close the house up, sit and do whatever sewing craft work that I want to do until the sun goes down at night.’

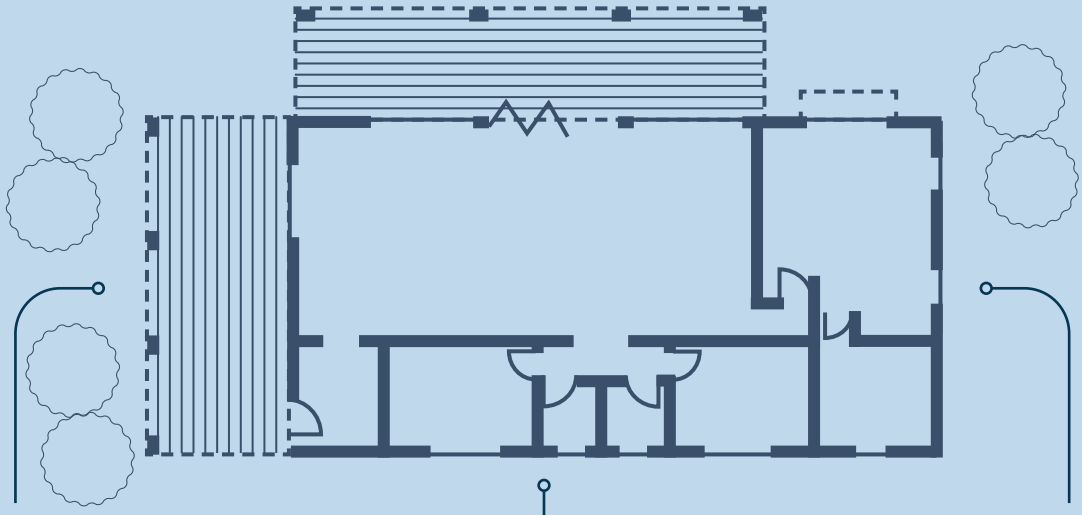
‘I’ve got a crocheted blanket my daughter made me… and if I want that bit extra on my legs, well, I just wrap that around me and I’m quite happy there without any heat on.’

B. Around the house

Room use

North

Use these rooms most often. North-facing windows allow the winter sun in and can be easily shaded from summer sun.



West

Can be too warm in summer due to the low sun angle in the afternoon unless shaded with blinds or a verandah.

East

Good in winter mornings as this area gets morning sun. Can warm up quickly in summer unless windows are shaded.

South

Rarely gets direct sun except early in the morning or late in the afternoon around the summer solstice.

Shading

- Use external shading to reduce heat gain for houses in warm climates. Internal blinds can also help but they are not as effective.
- Apply external blinds to west-facing veranda but without blocking the view.
- Consider planting deciduous plants to shade windows during summer.

Ventilation

- Ventilation is necessary to remove humidity and CO_2 build up over time.
- In summer, open the windows to bring in fresh air when it's cooler outside than inside, such as in the late afternoon. This also lets the warm air out of the house.
- Our research showed that older participants felt their wellbeing improved when they opened the windows for fresh air.

Draught-sealing

- Look for substantial gaps:
  - around window and door frames
  - at junctions between the wall and floor, and wall and ceiling
  - around openings for vents, plumbing and electrical supply.
- Air leakage is a significant source of unwanted heat loss and gain. A well-sealed room can increase the time most people consider comfortable by 300 hours or more in winter and reduce the heating load by 10-30%.
- Our research showed that, in some cases, comfort hours of a well-sealed room in summer decreased due to slow release of warm air inside the house to outside. Offset this by opening windows.
- Maintain indoor air quality once doors and windows are tightly sealed by installing a fresh air intake, such as a small mechanical ventilation system.

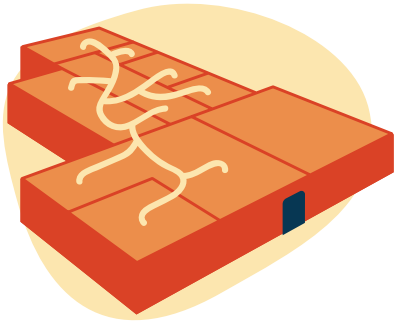
Draught-proofing and external blinds could reduce your total annual heating and cooling load by 20%

C. Equipment and technology

If you just need heating

Centralised heating

A single unit distributes heated air via ductwork to ceiling or floor vents. Also called ducted or whole-house heating.

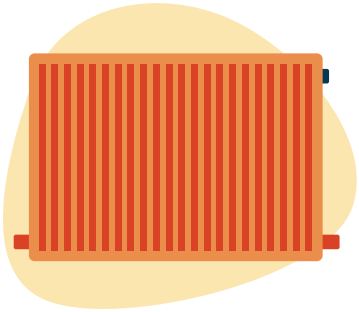


Gas ducted heating

Reticulated and other types of gas supply systems.

Good for...
Providing heat quickly.

Considerations
Must service the unit regularly or it may start to blow cold air or at least not warm air.

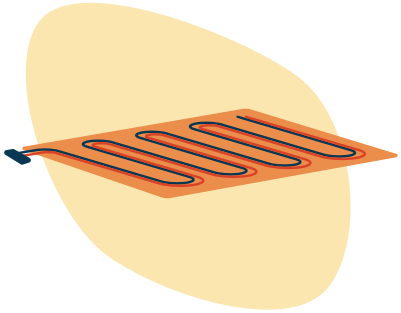


Hydronic heating

Heated water is pumped from gas boilers or heat pumps through radiators.

Good for...
New home or retro fit.

Considerations
Must be flushed every 10 years.



Under-floor heating

Electric elements or hydronic piping are built into the floor slab, usually during building.

Good for...
Subtle warmth without a breeze blowing.

Considerations
Has a slow response time but can be timer-controlled. The efficiency goes down if the floor is covered by rugs or carpets.

Individual body warming

Consider buying a heating device that warms you up rather than the room. These are cheap to buy and run; and ideal to use when sitting working, reading, watching television or lying down. Examples include:

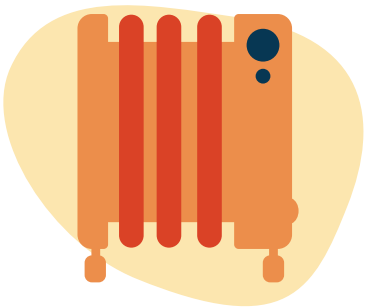
- radiant panels
- electric throws
- heated cushions
- heat pads
- wheat bags
- hot water bottles.

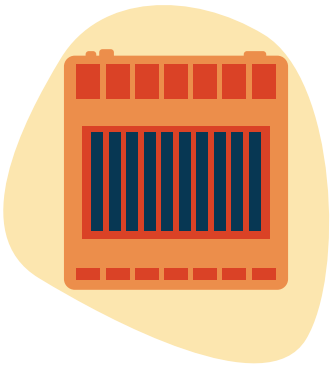
SAFETY ALERT:

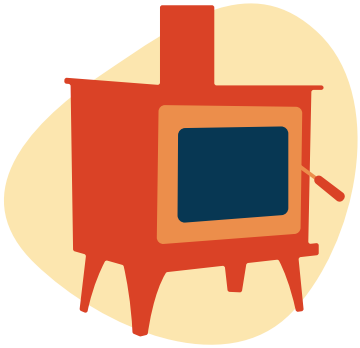
- Check electric blankets and throws, heated cushions and heat pads regularly for wear and tear.
- Hot water bottles should be filled with hot – not boiling – water and wrapped in a towel or other cover to avoid direct contact with the skin. Replace bottles every 2 years.
- Wheat bags and packs should be heated for the specified time only. Replace regularly.

Space heating

Individual heating systems which heat only one room or space. Also called room heaters. The heat can be fan forced or radiated to the space.







Electric heaters

These are portable and come in a range of types, sizes and efficiencies.

Good for...
Small rooms. Using for brief periods. Low budget.

Considerations
Energy-hungry. A 1.5 kW unit costs 60 cents per hour; if used for 3 hours a day over 3 winter months, it would cost $150 (based on the price of electricity of $0.37 per kWh).

Gas heaters

Can be wall-mounted or portable.

Good for...
Heating up room quickly.

Considerations
No longer cheaper to run than electric heaters, as modern electric heaters are more efficient, households have access to cheap solar electricity, and gas prices have risen.

Wood heaters

Slow combustion heaters or open fires. If there is access to a sustainable wood supply, they can be low-cost and environmentally friendly when properly installed, operated and maintained. To reduce air pollution and minimise impact on health, follow best practice guidance – see **www.environment.gov.au/protection/air-quality/woodheaters-and-woodsmoke.**

Good for...
Bringing a sense of warmth and cosiness from the radiant glow.

Considerations
Less efficient than other forms of heating. Can be difficult to manage the wood and clean the heaters. Escaped smoke may cause health problems for some. Room needs to have good ventilation. Should be regurlarly cleaned.

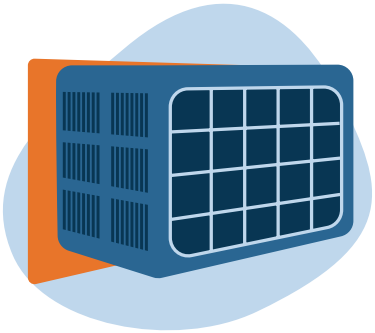
SAFETY ALERT

Buy a unit that turns off automatically if tipped over. Put heaters away from flammable materials such as curtains, and ensure electric cords are not trip hazards.

If you just need cooling

Central or space cooling

Cooling can be provided by either refrigerative or evaporative air-conditioning. Both technologies are available as ducted or window-mounted systems.



Refrigerative air-conditioning

Extracts heat from the space, compresses and condenses the air and supplies it back to the room while controlling the humidity. Cooling-only systems are common as window units or portable systems.

Good for...

Dehumidifying the air, working best with doors and windows shut. Portable units might suit renters.

Considerations

Cheap to buy but energy-hungry. A 1.6 kW unit costs 60 cents per hour; if used for 6 hours a day over 3 summer months, it would cost $320 to run it (based on the price of electricity of $0.37 per kWh).

Evaporative air-conditioning

Evaporates water to cool the air. A pump circulates water within the unit, and a fan draws air from outside. Air is cooled by evaporation and blown into the house. Can be used in fan-only mode to draw cooler air into the house (good option at night). When in use, open doors or windows to allow hot air to exit and to minimise humidity in the room.

Good for...

Dry climates, making it suitable for many areas in South Australia.

Considerations

Uses at least 50% less energy than refrigerative systems but requires connection to a water supply. Uses water at rates of up to 100 litres per hour; on a very, hot dry day annually*, this averages out to 2% of a household's water use.

Portable cooling systems

Use either refrigerative or evaporative technology.

Good for...

Cooling a single person or very small spaces. Mobile and easy to set up. Cheap.

Considerations

May not cool effectively and can be noisy.

*Sourced from www.waterrating.gov.au/sites/default/files/2019-01/evaporative-air-conditioners.pdf

Fans

- Create air movement to improve comfort without changing temperature of the room. Nearly 60% of older people surveyed had a fan in their bedroom and used it during summer nights.
- Cheap to run. Depending on their size and speed and the cost of electricity, the running cost of a fan is only 0.1 cents to 1.5 cents per hour.
- Most fixed (ceiling) fans can be switched to a winter setting which draws warm air accumulating at the ceiling and redistributes it down and around the room.

Cooling the person

Portable (pedestal, tower, personal, or mini USB-connected) fans can be positioned directly to you or where you want them.

Cheap, mini portable fans connected **to** the USB port of your computer are also available.

If you need both heating and cooling

Reverse-cycle or heat pump air-conditioning

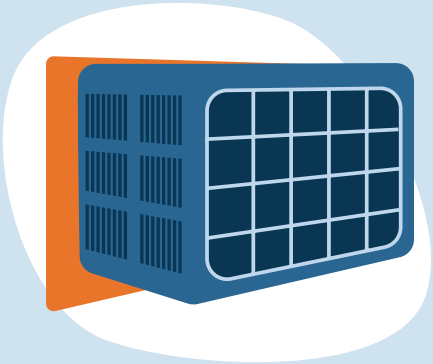
These will heat or cool a room quickly. Modern systems can also filter and dehumidify the air. They are very efficient with 1 kilowatt (1 kW = 1000 watts) of electricity generating 3 – 6 kW of heating or cooling.

In heating mode, air is pulled in from outside through a heat exchanger and transferred inside using a compressor, condenser and fan. For cooling, heat is removed from inside to outside.

TIPS:

- Look for a system with an inverter that adjusts the compressor speed according to the outdoor temperature, which makes it more energy efficient.
- Choose a suitable size of air-conditioner based on the size of the space, wall materials, insulation and window area.
- Consider installation costs as well as purchase price – upper levels may be more costly to install.
- Units can last for 15-20 years, but can then become inefficient.
- Regular cleaning and servicing is required for efficient and healthy operation.

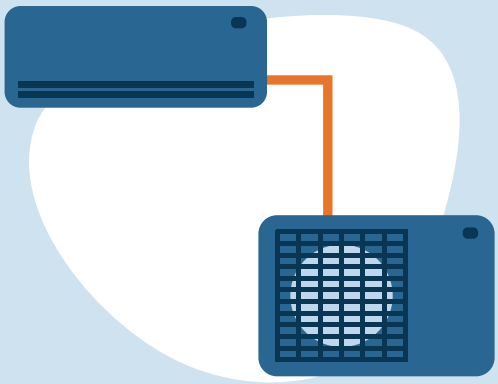
Types of reverse-cycle/heat pump air-conditioners



Window-mounted
A single unit is mounted on brackets outside a window.

Good for...
One room or space. The cheapest reverse-cycle equipment.

Considerations
Less efficient and more expensive to run than a split system.



Split system
The system has 2 parts:

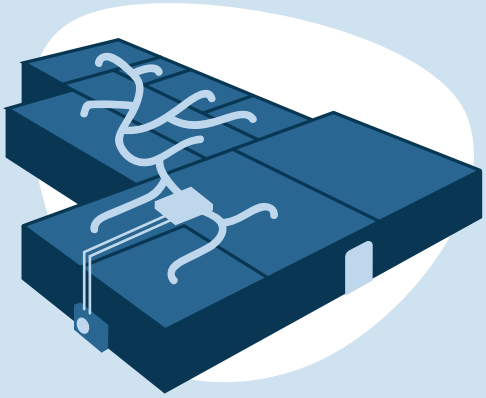
1. Compressor and condenser outside the house
2. Wall-mounted evaporator unit inside in the room.

The most popular air-conditioner in South Australia.

Good for...
Multi-head units are available for more than one room.

Considerations
The indoor unit fan should direct airflow to the whole room and not blow directly where people sit.

Outdoor unit can cause noise for neighbours.



Whole house
Central system with ductwork delivering treated air to rooms via ceiling or wall vents.

Modern systems allow zoning so that you can heat or cool specific areas, which reduces running cost.

Good for...
Heating or cooling several rooms.

Considerations
More complex than other options means it's more expensive to buy and install.

May be less efficient than split system due to losses via ductwork and a larger fan size.

Equipment controls and smart technology

- Most new heating and cooling systems come with smart controls and a thermostat that sense which rooms are occupied and adjust room temperature according to your preferred conditions. They can connect to an application ('app') on your smart phone so you can turn heating or cooling on before you get home.
- Voice-activated virtual assistants are also available to connect with air-conditioning controls, and indoor and outdoor window coverings.
- When buying a new heater or cooler, choose one that allows you to easily change the temperature, set timers and apply zoning.
- Most systems have a wireless remote control; some can be operated from a smart phone app.
- Look for simplified displays and large control buttons.

More information on heating and cooling

The Australian Government has information on heating and cooling energy ratings at **www.energy.gov.au** They have also a guide on heating and cooling for environmentally sustaining homes at **www.yourhome.gov.au/energy/heating-and-cooling**

The South Australian Government has a winter heating guide at **www.sa.gov.au/__data/assets/pdf_file/0017/14273/210226-Winter-heating-guide_web.pdf**

The Choice website has information on choosing the best heating or cooling option for your home – see **www.choice.com.au**

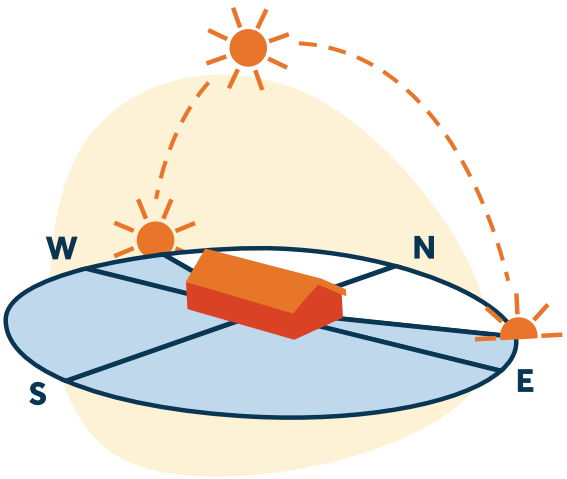
How to reduce energy use and impacts on the environment

- Reduce the volume of the space to be heated or cooled by closing doors and windows when you operate air-conditioning.
- Reduce running cost by around 10% if the thermostat setting is lowered by 1°C in winter or increased by 1°C in summer.
- Clean and service air-conditioners regularly.
- Dispose of old air-conditioners appropriately. It's illegal to dump them or put them out with the rubbish as the cooling liquid inside is harmful to the environment. Check with your local council for information on collection and recycling.

D. House design, renovation and construction

Building or renovating a home gives you an exciting opportunity to include thermal comfort principles in the design. To explore design and build options in more detail see "Your Home: Australia's guide to environmentally sustainable homes", at local libraries or online at **www.yourhome.gov.au.**

Any house design needs to consider many factors, including the occupants' needs, dwelling location, and budget. House design and thermal comfort principles are inter-related and have impacts on other factors such as accessibility. For best results, consult an architect or building designer and brief them with anything important you found in this guide.



Orientation

Think about the site of your new build or renovation, and the sun path and winds in summer and winter. How should your rooms be positioned? Align the design with your thermal comfort profile.

North

North orientation suits climates that need winter heating. Let the sun in through north-facing windows to reduce the need for heating, but ensure they're shaded in the summer to reduce the need for cooling.

West

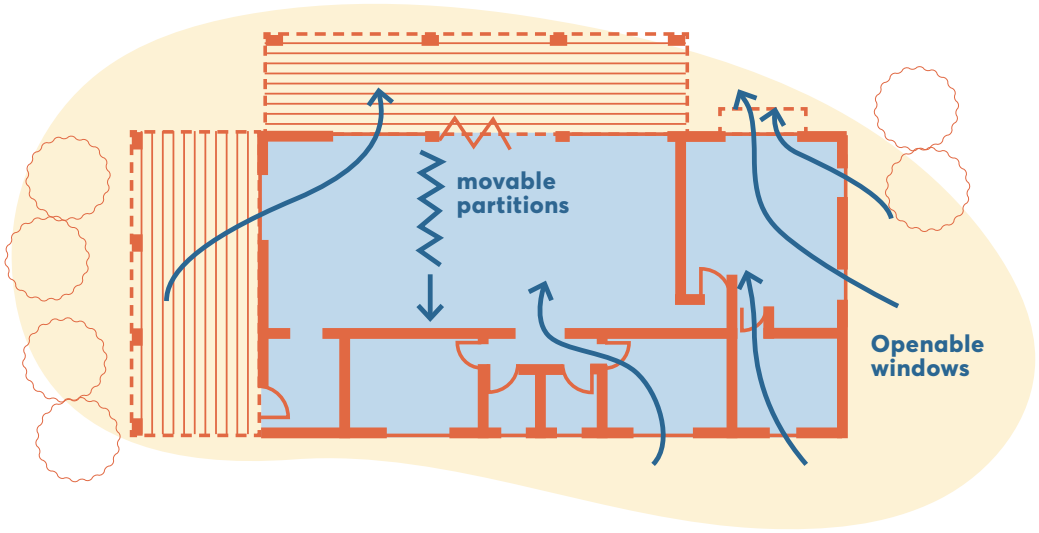
Minimise west-facing windows. You can shade them using blinds, but these may block views and natural light. Consider adding a veranda, which can help reduce heat from the lower angled afternoon sun that enters the house.

East

Good for bedrooms and kitchens, as east-facing windows receive morning sun in winter.

South

Good for rooms to be kept cool in summer, but plan carefully – south rooms can become too cold in winter.



Size

House size is an indicator of cost – both the initial financial and environmental costs, as well as on-going energy costs for heating and cooling.

Large rooms with large windows or high ceilings can be difficult or expensive to keep comfortable. Smaller rooms, and rooms with smaller or fewer windows and lower ceilings, are more economical to heat or cool. Heating smaller areas can reduce your home's heating load by a third. Be mindful about the window-to-floor area ratio or the area of the room – too many windows might make the room uncomfortable or too warm on hot days. So you can reduce a large space as needed, consider adding either:

- moveable wall dividers,
- curtains,
- retractable doors,
- partitions,
- hanging fabric, or
- false ceilings.

This strategy is useful for people sensitive to cold or on limited budgets.

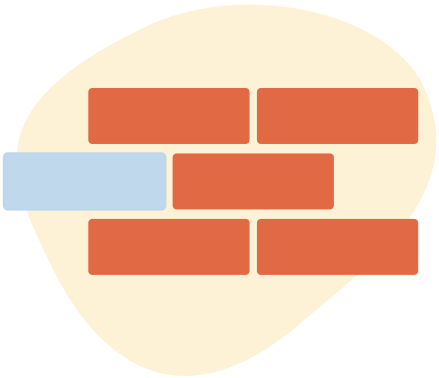
Ventilation

Fresh air replenishes the air inside our homes, which improves wellbeing. The extent to which you want to have breezes in your home depends on your climate zone and thermal comfort profile.

In most cases in South Australia, it's best to position your home to make use of any breezes in the summertime.

Position the doors and windows to catch breezes and position your most frequently used living and seating areas in the path of the breezes. You may also want to consider positioning beds in areas that receive summer breezes in the evenings.

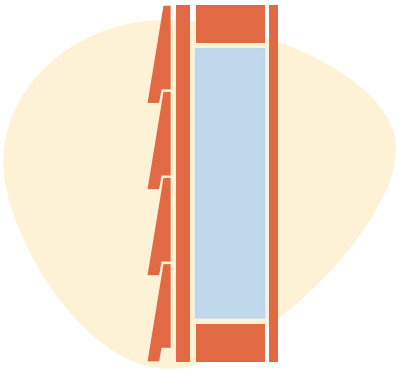
Materials



Heavyweight materials

Concrete slab-on-ground, internal stone or brick walls.

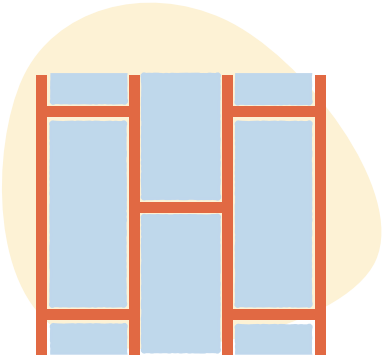
Their bulk helps moderate indoor temperature swings. In our study, the test houses with concrete slab-on-ground floors had more hours in the comfort range in both summer and winter than those with timber floors.



Lightweight construction

Insulated timber or steel frames with external weatherboard or metal cladding and plasterboard lining.

While it's quick to build, lightweight construction is often very responsive to changes in temperature – the house will heat up quickly in hot seasons and cool quickly when the sun goes down. This can be uncomfortably cold in winter with heat loss, especially if the floor is elevated and uninsulated.



Appropriate insulation

For new construction, the National Construction Code sets out minimum requirements for walls, roofs and floors.

For existing houses:

- **Ceiling insulation**

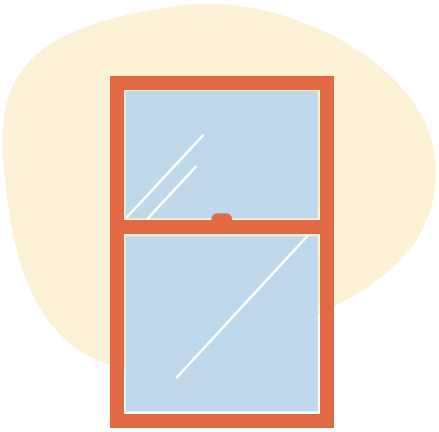
  Most houses in South Australia built or upgraded since the 1970s have ceiling insulation, but if the insulation has moved or compacted with time it may not be performing properly. Replace with insulation that meets the National Construction Code.

- **Wall insulation**

  Older brick veneer, lightweight stud-framed and cavity brick houses may not have wall insulation. If renovating an older house, it may be possible to remove internal wall linings and add insulation such as batts to meet the requirements of the current National Construction Code. For cavity brick construction, insulation can be 'blown' into the cavity from the top.

- **Floor insulation**

  Insulating timber floors near the ground may not be possible but insulating elevated timber floors may be worthwhile. Our study predicted that insulating the elevated timber floor of the lightweight test house would reduce the heating load by up to 25%. However, insulation can increase the number of hours a house is uncomfortable in summer.

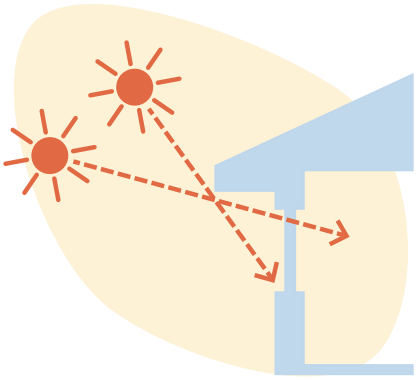


Windows

Window glazing and frames are a large source of heat loss and gain. Every 1m^2 of single pane glass loses and gains up to 10 times the heat of 1m^2 of insulated wall.

When choosing windows, consider:

- The window frame materials. Metal window frames lose and gain more heat than timber frames.
- The materials of the room and window-to-floor area ratio. A rule of thumb is a 30% ratio in rooms with concrete slab-on-ground and good shading design.
- Double glazing for large windows if you prefer warmer conditions and wish to reduce the cost of heating. This can reduce heating loads by 10-15%. However, double glazing doesn't let the heat out easily. It can reduce indoor comfort in summer if air-conditioning isn't used and can even increase the cooling load of an air-conditioned room.



Shading

Eaves, pergolas, external blinds, shutters and deciduous trees or shrubs.

- Choose shading that protects windows from hot summer sun but allows winter sun.
- Research shows that shading windows is particularly effective in the hotter climate. Without air-conditioning, using external blinds could increase the time in the comfort range during summer months by up to 400 hours compared to windows without shading.

PAIR UP
When air-conditioning is on, shading windows with external blinds during the day can reduce the cooling load by 30% compared to unshaded windows.

7. Scenarios

Six typical thermal comfort scenarios (or 'clusters') for older South Australians were identified in the research study. See page 40 for information about the study.

Scenario I:
Liz, Adelaide

Liz wants low-cost strategies for thermal comfort.

Liz* lives alone in her own house in Adelaide, which has a warm temperate climate. She receives a pension and is often worried about paying her electricity bill.

She lives in a 1940s semi-detached house with cavity brick walls and windows facing east and west, and a timber floor with linoleum to the living area. She thinks there is insulation in the ceiling. She uses an old electric heater in winter.

Liz's goal:

Reduce energy bills but keep the temperature above 15°C in winter, without buying expensive new equipment.

Problems

- The living area is large and long with windows that face east and west, and uninsulated walls.
- The electric heater is inefficient, so it's expensive to run.
- In winter, unless she uses the heater, her living area is much cooler than she would like it to be.
- No funds to undertake a renovation or buy a new air-conditioning system.

The plan

- **Room use** – Close all doors and windows when the heater is on to reduce the size of the area to be heated.
- **Draught-proofing** – Add caulking around window frames and draught stoppers to doors to minimise heat loss.
- **Shading** – Use shading such as bamboo blinds and external shading to both windows to reduce the cooling load.
- I**nsulation** – If possible, have someone check the insulation in the ceiling/roof; add extra if it is less than 50 mm thick.

Results

Draught-sealing and reducing the area to be heated in the living room reduces annual heating costs by about 20%.

* 'Liz' represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.

Scenario II:
Elsie, Whyalla

Elsie wants to reduce energy bills for heating and cooling.

Elsie* lives alone in a retirement village in a town that has hot dry summers and cool winters.

Her semi-detached house has uninsulated and leaky cavity brick walls, a concrete floor with linoleum and a tiled roof with insulated plasterboard ceiling. Recently, her mobility and eyesight have declined, and she is surprised to find herself feeling more sensitive to changes in temperature. She has a 25-year old window mounted reverse-cycle air-conditioner.

Elsie needs air-conditioning because without heating or cooling her west-facing living room never achieves her desired minimum temperature of 24°C in winter, although it does so nearly 70% of the time in summer.

Elsie's goal:

Spend less on heating, but keep living room at 24°C all year.

Problems

- The living room has only one, west-facing window which only gets sun in the afternoon.
- Without heating or cooling, the living room never reaches 24°C in winter and can get warmer than 24°C for about one month during summer.
- High energy bills.
- Lack of insulation and leaky construction.
- Limited ability to make changes to the dwelling (retirement village rules).

The plan

- **Room use** – In winter, position the main seating area near the window to catch the sun's rays in the afternoons.
- **Shading** – Apply external shading, such as a roller blind, to the west-facing window to reduce the heat in summer afternoons. In winter, open the blinds or curtains to let in sun, close when the sun goes down.
- **Draught-proofing** – Improve window seals by adding caulking around window frames, and add a draught-stopper to the door.
- **Energy-efficient heating** – Replace the existing air-conditioner. Buy an efficient new model, preferably a split system reverse-cycle air-conditioner.
- **Insulation** – If possible, have someone check the insulation in the ceiling/roof, and add extra if it is less than 50 mm thick.

Results

- Draught-proofing and external blinds reduce the total annual heating and cooling load by 20%.
- Installing a new 2.4kW reverse-cycle split system reduces her heating and cooling costs by about 85%.
- The payback period for the new air-conditioner and external blinds is just over 5 years.

* 'Elsie represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.

Scenario III: Joe, Fleurieu Peninsula

Joe wants to upgrade his living areas and improve the air-conditioning.

Joe* lives with his wife on the Fleurieu Peninsula, which has a cool temperate climate.

Their brick veneer house has a metal roof with an insulated ceiling, and slab-on-ground floor with carpet to the living area. The living area is large with big windows to the north and west. There is a slow combustion heater and a portable electric heater. Joe wants to explore any changes to the house that could reduce the need for heating. He has a budget for light renovations and equipment.

Joe's goal:

Maintain indoor temperatures between 17°C to 27°C in summer and 16°C to 26°C** in winter.

Problems

- In winter, without heating, Joe is thermally uncomfortable about 15% of the time.
- Large sitting area, difficult to heat in winter.
- Heat loss through the large windows and leaky frames.
- High energy bills, especially for heating.

The plan

- Central heating – Install energy-efficient reverse-cycle air-conditioners with a Coefficient of Performance (COP) of at least 4 in the living area and bedrooms.
- Shading – Draw up the external blinds covering the western windows to allow winter sun to enter the room; draw them down in summer afternoons.
- Windows – To reduce heat loss, replace windows with double glazing and improve internal coverings such as blinds or curtains; they should fit snugly.

Results

An efficient reverse-cycle split system air-conditioner halves the current annual cost of heating and cooling.

Check – is it worth it?

Some houses perform well in terms of thermal comfort with or without air-conditioning and you need to decide if a renovation is worthwhile from a cost point of view. For example, if Joe's house performs well, replacing the large single pane windows (14 m^2) with double glazing would be very expensive (more than $15,000) for an annual heating and cooling energy cost saving of only $100.

However, Joe could still decide to:

- Improve draught-proofing – caulking around windows and doors and adding draught-stoppers to doors. This measure improves comfort in winter (without heating) by 8%.
- Install external blinds. This would further improve comfort in summer even without cooling.

* 'Joe' represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.
** These comfort ranges are based on the preferred temperatures of real people in the 'Joe' cluster from the study.

Scenario IV: Peggy, Adelaide

Peggy wants to look for an energy-efficient house to minimise environmental impact.

Peggy* and her partner are looking for a house in metropolitan Adelaide. She is concerned about climate change and the link between global warming and burning fossil fuels, so she is interested in buying or constructing a house that requires minimal heating or cooling to be comfortable. She would like a strong inside-outside connection and large windows.

Peggy's goal:

Buy or build a house that's comfortable (18°C to 27°C in summer and 16°C to 25°C in winter**) without heating or cooling.

Problems

- Her current house is cold, dark and draughty with uninsulated cavity brick walls, uninsulated timber floors and a window to floor area ratio of only 7%.
- Although comfortable in summer nearly 90% of the time, the current house is very cold in winter.

The plan

- **Orientation** – Find or design a house in which frequently-used rooms face north to get more sun in winter.
- **Materials** – Use sustainable materials that last a long time, are locally manufactured, and have low embodied energy.
  - **External** – Insulate walls and ceilings to at least comply with the National Construction Code for the location. In Adelaide, walls should have an overall R-value of at least R2.4 to R2.8 (m^2.K/W) and roof/ceilings R4.6 to R5.1 (m^2.K/W).
  - **Internal** – Install concrete slab-on-ground or internal masonry walls, which have the internal mass to minimise temperature swings.
- **Shading** – Have properly designed eaves, movable shading devices or pergolas with deciduous plants to shade windows in summer but still allow the sun in winter.
- **Size** – Avoid living areas with large volumes (such as very large floor areas or very high ceilings) as these are difficult spaces to heat and cool. If the living space is combined with dining and kitchen ('open plan'), consider ways to use movable partitions to reduce the room size in winter.
- **Ventilation** – Design the layout of the doors and openable windows for cross-ventilation on warm days.
- **Fans** – Install ceiling fans which use minimal energy but can provide cooling in summer and distribute warm air in winter.

Results

- Large, north-facing, double-glazed windows in the living area (window to floor area ratio approximately 45%) and openable windows for cross-ventilation, together with concrete slab-on-ground and highly insulated walls and ceilings, result in preferred indoor temperatures at all times in summer and winter.
- When using heating and cooling with conventional set points (24°C in summer and 21°C in winter), the new living area uses half the heating and cooling energy of the old house, even though the floor area is 60% larger.
- Low-energy fans for cooling and radiant panels or personal heating devices are all Peggy needs occasionally to maintain her preferred thermal comfort.

Technical terms

Embodied energy is the sum of all the energy required to produce the building products from which the house is built. Learn more about embodied energy at **www.yourhome.gov.au/materials/embodied-energy**

R-value is thermal resistance of a material. The higher the R-value, the higher the heat resistance, the less heat can enter or leave the building. You may want to discuss this with your builder or architect, or seek advice from a building expert.

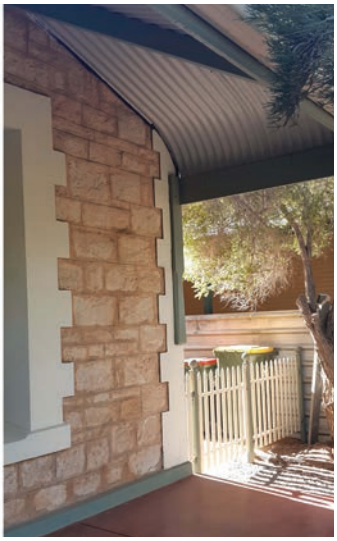
* 'Peggy' represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.
** These comfort ranges are based on the preferred temperatures of real people in the 'Peggy' cluster from the study.

Scenario V:
Tina, Adelaide Hills

Tina wants to rebuild her living areas for warmer winters.

Tina* lives in the Adelaide Hills, which has a mild temperate climate.

She lives in an old stone villa with timber floors and single-glazed windows. She likes cool conditions (between 13°C to 20°C**). But in winter, the living room is much cooler than she can tolerate and she is uncomfortable for more than 75% of the time. Tina's increasing health problems are affected by the weather too.



Tina's goal:

As her health continues to decline, aim to maintain indoor temperatures of at least 18°C in the future.

Problems

- A World Health Organization study shows exposure to temperatures below 18°C for prolonged periods can impact health***. Tina's house doesn't reach this at all during winter.
- One window faces west, the other north, and the living area has a low window to floor area ratio (8%).
- Very high, costly heating load.
- Heat loss through gaps in the floor, windows and walls.
- Not much direct sunlight.

The plan

- **Floor materials** – Replace the timber floor with a concrete slab-on-ground with tiles. Considered adding insulation under the timber floor but it is not worth the effort since the existing timber flooring is not in a good condition.
- **Insulation** – Replace the external walls with R2.5 insulated brick veneer walls and install R4.5 insulation to the ceiling to comply with the National Construction Code's thermal insulation requirements.
- **Improved solar gain** – Increase window to floor area ratio to 25%, design the windows to face north. Install seasonal shade that allows sunlight in winter. Use double-glazing to reduce heat loss.
- **Draught-proofing** – The new construction should be well-sealed with careful attention to windows, doors and other gaps.

Results

- Without heating, the renovated design stays in Tina's current comfort zone (13-20°C) for almost all the time.
- As she lives in a cool climate, the renovated living area doesn't reach 18°C in winter; so at these times, she will need to use heating. With the energy-saving features (larger window area, double-glazing and external blinds) of the new design, the annual cost of heating and cooling is about half of the cost in the old space. However, the payback from this renovation is longer than 15 years.

* 'Tina' represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.
** These comfort ranges are based on the preferred temperatures of real people in the 'Tina' cluster from the study.
***WHO Housing and health guidelines. World Health Organization. 2018. pp. 34, 47–48. ISBN 978-92-4-155037-6.

Scenario VI:
Philip, north of Adelaide

Philip wants to rebuild to create a comfortable living area.

Philip* lives with his wife in a town 250 kilometres north of Adelaide that has hot dry summers and mild winters. Philip is concerned about the cost of heating and cooling and wants to demolish the existing house and re-build.

Their home is lightweight with weatherboard cladding and while the walls and ceiling are insulated, the elevated timber floor is not. Without heating or cooling, Philip finds the large open plan living area too hot in summer and too cold in winter for more than two-thirds of the season.

Philip's goal:

A passive design for his new living area that maintains his comfortable range (20°C to 29°C in summer and 18°C to 27°C in winter**) mostly without heating or cooling.

Problems

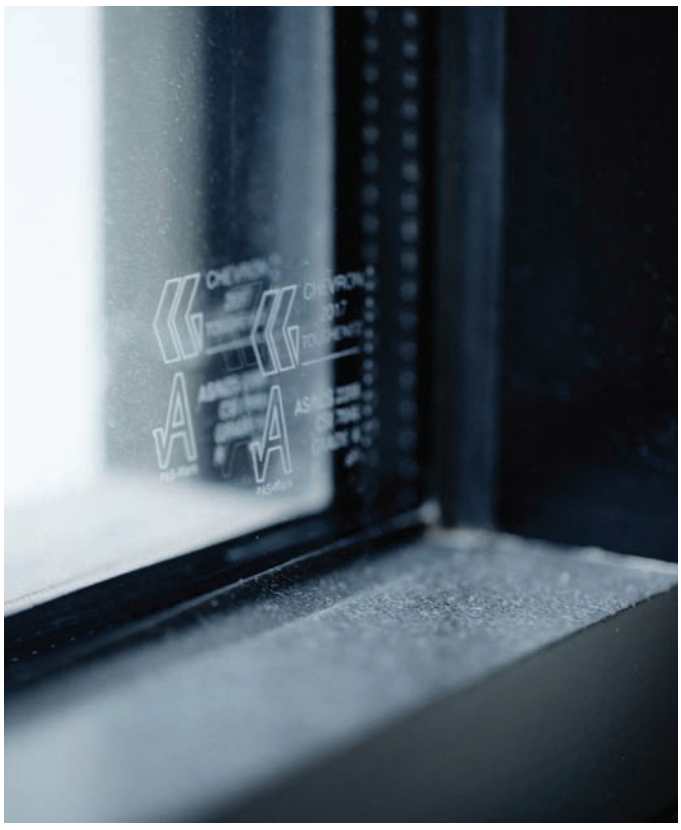
- The building is lightweight; there is not enough thermal mass.
- Too much heat loss through uninsulated raised floor.
- Large sitting area, difficult to heat in winter.

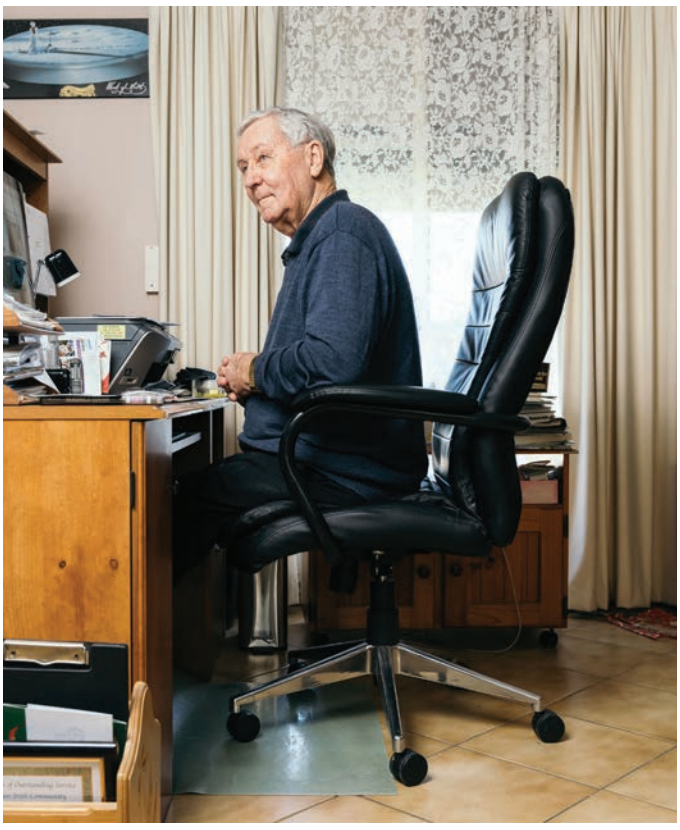
The plan

- **Materials** – Build a concrete slab-on-ground floor to help maintain comfortable temperatures. Install double glazing windows.
- **Insulation** – The new living area will have insulated brick veneer walls (e.g. R3.2) and highly insulated ceiling (e.g. R5.1).
- **Size** – Install large sliding doors in the open plan area so that the sitting area can be separated off in colder weather.
- **Shading** – Design the roof overhangs to shade northern windows in summer and let sun in during winter. For extra shading, allow for the installation of external blinds later. Shade other windows with adjustable blinds.
- **Sealing** – Pay attention to window and door frames, floor/wall/ceiling junctions and downlights.

Results

- Without heating or cooling, the new living area is more comfortable. Philip's preferred temperature range is achieved almost all the time in summer and more than 80% of the time in winter.
- Using heating and cooling with conventional set points (summer 24°C and winter 21°C), the renovated living area uses less than a third of the heating and cooling energy of the current house.
- The energy-saving features in the new design (double glazing, blinds and a new energy-efficient air-conditioner) have a payback of around 10 years.





* 'Philip' represents one of 6 "clusters" of older South Australians determined in the study. See page 40 for more information.
** These comfort ranges are based on the preferred temperatures of real people in the 'Philip' cluster from the study.

8. About the research project

The study 'Improving thermal environment of housing for older Australians' funded by the Australian Research Council (ARC DP180102019) was conducted in 2018-2021.

Research involved collecting data from older South Australians through:

- telephone survey
- focus group discussions in 6 councils
- detailed occupant surveys
- house monitoring 71 participants over 9 months in 57 homes in all 3 climate zones.

Researchers looked at the participants' personal factors such as:

- age
- income
- living arrangements
- health and wellbeing status
- housing type
- heating and cooling strategies used in the house.

They found that older people cannot be described as a single group. So the participants were grouped into 6 "clusters" based on the analysis of their personal factors. Each of these clusters is reflected in one of the case studies in Section 7.

The results of applying the plans shown in the case studies were predicted by the researchers based on detailed investigation using building performance simulations.

It is worth noting that while the study was conducted in South Australia, this guideline is also relevant to other parts of Australia that have similar climates.

Perception of thermal comfort versus wellbeing

The study found that the perception of having 'very good' health and wellbeing occurred mostly when the thermal environment was perceived by the participants to be comfortable and satisfactory. However, it also discovered some concerning outcomes. Some participants expressed feeling thermally comfortable at temperatures lower than 15°C or higher than 28°C, but when researchers asked about their wellbeing (without the participants knowing the temperature at the time), they actually perceived wellbeing to decline.

This highlights the important relationship between indoor temperatures, thermal comfort and wellbeing.

Relevant publications

The following publications by the researchers informed the development of this guide.

- Soebarto V, Bennetts H, Hansen A, Zuo J, Williamson T, Pisaniello D, ... Visvanathan R (2019) Living environment, heating-cooling behaviours and wellbeing: Survey of older South Australians. Building and Environment, 157, 215-226. Link: https://doi.org/10.1016/j.buildenv.2019.03.023
- van Hoof J, Bennetts H, Hansen A, Kazak J, & Soebarto V (2019) The living environment and thermal behaviours of older South Australians: a multi-focus group study. International Journal of Environmental Research and Public Health, 16(6), 935-1-935-19. Link: http://dx.doi.org/10.3390/ijerph16060935
- Bennetts H, Martins LA, van Hoof J, & Soebarto V (2020) Thermal personalities of older people in South Australia: A personas-based approach to develop thermal comfort guidelines. International Journal of Environmental Research and Public Health, 17(22), 1-22. Link: https://www.mdpi.com/1660-4601/17/22/8402
- Soebarto V, Williamson T, Carre A, & Arakawa Martins L (2019) Understanding indoor environmental conditions and occupant's responses in houses of older people. In IOP Conference Series: Materials Science and Engineering, 609 (pp. 1-7). Link: http://dx.doi.org/10.1088/1757-899X/609/4/042096
- Williamson T, Soebarto V, Bennetts H, Arakawa Martins L, Pisaniello D, Hansen A, Visvanathan R, Carre A, van Hoof J. (2022) Assessing human resilience: A study of thermal comfort, wellbeing and health of older people (Chapter 7). In Nicol, Roaf, Rijal (Eds) The Handbook of Resilient Thermal Comfort, Routledge, UK.

From left: Professor Jian Zuo (Building), Dr Helen Bennetts (Research Associate), Professor Veronica Soebarto (Architecture, Team Leader), Professor Joost van Hoof (The Hague University of Applied Science), Adjunct Professor Terence Williamson (Architecture), Professor Renuka Visvanathan (Gerontology), Dr Alana Hansen (Public Health), Dr Jan Kazak (Visiting Researcher, Wrocław University of Environmental and Life Sciences), and Professor Dino Pisaniello (Public Health). Not pictured: PhD Candidate Larissa Arakawa Martins (Architecture).

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