



## CHAPTER 3

# SUN, CLIMATE AND COMFORT

The contents of this chapter outline background information relating to movement of the sun and how to determine its position at a given site; climate zones in Victoria and their particular energy requirements; and factors influencing our perception of thermal comfort.

## The sun and the seasons

The tilt of the Earth's axis as it orbits the sun creates the different paths and angles of the sun from summer to winter. In one half of the year the northern hemisphere receives more sun than the southern hemisphere, with the reverse occurring in the other part of the year. Between these two extremes is the equinox, when both hemispheres receive the same amount of sunlight.

### EQUINOXES

At the equinoxes (21 March and 21 September), the sun rises exactly in the east and sets exactly in the west. The point directly above the observer is called the zenith (see figure 3.1). The angle between the zenith and the position of the sun at noon (solar noon) is equal to the site latitude.

Figure 3.2 shows the apparent movement of the sun to an observer in Melbourne and the resultant summer and winter shadows. The relative angles and position of the sun vary according to latitude.

### WINTER SOLSTICE

The winter solstice on 21 June has the least daylight of the year (around nine hours). In Melbourne the sun rises from a position on the horizon about 30° north of due east, travels low across the sky and sets about 30° north of due west. Its maximum altitude angle at solar noon is about 29° (see figure 3.1).

### SUMMER SOLSTICE

The summer solstice on 21 December has the most daylight of the year (around 14.5 hours). In Melbourne the sun rises from a position on the horizon about 30° south of due east, travels high in the sky and sets about 30° south of due west. Its maximum altitude angle at solar noon is around 75° (see figure 3.1).

## Locating the position of the sun

Figure 3.3 is a Hassall Sun Chart for Melbourne, but can also be used for all parts of Victoria. Similar charts are available for all capital cities. The chart shows the approximate position of the sun at any time of the day or year. This information is useful for calculating the size of overhang for window shading for any orientation at any location. Simple rules of thumb are available (refer to Chapter 5).

The outer circle represents the horizon while the centre represents the zenith and the observer's position. The outer circle is marked with 360 graduations to show the angular measurement of the sun from north (azimuth) and the concentric circles show the sun's elevation (altitude). The long arcs represent the sun's path through the sky at particular dates, and the short arcs indicate the time of day (mean solar time).

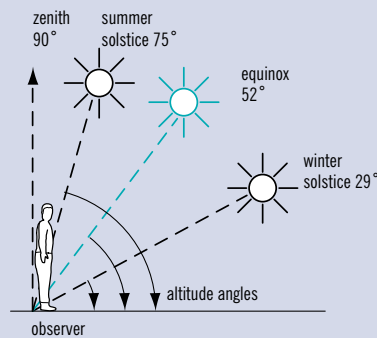


Figure 3.1: Solar noon altitude angles for Melbourne

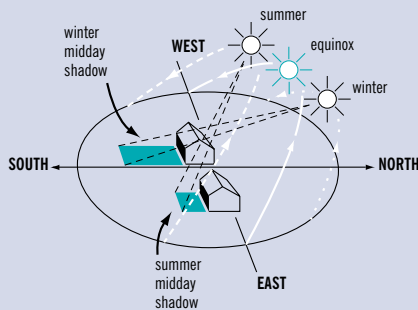


Figure 3.2: Apparent movement of the sun with summer and winter shadows

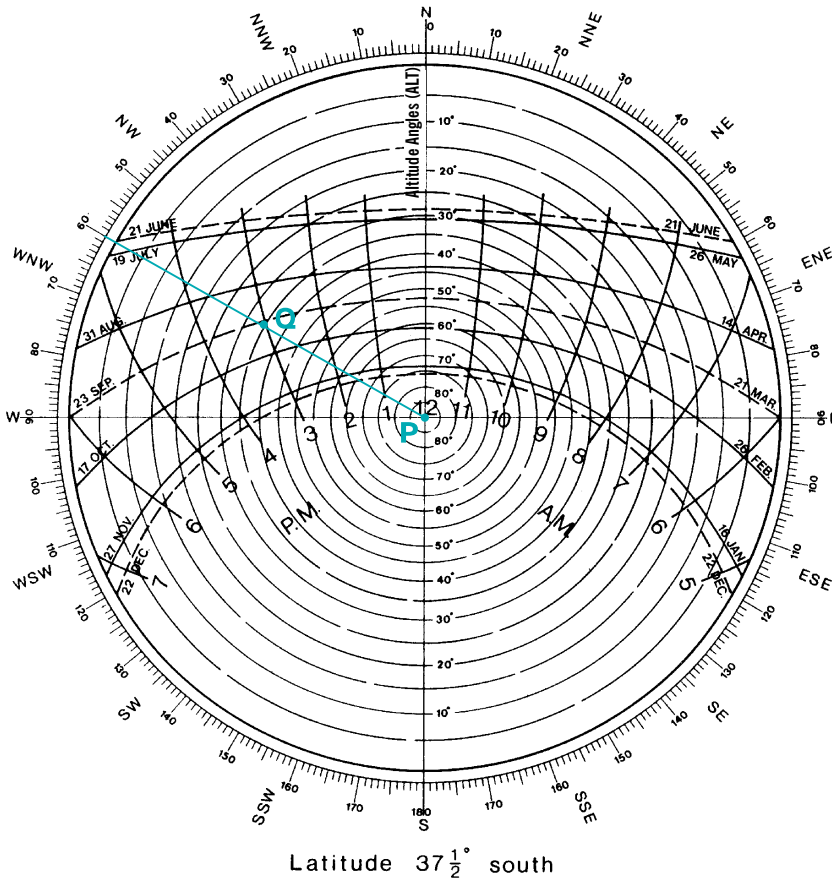


Figure 3.3: Hassall Sun Chart for Melbourne

The centre of the diagram represents the observer's position. The heavy curved lines represent the sun's path for selected dates and latitudes, and are crossed by lines indicating hours. To find the sun's position for the required conditions, select the point where the appropriate lines interact. The sun's altitude (in degrees above the horizontal plane) is shown by the relation of this point to the concentric circular lines within the diagram. The direction of the sun's rays is shown by a line drawn through this point from the outer graduated circle towards the centre.

### WORKED EXAMPLE USING HASSALL SUN CHART

How to find the sun's position at 3 pm on 23 September in Melbourne:

- ▶ draw a line from observer's position P to the sun's position Q (intersection of 3 pm arc over 23 September arc);
- ▶ continue the line to the outer circle;
- ▶ observe the sun's azimuth (AZI) at approximately 300° (measure clockwise from north); and
- ▶ observe the sun's altitude (ALT) to be approximately 35°.



## Climate zones in Victoria

Residential design for comfort and energy efficiency is influenced by climatic considerations. There are considerable differences between maximum and minimum temperatures in summer and winter, the diurnal temperature range (day/night differences) and the length of the heating and cooling seasons across Australia.

For simplicity, five broad climatic zones have been identified for Victoria on the basis of heating and cooling needs (see figure 3.4). Climatic data from these zones is used for the Nationwide House Energy Rating Scheme (NatHERS). Within a zone, there are still locations with slightly different temperature ranges and heating and cooling needs, however, their relative requirements are sufficiently similar to warrant grouping them together.

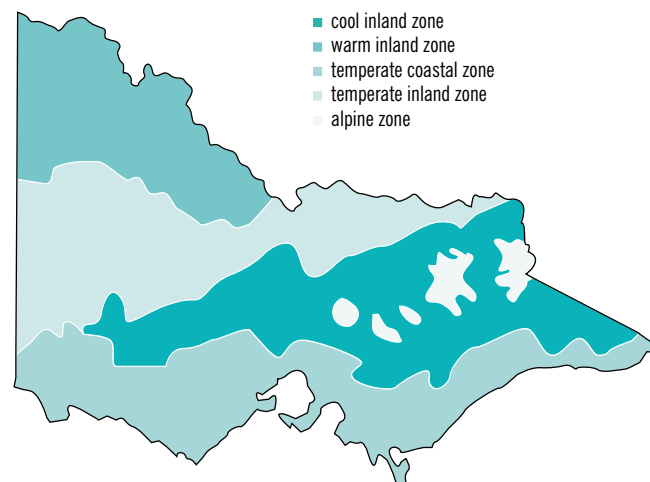


Figure 3.4: Victorian climate zones

### COOL INLAND ZONE (BALLARAT)

Areas contained within the Great Dividing Range, not including alpine areas, are characterised by warmer summers and cooler winters than the temperate coastal zone. The diurnal temperature range is large all year-round, with average minimum temperatures in winter often dropping to as low as 0°C.

### WARM INLAND ZONE (MILDURA)

Covering the north-west region of Victoria, the warm inland zone is characterised by warmer summers than all other zones, and slightly milder winters than the temperate inland zone. The diurnal temperature range is large year-round, with maximum summer temperatures often averaging above 30°C.

### TEMPERATE COASTAL ZONE (MELBOURNE)

Covering areas south of the Great Dividing Range, including Melbourne, the temperate coastal zone is characterised by warm, dry summers and cool, wet winters, with a wider diurnal temperature range in summer than in winter. Weather is often changeable, with rapid drops in temperature due to the effects of coastal winds.



### TEMPERATE INLAND ZONE (WODONGA)

Covering the areas north of the Great Dividing Range, the temperate inland zone extends west to the Victoria/South Australia border and north to around the Ouyen area. The zone is characterised by lower average minimum winter temperatures than the temperate coastal zone, and higher average maximum summer temperatures than both the temperate coastal and cool inland zones. The diurnal temperature range is wider in summer than in winter.

### ALPINE ZONE (ABOVE 1200 M)

This covers the most elevated areas of the Great Dividing Range (eastern Victoria), and is characterised by cooler year-round conditions than the other zones. Winter temperatures often fall below freezing point at night, and there is a combination of high solar radiation and cloud cover all year-round. Some higher areas are subject to snowfalls.

## House design in different climate zones

Winter heating is the predominant concern throughout all of Victoria, with summer cooling requirements being more variable. Table 3.1 illustrates the significant daily temperature ranges across the state.

Table 3.1: Average day and night temperatures

LOCATION	SUMMER (°C)		WINTER (°C)	
	DAY-NIGHT	RANGE	DAY-NIGHT	RANGE
Mildura	32–17	15	15–4	11
Hotham Heights	17–7	10	-1–3	4
Melbourne	26–15	11	13–6	7
Cape Schank	24–14	10	12–7	5

To achieve the best results, housing design and construction materials should be appropriate to the climate of a region (macro-climate). While each of the five climate zones have different heating and cooling needs, the same principles of energy efficient house design apply, with their application varying slightly, e.g. different levels of insulation or thermal mass or variations in window sizes.

Winter heating is the primary concern in the temperate coastal and cool inland zones, with summer cooling being variable but generally of secondary importance. In addition to general energy smart design principles, house design in these zones requires attention to higher insulation levels, winter window protection, draught proofing and summer shading.



The temperate inland and warm inland zones north of the Divide still require a focus on heating. Even Mildura, ranked as the location with the least need for supplementary heating, still has heating requirements, which are around 80% of those in Melbourne. The need for cooling is greatest for this zone. Due to the warmer summer temperatures (particularly in the warm inland zone) and large diurnal temperature ranges, house design in these zones should pay particular attention to the inclusion of extra thermal mass, cross-ventilation and summer shading.

In alpine regions the primary concern is to maintain comfortably warm conditions indoors. Heating requirements are approximately three times greater for alpine areas than for Melbourne. Heating may be required for 24 hours a day for much of the year. Cooling requirements in summer are negligible. House design should therefore focus on winter comfort.

## Thermal comfort

Thermal comfort refers to the range of conditions in which the majority of people feel comfortable. This is a limited range, as we need to maintain a relatively stable body temperature of 37°C. Our bodies produce heat depending primarily on the level of activity, and give off heat according to the surrounding environmental conditions.

Heat is lost from the body in three main ways:

1. Radiation 45%
2. Convection 30%
3. Evaporation 25%

Figure 3.5 shows the main factors affecting body heat gains and losses inside a building.

### THERMAL COMFORT VARIABLES

Comfort is influenced by the six main variables listed below.

1. **Air temperature** (also called dry bulb temperature): the most common measure of thermal comfort.
2. **Mean radiant temperature**: the weighted average temperature of all exposed surfaces in a space. Discomfort may be experienced when there is a large differential between internal surface temperatures (e.g. uncurtained windows) and the internal air temperature, causing radiant heat to be lost from the body to the cooler surfaces.
3. **Relative air velocity**: important in warm weather, as air moving across the skin increases heat loss by convection, lowering the perceived air temperature.
4. **Humidity**: moisture content of the air is defined as relative humidity and may cause discomfort when above 70% or below 30%.
5. **Activity levels**: lower air temperatures are acceptable when users of the space have higher activity levels, reducing their heating needs.
6. **Thermal resistance of clothing**: lower air temperatures are acceptable if users of the space wear warm clothing or use enough blankets to lower their heating needs (e.g. in bedrooms at night).

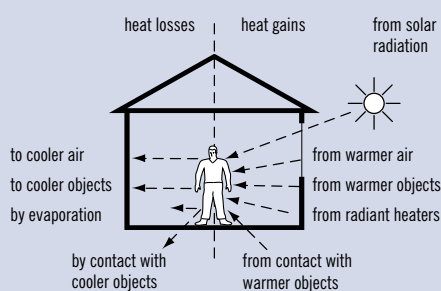


Figure 3.5: Body heat gains and losses



Building design affects the first four of these thermal comfort variables, whilst the last two are dependent on behaviour and actions of people. With an understanding of the effect of building design changes on thermal comfort, designs may be manipulated to achieve particular comfort conditions.

### PERCEPTION OF COMFORT

There are considerable individual differences in perception of comfort. There are different heating requirements as people get older and between different sexes. These differences are often reflected in variations in energy costs for homes.

The general rule combining comfort and energy efficiency is the **lowest comfortable temperature** in winter, and the **highest comfortable temperature** in summer. The recommended winter heating temperature range for living areas in Melbourne is 18–21°C, and 24–27°C for summer cooling. Keeping thermostats to these settings can help to considerably lower heating and cooling energy needs.