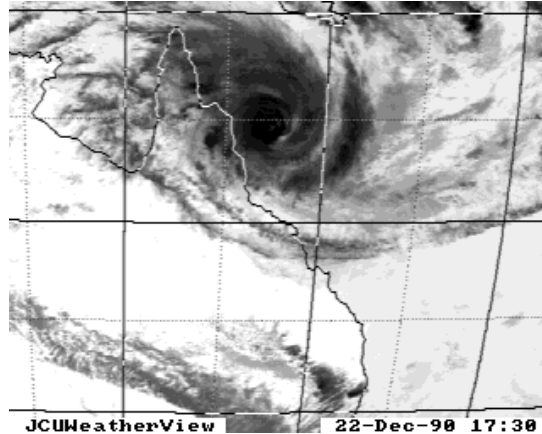


DESIGNING FOR CLIMATE



Residential Design in the Tropics

Martin Clark
BA GradDipTP

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The original of this document was prepared as lecture notes for the Bachelor of Construction Management course at James Cook University, Department of Civil and Systems Engineering, 1992. The author was formerly a Lecturer in Architecture and Building at the Papua New Guinea University of Technology, and at James Cook University of North Queensland. He was the Building and Urban Design Officer at Thuringowa City Council, NQ from 2003 – 2008 and a Development Advice Officer at Townsville City Council from 2008 - 2010, following the amalgamation of the two Councils. He is now a consultant in private practice.

An earlier version of this document is listed as a research reference in the City of Thuringowa Planning Scheme 2003, and part has been retained in the (Townsville) City Plan 2014.

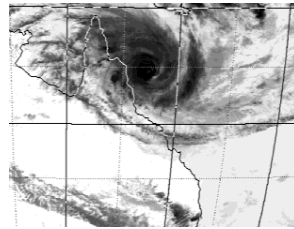
The above JCUmetSat image of Cyclone Joy is reproduced by permission of James Cook University.

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The author can be contacted via the website: tropicdesign.net.au

DESIGNING FOR CLIMATE - 1

CLIMATE



This section is based largely on *Manual of Tropical Housing and Building : Part 1 Climatic Design* (see references).

Climate may be defined as "an integration in time of the physical states of the atmospheric environment, characteristic of a certain geographical location". **Tropical climates** are those in which **heat** is the dominant problem, and where, at least for a substantial part of the year, buildings serve to keep the occupants cool, rather than warm, and the annual mean temperature is not less than 20°C.

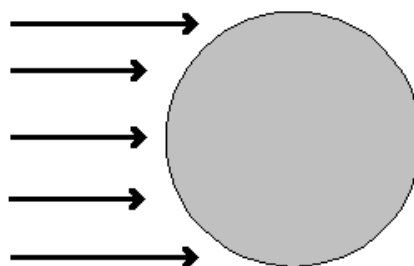
The earth receives almost all its energy from the sun in the form of **radiation**, and the sun is the dominant influence on climate. This radiation can be classified as ultra-violet radiation, of higher frequency and shorter wavelength, which causes photochemical effects, bleaching, sunburn, etc; visible light radiation, and infra-red radiation of longer wavelength, producing radiant heat and some photo-chemical effects.

The spectral distribution varies with altitude, due to the filtering effect of the atmosphere. The intensity of radiation reaching the upper atmosphere can vary $\pm 2\%$ due to variations in the output of the sun itself, and $\pm 3.5\%$ due to variations in the sun/earth distance.

The earth rotates around the sun in a slightly elliptical orbit, and rotates on its own axis at an angle to this orbit of 66.5° . Therefore the area of the earth's surface receiving maximum solar intensity varies throughout the year, as each hemisphere in turn is inclined toward the sun, and the hours of daylight and darkness also vary. The areas of maximum intensity move between the Tropic of Cancer and the Tropic of Capricorn each 23.5° north and south of the equator (e.g. 90° minus 66.5°).

The intensity of sunlight reaching a given point on the surface of the earth is affected by three factors:

1. The Cosine Law; the intensity reaching an inclined surface is equal to the normal intensity multiplied by the cosine of the angle of incidence. This decreases as the light approaches the poles.



2. Atmospheric depletion; the absorption of radiation by ozone, vapours and dust particles; the lower the solar angle, the longer the path through the atmosphere. Depletion varies by a factor of between 0.2 and 0.7.
3. Duration of daylight hours.

The amount of heat absorbed by the earth is balanced by a corresponding heat loss. Without this loss, the temperature would continue to rise, and the planet would soon cease to be able to support most forms of life.

This heat loss is produced by three processes:

- (1) long-wave re-radiation: about 84% of this is absorbed in the atmosphere, 16% escaping to space.
- (2) Evaporation: as surface water changes into vapour and mixes with air, surface cooling occurs.
- (3) Convection: air heated by contact with the surface becomes lighter and rises to the upper atmosphere.

These convection currents are one of the causes of winds. The main factor influencing the direction of principal winds is the Coriolis Effect. This is a phenomenon caused by the tendency of the atmosphere to 'slip' relative to the rotation of the earth. The resultant of the thermal force and the Coriolis Effect creates the Trade Winds - the north-east trades in the northern tropics, the south-east trades in the southern tropics, and the westerlies in the temperate zones. The location of wind zones changes with the seasons, roughly following maximum solar heating.

Winds (and weather) can be affected by the interaction of global patterns, and regional patterns created by the sun's differential heating effect on land, forest, and water, and more locally, by topography. Human activity can therefore have an effect on climate, both negatively and positively.

[This paper does not deal with issues of alleged global warming anthropogenic climate change, or the "greenhouse effect". The author's attitude on these subjects remains sceptical.]

The recently perceived global warming trend is now very much in question. The global average temperature has levelled off since 1998, and has fallen slightly. As concentrations of CO₂ (natural or man-made) have increased over the same period, it is now apparent that there is no causal relationship in the sense that increasing CO₂ levels are causing a rise in temperature. The reverse may well be the case, eg warmer conditions result in greater out-gassing from the oceans, or both phenomena are co-related as part of long-term, natural, cyclical patterns.]

CLIMATIC INDICATORS

These are principally temperature, humidity, precipitation, sky condition, solar radiation, and intensity and direction of winds.

Temperature is usually expressed as a monthly mean, but average monthly maximum and minimum values may be preferable.

Humidity is the amount of water vapour present in the air. The amount of moisture the air can hold varies with temperature. Usually the indicator used is relative humidity, which is the ratio of the actual moisture present to the amount of moisture the air is capable of holding at the same temperature, expressed as a percentage. RH is established by the use of the wet and dry bulb hygrometer. This consists of two mercury thermometers side by side. The first measures the air (dry bulb) temperature (DBT). The second bulb is covered by a wick which is kept wet. As moisture evaporating gives a cooling effect, the wet bulb temperature (WBT) will be less than DBT. Evaporation is faster in dry air, producing a more pronounced difference between WBT and DBT, or wet bulb depression. In the case of 100% RH the temperatures will be the same, as no evaporation takes place. Given the two values, RH can be read from a psychrometric chart. Another device for measuring RH is the hygrograph, which produces a paper plot (or A/D computer file) or RH values over time.

[There are now electronic devices which are capable of measuring humidity, however, the terminology developed for the older analog devices is retained.]

RH is likely to be at its highest in most climates just before sunrise. The minimum value usually occurs around 1500 hrs and this is frequently used as the indicator value.

Precipitation, which includes rain, hail and dew, is measured in mm/time units, using a rain gauge. Data are collated in a form which indicates the pattern of dry and wet seasons. Also useful are 'ever recorded' maxima and minima, and maxima in any 24 hr period, which will provide degrees of deviation from average, and prediction factors for flooding.

Building designers also need to know the probability of intense periods of rain being associated with strong winds, in order to predict the degree of **exposure** to driving rain.

Sky condition is usually indicated in terms of the degree and frequency of cloud cover, and may be used in calculations of luminance of daylight factors for building interiors, and also for decisions on shading devices.

The SI standard for measuring **solar radiation** is the watt per square metre.(w/m²). Solar radiation values will be required for estimation of the amount of heat reaching the inside of a building envelope. A simple sunshine recorder produces a burn track on a cylinder of paper each time the sun is exposed, but a wide range of more sophisticated devices are now used.

Wind Velocity is measured with anemometers, using propeller type blades or cups. Direction is recorded by a wind vane. These can be recorded on paper or by computerised A/D systems. Values (usually meters/second) are taken at (or calculated to) a height of 10 meters in flat open country. Directions are usually grouped into 8 or 16 categories, corresponding to the 8 cardinal or semi-cardinal compass points, and the 8 tertiary points.

Wind charts or roses are used to plot the force, percentage frequency and direction of winds for any given location.

In addition to the above, indicators may be required for phenomena which are infrequent, irregular, but significant, e.g. tropical cyclones.

TROPICAL CLIMATE TYPES

It is not possible to define accurately the boundary between climatic zones, as variations are usually gradual, but it is usually possible to define which zone, or area of transition, a particular site lies in. In 1953 G.A. Atkinson developed a classification based on two factors, temperature and humidity, which has since become widely accepted.

Atkinson defined three major zones and three sub-groups:

- (1) Warm/humid equatorial; sub-group warm/humid island or trade wind climate.
- (2) Hot/dry desert or semi-desert; sub-group hot dry maritime desert.
- (3) Composite or monsoon climate; sub-group tropical island climate.

Warm humid climates occur in a belt extending roughly 15° either side of the equator. There is very little seasonal variation, other than the amount of rain, which is high throughout the year, and the incidence of gusty winds and electric storms. Mean maximum DBT is between 27 and 32°C. Night minimum varies between 21 and 27°. RH is usually high at around 75%, but may vary between 55 and 100%. Sky conditions are fairly cloudy throughout the year, although luminance can vary considerably. Solar radiation is partly reflected and partly scattered by cloud and the high humidity. The latter also reduces outgoing radiation. Wind velocities are generally low. Vegetation grows quickly, and the high humidity encourages mould, algae and rusting. Mosquitos, usually malarial, and other insects abound.

Warm humid island climates differ from the above in that nighttime temperature minima may be slightly lower, and humidity is more variable. Skies are more likely to be clear, and solar radiation stronger and more direct. Winds are frequently constant at 6-7m/s, and provide relief from temperature and humidity. Salt in the atmosphere encourages corrosion. The greatest difference is the risk of cyclonic winds, which are frequent, unmitigated, and destructive. Precipitation may be less, but deluges are similar.

Hot dry desert climates occur in two belts between 15 and 30° N/S. There are two seasons, one hot, one cooler. DBT maxima range from 43-49°C in the hot season and 27-32° in the cool. Night mean minima are 24-30° hot, 10-18° cool. RH varies from 10% to 55%. Precipitation is slight and variable. Flash storms may occur, although droughts of several years are possible. Sky conditions are normally clear, with limited luminance which may be further reduced by dust storms. High glare and luminance may be caused by white dust haze. Solar radiation is strong but long wave re-radiation releases heat at night into the cold sky. Winds are usually local and turbulent. High day temperatures and rapid night cooling may cause materials to break up.

In **maritime desert climates** the DBT maxima are usually lower, but humidity tends to remain high, due to evaporation from the sea. These climates are generally regarded as among the most uncomfortable. Kuwait is an example, also the dry tropics region of North Queensland in a 'dry' wet season.

Composite or monsoon climates usually occur in large land masses near the tropics of Cancer and Capricorn. Approximately 2/3rds of the year is hot/dry, and the other third is warm/humid. Localities further north and south sometimes have a third season of cool/dry. Typical DBT values are:

	hot/dry	warm/humid	cool/dry
Day mean max	32-43	27-32	up to 27
Night mean max	21-27	24-27	4-10

RH is 20-55% during dry seasons, and 55-95% during the wet. Monsoon rains can be heavy and prolonged. Annual rainfall varies between 500-1300mm, with little or no rain during the dry season.

Sky conditions vary considerably with the seasons; heavily overcast and dull during monsoons, clear and dark blue during the dry. Glare increases towards the end of the dry season, due to dust haze. Solar radiation varies accordingly. Winds are hot and dusty during the dry season, and steady, humid and often strong during the monsoon. Seasonal changes in RH tend to weaken building materials. Termites are common.

Tropical Upland Climates, i.e. mountain and plateau, around 900-1200m + above sea level, have a composite climate. DBT maxima and minima vary with altitude, and the range increases with distance from the equator. Humidity may vary between 45 and 99%. When the sky is clear, radiation is stronger than at sea level, but radiation loss at night may result in fog.

NORTH QUEENSLAND COASTAL CLIMATE

This has characteristics of the composite climate and of the warm/humid island climate. The warm/humid period is similar in nature and duration to the composite type, although the associated period of high rainfall is more variable. The source of rainfall may be the north west monsoons, but rain is frequently brought by cyclonic or semi-cyclonic activity, originating in the Solomon Sea and moving south west into the Coral Sea. The remaining 2/3rds of the year may be described as warm/dry. Precipitation tends to be higher north of Ingham, and humidity slightly higher and less subject to seasonal variation. Solar radiation values vary between 400 and 600 w/m², compared to 350-850 for south west Queensland. Average daily hours of sunshine varies between 6 and 8 for January and 8-9 for July. Wind data collected at Willis Island (16°8'S/150°E) show a predominance of easterlies and south east trades. On the coast, these are modified by coastal breezes; on-shore winds tend to dominate in the afternoons due to differential heating of land and sea masses. These are fairly constant from the north-east and east, with an overall frequency of 50%, and strength mainly in the 5-10m/s band.

Centres inland from the coast tend to show higher DBT maxima and minima, lower precipitation and lower mean RH. Locations such as Mount Isa have more in common with dry desert climates than other types.

The diagrams below show the general division between arid and humid in Australia.



MICROCLIMATE

Variations may occur in the climate of a particular location within a broad climatic zone, due to local factors such as topography, ground surface conditions and the nature and distribution of 3-dimensional objects. The term **microclimate** can be applied to a city or a single shrub, so the building designer tends to use the term **site climate** under which to assess the local variations in climate which have a bearing on design.

For a large project covering an extensive area, it may well be worthwhile to undertake extensive evaluation of local conditions. On small sites, where there is less scope for variations in siting and orientation, this exercise will be more limited, but some consideration of local climatic patterns will always be justified.

Temperature

It is, or should be, common knowledge that temperature tends to decrease with altitude. During the day, the ground absorbs solar radiation and the air in contact with the ground reaches the highest temperature. From about 2m a.g.l. the air is stratified in layers of differing temperatures. However, as the warmest air is also lighter, eddies of air movement take place. After nightfall, the temperature of the ground drops to below that of the air, and **temperature inversion** occurs. Turbulence is absent, and the coldest air remains at ground level. This may flow and collect in pockets, like a highly viscous liquid. Certain land forms can produce a concentrated flow, in the form of a **katabatic wind**.

Sites at, say, 300m above the surrounding area may show very little temperature variation, relative to the variation at normal ground level. A height of 7-8m a.g.l. may result in a difference of 5-6° in temperature.

Humidity

Height has a similar effect on humidity. At ground level, during the day, RH rapidly decreases. If moisture is available in the form of water or rich vegetation, strong evaporation may increase RH. At night the situation is reversed; as the lowest level cools its RH rapidly increases, and condensation may occur if the saturation point is reached. The above, together with the termite problem, explains the development of the traditional stilt house in the region, and its modern counterpart, the high-set.

Precipitation

When moisture-laden winds come into contact with rising ground, the effect on precipitation may be considerable. Differences in excess of 300m will produce greater than average rainfall, and the difference between windward and leeward sides can be as much as 4:1. This effect is nowhere more significant than in eastern Australia, where rain precipitated on the Dividing Range, the height of which is insignificant by international standards, has a major effect. The run-off eastwards can be collected for use on the coastal belt. Water percolating into the ground is carried along the rock strata westward, into the **artesian basins**, and can be tapped many hundreds of kilometres inland from its source, and eastward to the coast.

Towns and cities may also produce climatic effects. The height and density of absorbent surfaces may cause warm updrafts; dust and pollution may alter local thermal effects, and heat is vented from a/c systems. The RH is usually lower. Run-off problems are usually greater, and winds may be lower, or may double, depending on the degree to which urban forms set up barriers or cause acceleration. Conversely, thick, managed vegetation may have an effect if it brings the cooler layer boundary lower. The "million trees for Townsville" policy if pursued, could have an

effect on the local climate. Generally, the temperature in conurbations can be up to 8% higher than that of the surrounding area.

Trees and shading topography will obviously affect the amount of solar radiation reaching the site; sites sloping towards the equator and west will receive significantly higher radiation.

Air Movement

Natural and man-made barriers affect wind speeds. A long horizontal barrier can reduce the wind speed by 25 - 50% at a distance of 20 times the height. Wind speed is always lower at ground level, and with uneven terrain, in addition to normal frictional effects. Cyclones, for example, rarely penetrate more than 50km inland as a destructive force, but may speed up again if they move out to sea. The greatest wind speeds occur on the crest of hills, and there may be a considerable diminution on the leeward side. Valleys have differing effects, depending on their nature and the wind direction; some may provide shelter, with lower velocities, others may funnel the wind and intensify the effect. A model of the effects of topography on wind has yet to be developed, and future research may focus on this. Damage resulting from cyclones often shows considerable variation; well-constructed buildings can be completely destroyed, while older dilapidated buildings perhaps only 200m away survive undamaged.

Large expanses of water may produce coastal breezes which can reduce the temperature by as much as 10°C, but are likely to increase humidity.

Other local effects may include electric storms, which should be considered for tall buildings or ridge-top sites. Variations in the electrical properties of the atmosphere may also be regarded as climate. There is evidence that excessively positively charged air causes discomfort, whether it is generated by electrical appliances or synthetic fabrics in indoor environments, or by external climatic conditions. One reason why the aftermath of a thunderstorm is refreshing is that it restores the balance of charge of the atmosphere to negative. Air passing over or through water has a similar effect, which is one reason why fountains and waterfalls are a feature of ornamental gardens from Morocco to Japan. Hot dry desert winds are often associated with effects ranging from discomfort to lunacy, because of their high positive charge. It is important to limit excess positive charge in artificial climates, and/or to reduce it using devices such as ionisers. Some locations seem to suffer disproportionately from electrical imbalance, e.g. Geneva in Switzerland, which given its lakeside and mountain location, might be expected to have a good balance.

Hot dry climates usually produce dust storms at some time of the year, and local storms of the "willy-willy" type may occur, due to hot ground air bursting through the cooler layers, with a whirlpool action, carrying dust particles with them. There is some evidence (chiefly from the United States) that they can be caused by large trucks or road trains passing each other at high speeds on desert roads.

Vegetation

In forming an additional layer between earth and sky, trees and vegetation transfer the point of contact to a higher level. Apart from the benefit of shade, some radiation is diverted to photochemical processes, which alters all the values, usually towards greater comfort. In hot dry climates the effect is usually considerable.

Existing natural vegetation is also useful as an indicator of local climatic conditions, and should be assessed to see if it confirms or contradicts general climatic data.

Comfort

Human beings can tolerate a fairly wide range of climatic conditions, but comfort in the climatic sense involves more than just avoiding the extremes of freezing to death and dying of heat exhaustion. Comfort depends on more than temperature; air temperature, humidity, radiation and air movement all produce thermal effects. Most climatic comfort indicators are objective, i.e. they can be measured, and acceptable ranges established quantitatively. Noise comfort indicators can be established quantitatively, at least with regard to pain thresholds and levels of exposure causing long-term damage. Subjective indicators are however no less important; noise, space, visual interest, colour, defensibility, and sensory deprivation and overload all have an effect.

Body Heat

Heat is continuously produced by the body due to metabolism, or the processes of food conversion and tissue building. Additional heat is produced by muscular activity, which varies from 70 watts while sleeping to 1100 watts for maximum heavy manual work. Of all the heat produced, 20% is utilised, and 80% must be dissipated, in order to maintain deep body temperature at 37°C. Any heat gained from the environment and from solar radiation must also be dissipated. The body can lose heat by convection, radiation and evaporation, and to a lesser extent by conduction.

Convection is produced when heat is transferred from the body to the air adjacent to the skin or clothing, which rises and is replaced by cooler air. Radiant heat loss depends on the temperature of the body surface and the temperature of opposing surfaces. Evaporative heat loss depends on the rate of evaporation which depends on the humidity of the air. Evaporation takes place in the lungs and on the skin as perspiration.

Vasomotor adjustments continually balance temperature by varying the flow of blood to the skin surface. If normal adjustments are insufficient sweating will occur in hot climates and shivering (which causes a rapid increase in metabolic heat production) in cold ones. Some acclimatisation occurs with movement between climates.

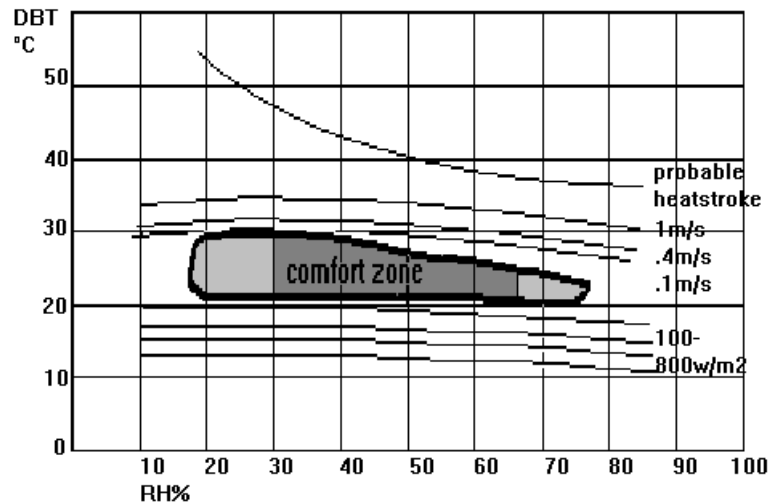
In temperate climates, it is rarely difficult to dissipate surplus heat; the most common problem is the prevention of excessive heat loss.

In hot climates, as air temperature approaches skin temperature convective heat loss gradually diminishes. When air temperature equals or exceeds skin temperature, heat loss will still take place by evaporation, even at RH around 90%, provided some air movement is present, as this will remove the fully saturated air from around the body. If this air movement is not present, and RH is near 100%, heat loss by evaporation will not take place, and if the condition is prolonged, heat stroke will occur. It is very rare for this condition to occur in natural environments, as even in the warmest and most humid climates, maximum RH usually occurs in the morning and evening, whereas maximum temperature occurs in the mid-afternoon, when RH is usually at its lowest. However, it is easy to produce hazardous effects in badly designed and managed buildings.

Another significant factor is clothing; a person wearing cotton underwear and a business suit (or its equivalent) will require a temperature about 9° lower than the naked body. Age, sex, body type and diet also influence the range of acceptable temperatures. Where radiant heat is concerned, the different skin colours show no net advantage. Dark skin absorbs heat much more readily than light skin, but is also much more able to emit heat. The advantage of dark skin is that it contains a greater amount of melanin, which protects against the damaging effects of ultra-violet rays.

Even under conditions which do not threaten life, considerable loss of efficiency may be experienced. It is also evident that some methods of providing comfort may induce stress, such as unvarying air conditioning or high air velocities produced by mechanical air pumping.

Indicators of **effective temperature** have been developed which attempt to reduce all the variables to a single scale. None of these has been found to be applicable in all situations. The **bioclimatic** chart below shows the result of studies by Olgay in Australia, and identifies a **comfort zone** of value combinations which have been found to be acceptable.



The comfort zone can be pushed up by the presence of air movement, but lowered by higher levels of radiation. The results were obtained from a study of men in sedentary occupations, wearing 1 clo of clothing (suit, cotton underwear) in a warm climate.

Other Factors

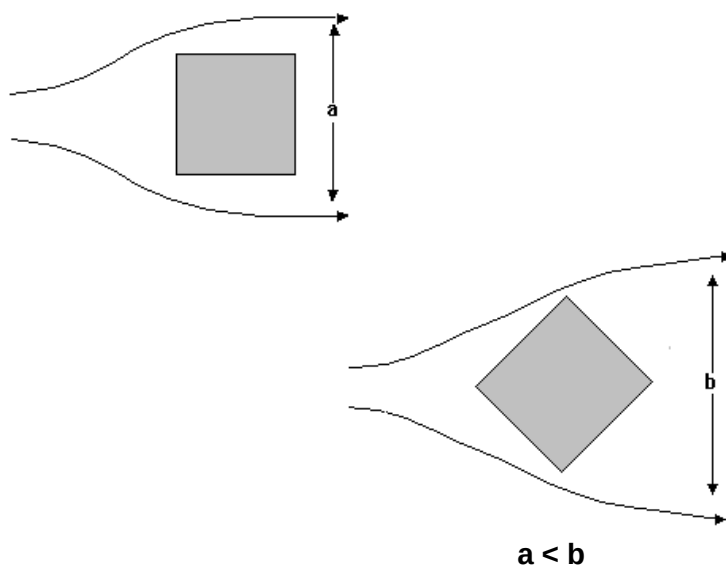
Building designers must also give consideration to the selection of materials, particularly with regard to thermal performance. This topic is discussed further below.

DESIGNING FOR CLIMATE - 2

VENTILATION

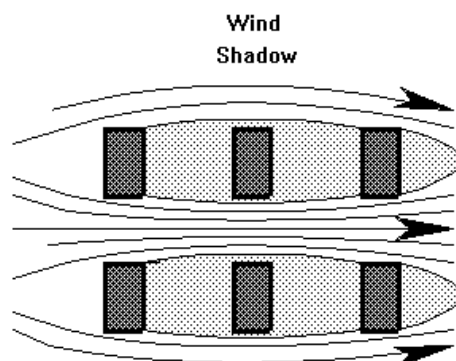
There are a number of design configurations which make use of air movement to assist climate control in buildings.

The greatest pressure on the windward side of a building is generated when the elevation is at right angles to the wind direction. It follows that a wind incidence of 45° would reduce the pressure, and hence the indoor velocity, by 50%. However, this is not necessarily the case. If large openings are placed on the leeward side, a greater velocity of air flow and less attenuation will be achieved, producing a broader area of negative pressure on the outlet side, and hence increased internal airflow due to the suction effect. This is often referred to as the Venturi Effect.

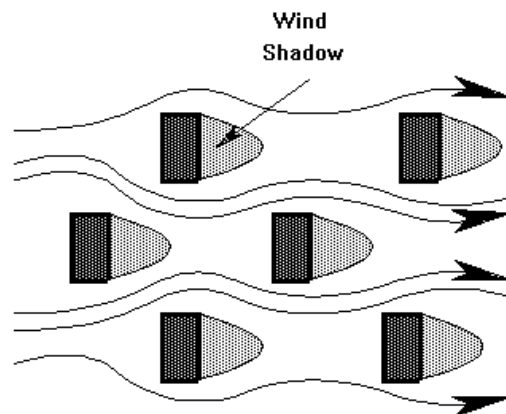


This effect will probably only occur if there are large openings on the downwind side. If more conventional openings exist, it will probably be better to set the building at right angles to the prevailing wind, but the benefit of negative pressure will probably be enhanced if the downwind openings are larger than on the side facing the wind. If there is a conflict between the optimum orientation for sunshading, and the direction of the prevailing wind, it is probably preferable to give priority to orientation relative to the sun.

The positioning of windows, the nature of elevations, the disposition of internal divisions, and the position of external obstructions all affect the passage of air through enclosed spaces.

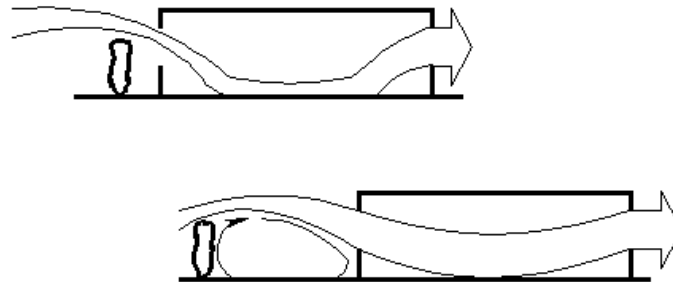


If buildings are laid out on a regular grid, the benefit of wind may be lost altogether. If buildings are staggered, and preferably spaced at least 50m apart, then the flow of air may be maintained, and the wind shadow reduced.

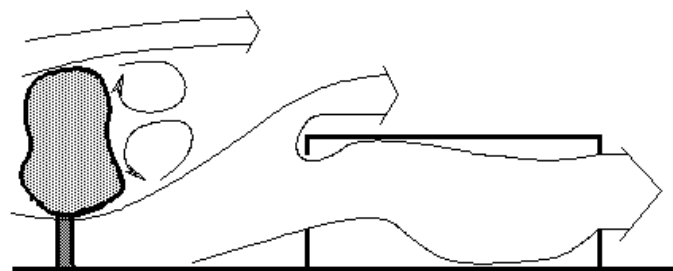


The following diagrams illustrate the effect of various configurations and types of obstruction on the internal flow of air. Note that the objective is to produce maximum flow through the area at body height, rather than across the floor or over the ceiling.

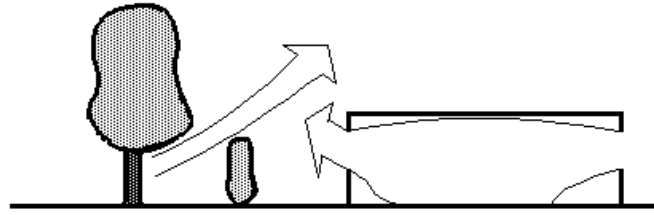
A. An obstruction set at a distance from the window is likely to produce a more even spread of air movement through the room.



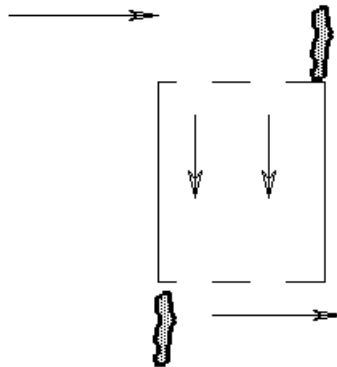
B. A barrier such as a tree may cause acceleration of air underneath it, with a wider band of moving air beyond.



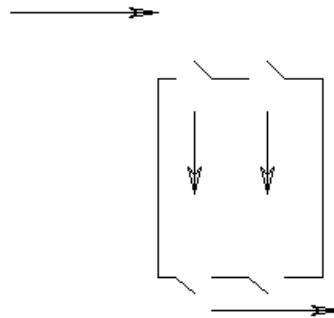
C. The combination of a tree and a hedge, for example, may have the effect of reversing the flow of air.



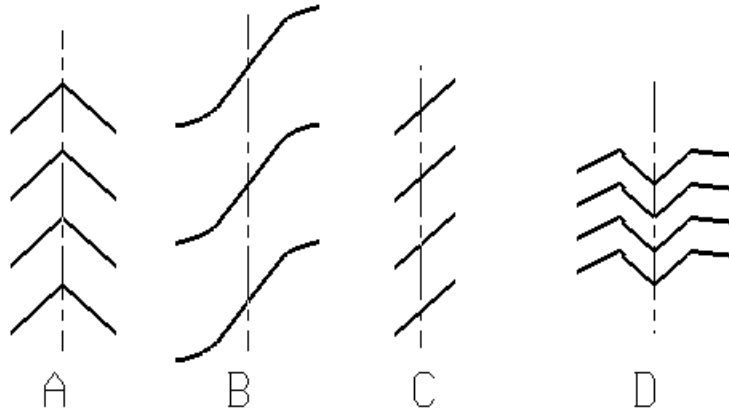
D. External obstructions may also be used to re-direct the flow of air, where the main windows do not face the flow of air.



E. This can also be effected by the way the windows open.

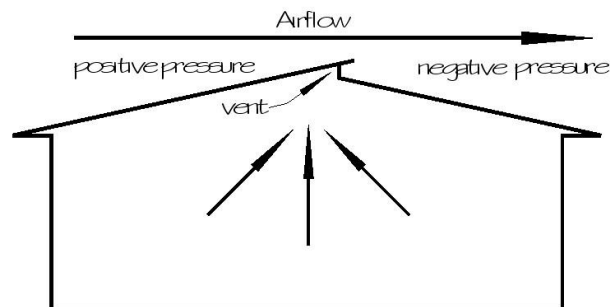


F. Louvres are a useful way of maximising the flow of air through openings, and are generally more efficient than casement windows in this respect. However, louvres (and other windows for that matter) usually have to be closed if there is wind-driven rain. A number of louvre types have been evaluated to determine whether the system can be used to admit a flow of air, but at the same time exclude rain. Of the types shown below (C being the conventional louvre) only D showed any capacity to keep out rain - at the cost of significantly reducing airflow.



The flow of air through windows is also affected by the nature and position of sunshading. A hood projecting outwards from above the window will tend to direct the flow of air downwards. This can be corrected by leaving a gap between the inner edge of the screen and the wall above the window.

G. Airflow through a building may be promoted through the use of high-level vents facing downwind – sometimes referred to as the **Bernoulli Effect**. Air passing over the roof creates a negative pressure zone on the leeward slope of the roof. If this zone is open to the interior of the building, the difference in pressure will cause air to be drawn from the interior.



The same phenomenon provides 'lift' above the rear of an aircraft wing.

This type of device can be used in situations where airflow is absent at ground level due to obstructions or the density of development, and the airflow is 'skimming' at roof level. Convective airflow will also occur if there is a temperature differential, but the pressure differential is likely to be the most effective.

Target Winds

Since the most uncomfortable weather usually occurs on summer afternoons, the "target winds" for the Townsville region are the north-easterlies, being the most reliable winds at this time (60% probability). The **Wind Roses** below (generated by Ecotect) indicate the situation for the region.

Prevailing Winds

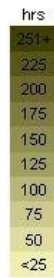
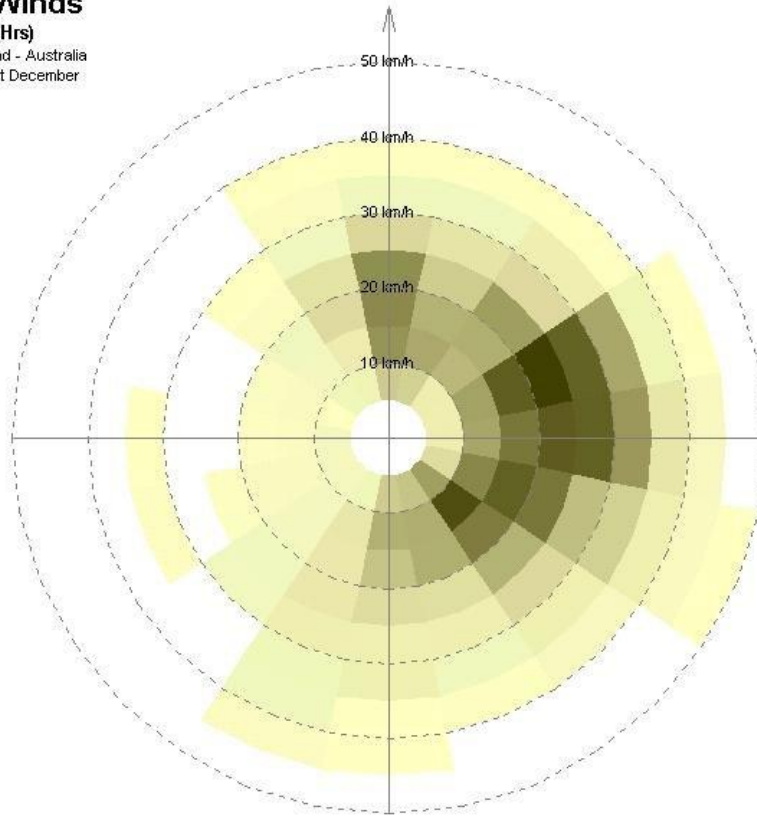
Wind Frequency (Hrs)

Townsville - Queensland - Australia

Date: 1st January - 31st December

Time: 00:00 - 24:00

© ECOTECT v5.00



Prevailing Winds

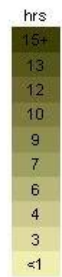
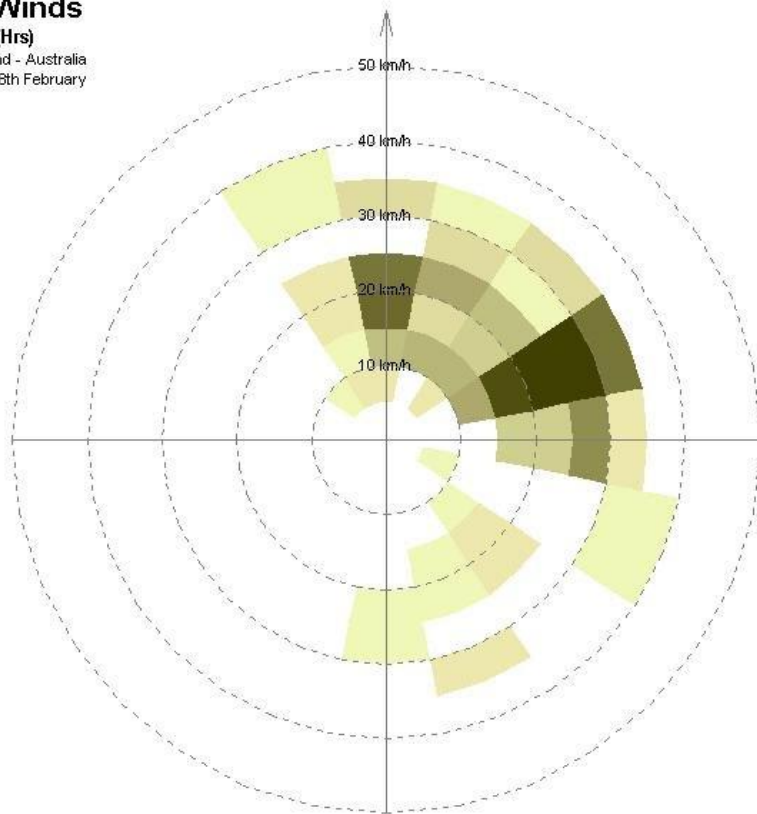
Wind Frequency (Hrs)

Townsville - Queensland - Australia

Date: 1st December - 28th February

Time: 14:00 - 16:00

© ECOTECT v5.00



A north-easterly wind at 30km per hour (black shading) represents around 8m per second.

It should be noted that these wind speeds, probabilities and directions are based on average readings at the weather station located at Townsville airport. The values are fairly reliable for the coastal plains, but may be varied further inland by obstructions and topography. In the Upper Ross (Rasmussen, Kelso) for example, the north-easterlies tend to be more northerly, due to the airflow being 'turned' by the Mount Louisa range, and the effect of Mount Stuart.

DESIGNING FOR CLIMATE - 3

SUNSHADING

Buildings should generally be designed using materials which limit the transfer of heat from solar radiation into the building.

There is an advantage in using low thermal capacity, lightweight materials, which, although they absorb heat readily, also lose heat rapidly, so that living spaces cool down after sunset. Masonry block walls should if possible be shielded from the sun because although they gain heat slowly, they may act as a store of heat during the night. Insulation in the roof space of lightweight structures may also be counter-productive, in that although it reduces solar gain, it also prevents the dissipation of heat from within the building, including that generated by people, cooking, etc. High level ventilators combined with high or 'cathedral' ceilings will help maintain convection heat loss. Roof ventilators are also effective in venting warm air.

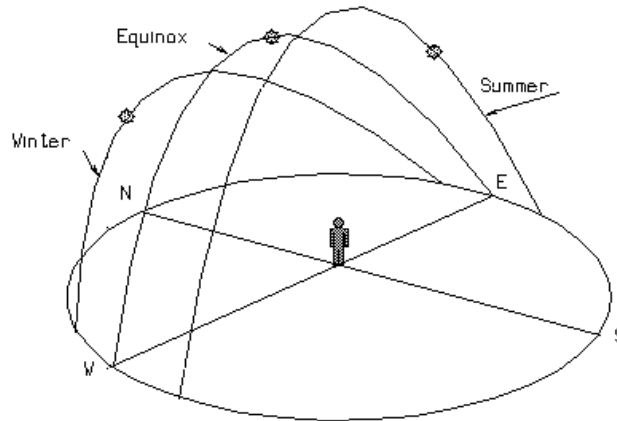
Tall buildings can be designed to make use of the 'stack effect', whereby warm - and hence lighter - air is encouraged to rise in an internal multi-storey 'chimney', venting at roof level and drawing air in from below. This works well with buildings of three or more storeys, but is unlikely to be significant in a conventional domestic building.

Orientation should generally be east-west to present the smallest faces of the building towards the lower angle sun.

WINDOWS

Windows allow a view of the outside world, and provide natural ventilation and light. They are also a major source of solar heat gain and glare if subject to direct sunlight. Consideration must be given to the positioning of windows, relative to the path of the sun throughout the year. Various methods can be employed to calculate the position of the sun throughout the year. Calculations may be made, and most textbooks on climatic design outline the method. A number of textbooks also provide solar protractors, in the form of a plastic film which can be placed directly onto plans and elevations. Computer programs are available which calculate the bearing and angle of the sun given latitude and longitude of the site, and time zone. These values can then be used to calculate the effect of the sun on windows, and allows for the detailed design of sunshading.

The diagram below illustrates the path of the sun at different times of the year in the southern hemisphere. It is possible in tropical and sub-tropical zones that the worst problem arises during the spring and autumn, when the solar angle is more oblique. It should also be noted that in the tropical summer, the sun will at some time shine on all the elevations of a building.



The table below shows solar angle and bearing for Townsville for December and June. The angles shown are the **solar altitude angle** which is the vertical angle at the point of observation between the **horizon plane** and the line connecting the sun with the observer, and the **solar azimuth angle** (bearing) which is the angle at the point of observation measured on a **horizontal** plane between the northerly direction and a point on the horizon circle, where it is intersected by the arc of a vertical circle, going through the zenith and the sun's position.

The table below gives values for Townsville calculated using my software package, **Sunpath**. The values can be used to design sunshading devices using drawings, as in the diagram following.

Data for Townsville
 Latitude 19.25 S.
 Longitude 146.77 E.
 Hours ahead of GMT = 10
 Date : **22nd Jan**
 Sunrise 5 54 Sunset 18 52

Data for Townsville
 Latitude 19.25 S.
 Longitude 146.77 E.
 Hours ahead of GMT = 10
 Date : **22nd Jun**
 Sunrise 6 49 Sunset 17 39

***** Sun Positions *****

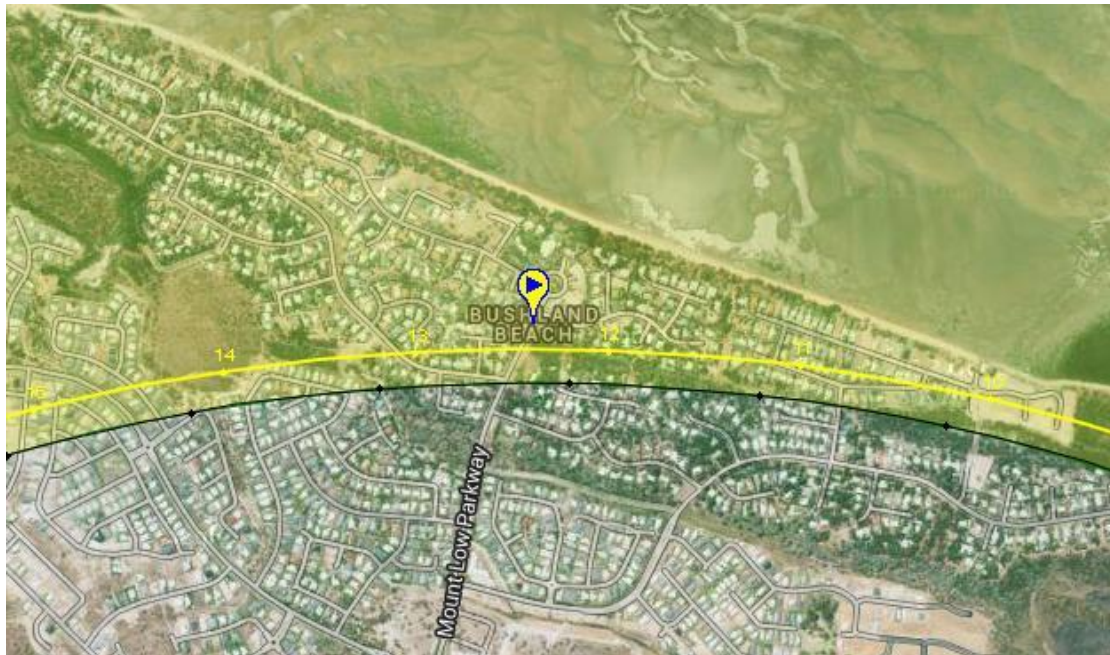
Time	Altitude	Bearing
6	1.14	110.67
7	14.57	106.32
For additional locations and Values ...		
16	39.29	259.66
17	25.43	256.55
18	11.77	252.85

***** Sun Positions *****

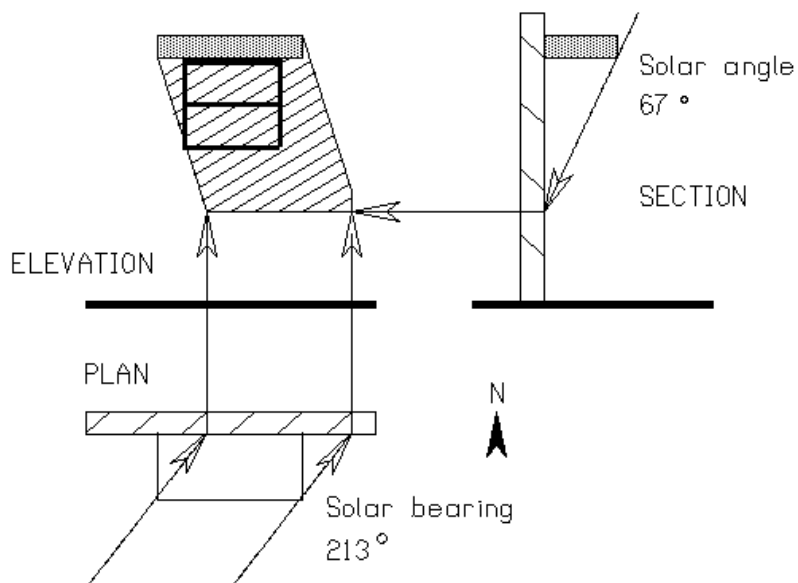
Time	Altitude	Bearing
6	-10.72	68.71
7	2.27	64.16
get a copy of my software !		
16	20.38	305.41
17	8.35	298.51
18	-4.40	293.33

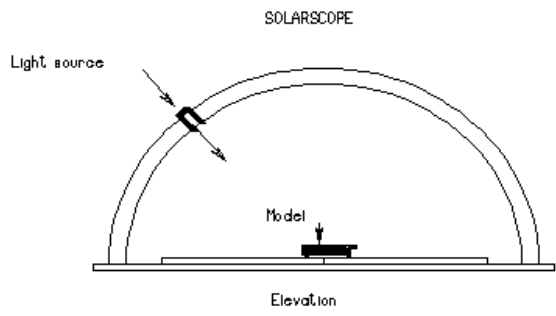
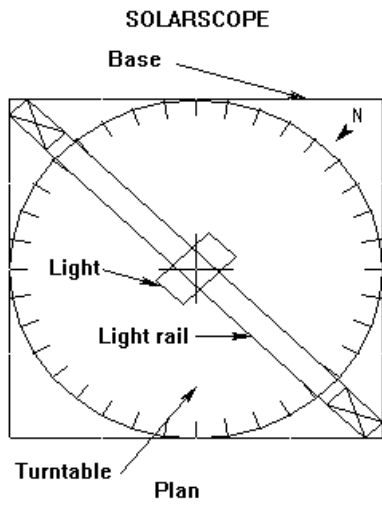
It is possible to create shade patterns using a 3D modelling in high-end CAD software and (apparently) Sketchup Pro. However, the 3D model needs to be drawn and the nature of the surfaces specified to an extent. Personally, I find it easier to print the relevant 2D drawings, paste the elevations onto balsa sheet, and test the model with a solarscope.

My software above is now long past its use-by date. The easiest way to obtain this information now is to access the website SunEarthTools.com:

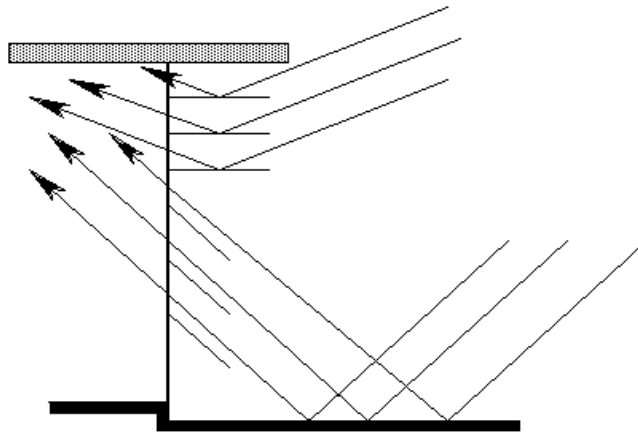


This will superimpose the sun path over a Google Earth image, and provides a table of the hourly bearing (azimuth) and angle (elevation).

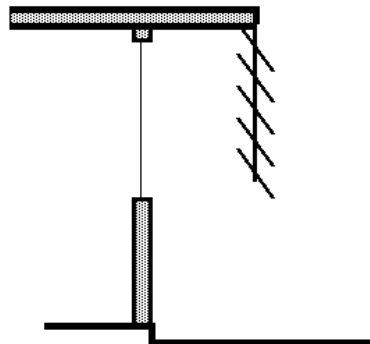




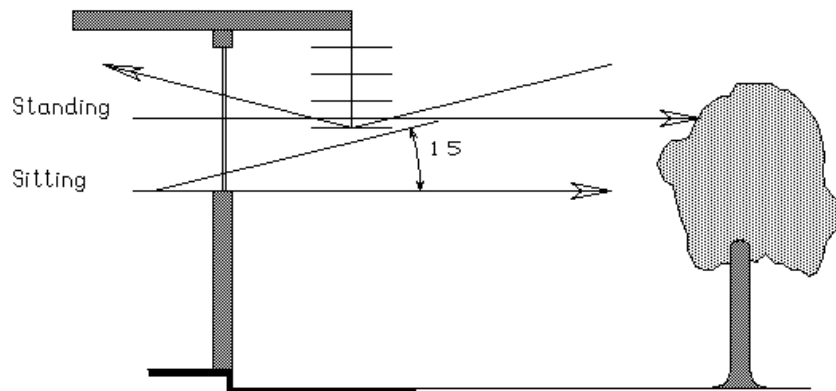
The sunshading device shown below excludes all direct sunlight, but admits some reflected light which is directed up to the ceiling.



If the ground outside is reflective (eg paving or grass), this can cause glare. The device above would permit through movement of air, and allow a view of the outside space. The device below would exclude all sunlight, at the expense of obstructing the view and reducing ventilation. A traditional form of louvred window has glass louvres at the top, a fixed glass panel centre, and opaque (usually steel or timber) louvres at the bottom. The two sets of louvres can be manipulated to control airflow, and the lower set will largely exclude heat gain reflected from external ground.



The solution illustrated above is seldom necessary, even for a window facing directly west. An adjustable version would be preferable. It is not usually necessary to exclude early morning sun (eg the first 15°) on the grounds of solar gain alone. Few buildings have an unobstructed horizon, and external features can be used to limit direct sunlight and at the same time allow a view of the outside space.



As an adjunct to or replacement of sunshade devices, tinted glass may be considered. This should preferably be incorporated in the glass rather than applied as a film. The first level of tinting makes a noticeable difference, and the best (and most expensive) 'Green Glass' reduces solar gain to a negligible level. Tinting may now be required under the Building Code – see below.

Overhangs will also assist in protecting windows from solar gain, and provide a fixing point for screens, or window hoods can be added individually. If space and cost permits, verandahs on all or the most exposed elevations are the best option.

DESIGNING FOR CLIMATE - 4

THE 'STACK' EFFECT, 'COOL POOLS' AND ELEVATED FLOORS

Ventilation is concerned with the supply of fresh air, and, in hot climates, the promotion of convective cooling, by the movement of air at a relatively slow rate. The motive force can be either thermal or dynamic (wind), the latter being discussed above.

The stack effect relies on thermal forces, set up by density difference (caused by temperature differences), between the outdoor and indoor air, and air at a lower level relative to air at a higher level. It can occur adjacent to an open window, where warmer air may flow out of the top part of the window, and cooler air may be drawn in at the bottom. Floor-to-ceiling windows with fixed lights in the middle and louvres at the top and bottom, are designed to exploit this potential. The principle is the same as for wind generation, and of course wind can be used to assist the effect.

Special provision can be made for the effect by the installation of ventilating shafts. The higher the shaft, the greater the cross-sectional area, and the greater the temperature difference, the greater the motive force, and therefore the more air will be moved.

The motive force is the 'stack' pressure multiplied by the area (Newtons x area in m²). The formula is:

$$P_s = 0.042 \times h \times T$$

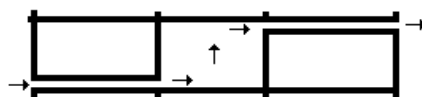
Where P_s = stack pressure in N/m²

h = height of stack in m

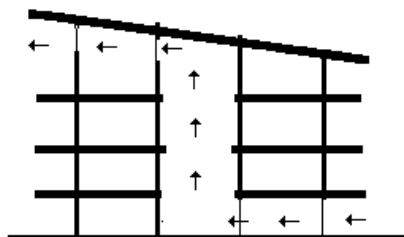
T = temperature difference in °C

(the constant is N/m³°C)

Such shafts are used for internal ventilation in cooler climates where the temperature difference in winter is fairly large;



The same principle can be used in tropical buildings to promote vertical air movement;



The volume of air passing up through the central well can be drawn in at the bottom corner of the wall of each room facing the well, and discharged through openings at the top of the same wall. Arrangements such as that shown above can provide a comfortable even temperature without the use of air-conditioning, providing the well

or shaft is large enough and high enough, and the intakes and exits are designed to maximise the effect of prevailing winds.

It is sometimes suggested that the traditional Queenslander house style, with cathedral ceilings of up to 4m, is intended to use this phenomenon, but in most cases the opening at the top and the height of the stack is insufficient to promote any significant cooling through the stack effect alone. Any benefit probably derives from the Bernoulli Effect described above.

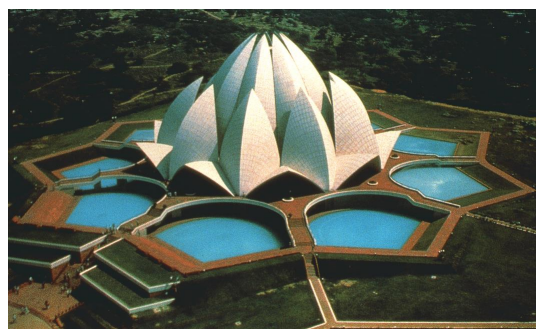
COOL POOLS

Evaporative cooling produced by the passage of air over water has been utilised since earliest times, using ponds, lakes, fountains, etc. or more ingenious devices such as air scoops in which a porous clay water pot is placed so that the passing air comes into contact with a continual supply of water droplets. This is the basic method used in the modern evaporative cooling system, except that the water is now dripped through a screen suspended in the air flow. Evaporative cooling is less effective when the air is very humid, and most effective when the moving air is hot and dry.

However, cool pools, if large enough, can have a significant effect, and may not in fact have to contain water to work. If moving air can be funnelled through a space which is out of the direct sun, it will lose some of its heat before reaching the building. Verandahs can act as simple cool pools as well as shading devices.

A swimming pool located upwind of window openings may have a beneficial effect, at a possible cost of loss of water by evaporation.

In some large institutional buildings, use has been made of the mass of the structure and the landscaping around it to channel moving air along a path which increases its velocity, removes heat gain from the sun, and produces evaporative cooling. A good example is the Baha'i Temple at Bahapur, outside New Delhi, India. This is a complex concrete shell structure which is a place of assembly, but does not utilise air-conditioning, even though a hot dry wind blows through the area for a significant period during the year. The wind is funnelled over embankments, and, in the case of the prevailing wind, over standing water which is below natural ground level. It then passes through the openings around the base of the dome, and rises up through the interior.



'Cool pool' effects can of course be enhanced with mechanical assistance, producing a reasonable trade-off against conventional air-conditioning systems.

Swimming pools may be located on the windward side of dwellings to provide a 'cool pool' airflow. There will be a trade-off here between the need to cool airflow and the need to limit water loss by evaporation. A pool cover will diminish the effect but

reduce loss by evaporation. Providing shade-cloth or sails above the pool may represent a reasonable compromise.

ELEVATED FLOOR OR SLAB-ON-GROUND?

This issue remains controversial. Traditional tropical designers favour dwellings elevated off the ground, either low-set (1m) or high-set (2m or more). The justification for this includes:

- A building on the ground is a 'Bluff body'. The wind must flow round it or over it. There may be dead zones of unmoving or slowly rotating air adjacent to walls. With an elevated house, the air can pass under the floor as well.
- The living areas of the house are at ground level, where the air is hottest. As noted above, air temperature decreases with height.
- In an urban situation, where the density of building is more than 28%, there is a tendency for natural airflow at ground level to diminish, and eventually to disappear altogether. All things being equal, if a house is elevated it will have better access to cooling breezes.
- Uninsulated floors open to the airflow may be cold in the early morning during cooler months, but cold is more of a novelty than a problem in the tropics.

The argument for slab-on-ground is that the floor has a temperature-stabilising effect. If shielded from the sun in the hotter months, it will remain cooler than the surrounding environment. It may absorb and retain heat during the cooler months when the solar angle is lower, but that is assumed to be beneficial. The same argument is used to promote the benefit of internal mass walls. The argument may be valid for temperate and even sub-tropical environments, where cold can be a problem, but its value is doubtful here.

Slab-on-ground construction is favoured over elevated floors in energy efficiency software, including the most recent "Second Generation" software. This issue is discussed in more detail in Part 7 below.

DESIGNING FOR CLIMATE - 5

RESIDENTIAL LOTS

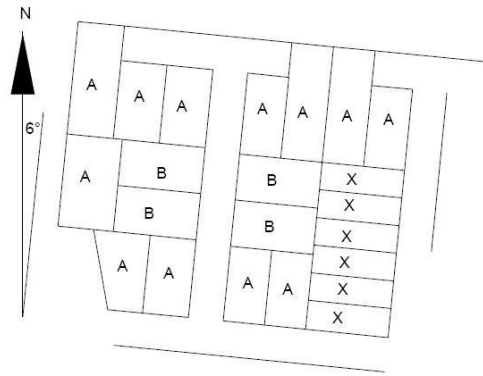
In recent years, there has been a trend in North Queensland housing away from traditional building forms in favour of houses more suitable for temperate climates, e.g. slab-on-ground, high thermal capacity enclosures (masonry exposed to the sun), full height windows, lack of overhangs, etc. In spite of the decline in average household size, houses have tended to become larger, while lots are getting smaller. The result has been a growing problem of "hot boxes" and "heat islands", where spaces between buildings are impervious to winds, and a positive feedback loop is created in which there is greater dependence on air-conditioning, which vents to the outside, thereby making the situation worse.

Designers who are aware of these problems frequently complain that in any typical residential subdivision, it is usual that less than 30% of lots represent a site which they are able to provide a suitable design for.

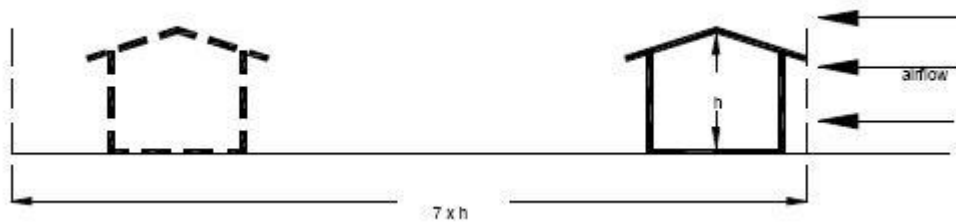
Lot designers and buyers should consider:

- Solar orientation: the development of lots which allow dwellings to be built with optimum orientation for solar control and sunshading, and which allow dwellings to be built with roofs oriented to optimise use of photovoltaic and solar water heating facilities.
- The direction of natural airflow, particularly summer afternoon winds from the NE and ENE (*these are the "target winds" in North Queensland, in that they are the most commonly occurring winds at the time when they are most needed*).
- Local micro-climate and topographic effects (if any) of the site which modify standard characteristics
- The need to maintain, as far as practicable, air-permeability in the resulting built environment, with a preferred overall ratio of buildings to open space of 30% or less
- Minimisation of areas where wind shadow (air-flow skimming) will take place
- A street pattern which enhances rather than detracts from air-permeability
- Adaptation of the layout to utilise parks, drainage and other reserves to maintain air-permeability
- Avoidance of concentrations of small lots, fencing or other barriers perpendicular to target winds
- Assessment across the site of circumstances where down-wind distance from one barrier to the next is less than 7 times the height of the up-wind barrier.
- Possibility of off-setting parallel side boundaries to reduce wind-shadow effects (*covered above*)
- Use of building envelope plans and landscape plans to enhance climate-response
- Avoidance of 'build-to-boundary' features unless attached development is proposed.
- Use of attenuation distances rather than solid fencing for acoustic protection

EXAMPLES: Orientation



On the above plan, the lots marked A are within $\pm 15^\circ$ of north, and are capable of containing a dwelling with an optimal solar aspect. Lots marked B are oriented east-west, but are wide enough to provide for appropriate orientation. Lots marked X have an adverse orientation, and provide little scope for adaptation.



Airflow and Barriers

Research confirms (Su San Lee below) that long horizontal barriers perpendicular to airflow, such as solid fencing or continuous building lines, attenuates airflow for a horizontal distance of seven times the height of the barrier. Where a second barrier occurs, airflow continues to 'skim' and does not return to the unimpeded pattern for the same seven-times-height distance.

DESIGNING FOR CLIMATE – 6
RECENT DEVELOPMENTS IN THURINGOWA, NORTH QUEENSLAND:
THE PLANNING SCHEME

The first IPA (Integrated Planning Act) Planning Scheme for the City of Thuringowa was gazetted on 10th October 2003 and came into effect on 20th October 2003.

The Scheme, which is largely performance- rather than prescription-based, requires that climate is considered for all forms of development, and in particular, residential development. It contains performance criteria for climate-response in the design and assessment of mixed residential, multi-unit and duplex dwellings, as well as single dwellings constructed on lots less than 450m². An innovative feature of the Scheme is the introduction of climate-responsive design for residential lots. The Scheme is supported by Planning Scheme Policies on Climate-Responsive Design for these forms of development, which incorporate most of the principles outlined in this paper. The measures complement Amendment 12 of the Building Code of Australia, which introduces energy-efficiency requirements for residential building, and differing requirements according to Climate Zone.

In Queensland, the Scheme won the Planning Institute of Australia Award for 2003 in the category of Urban Planning, and the Climate-Responsive Design Policies won Merit Awards in the same category.

In 2004 the Scheme won the PIA National Award for excellence in Urban Planning.

The Planning Scheme Policy “Climate-responsive Design for Residential Lots” was the work of this author. (This policy is to be included in the new draft planning scheme for Townsville, likely to be gazetted mid-2014.)

The Planning Scheme Policy “Climate-Responsive Design for Housing” was the work of Buckley Vann Consultants – Architect Caroline Stalker, peer review by this author.

During 2003, the Council ran a Climate-Responsive Design Competition, in association with the Housing Industry Association, and Australian Institute of Architects, Queensland Division. One of the purposes of the competition was to provide input for the development of Planning Scheme Policies. Details of the winning entries are attached to the CRD Policy on Housing as an Appendix “Housing Exemplars”.

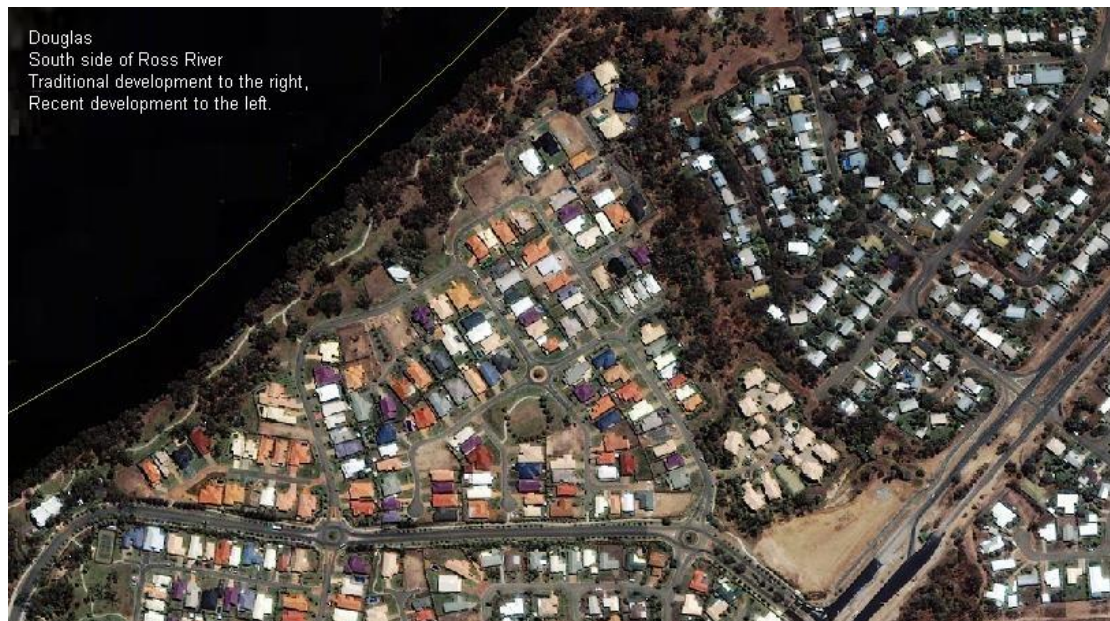
Copies of the Planning Scheme, Policies, and the housing exemplars are available from the Council’s website – see references.

In 2008, the former city councils of Townsville and Thuringowa were amalgamated.

DESIGNING FOR CLIMATE – 7

CLIMATE - RESPONSE AND THE CONSTRUCTION INDUSTRY

The climate-responsive design principles outlined above tend to support the more traditional “Queenslander” form of dwelling design, comprising elevated floors, lightweight frame and ‘free run’ ventilation. This type of dwelling is still being built. There are local designers, architects and builders producing excellent examples of adapted traditional design. However, most new dwellings constructed in the region are slab-on-ground, in a style more typical of temperate- rather than tropical-climate development.



The aerial photograph above shows part of the Douglas suburb of Townsville. Ross River is at the top (north), and James Cook University lies below the bottom of the image.

The area on the right was constructed around 20-30 years ago. Here the houses are mostly 2-storey ‘highsets’. Plot ratio (the ratio between the house area and the lot area) is around 25-30%. There is mature vegetation cover, and reasonable exposure to target winds from the north-east, which in this location is enhanced by the river corridor.

On the left is the first stage of Delfin’s Riverside development. The house footprints are larger, while the average lot size is smaller. The dwellings are mostly single storey, slab-on-ground, with plot ratios much closer to the maximum of 50%. There are rows of small lots with houses that are very close to each other, and back yard open space which in many cases will have little or no access to the target winds. Because of the density of development, the air will be skimming over the top. There is evidence here (confirmed by the observations of residents) that ‘heat islands’ exist – pockets of space where the air doesn’t move, and the resulting ambient heat is being raised by the exhaust from air-conditioning. It should also be noted that in the older traditional area, roof colours are light, comprising reflective unpainted zincalume or light colorbond. In the newer area there are more dark-coloured (heat absorbing) roof surfaces.

The early stages of Delfin's Willow Gardens development in Thuringowa was the subject of Su San Lee's PhD study. This established that this form of development is significantly lacking in passive climate-response. In the course of time, Councillors in Thuringowa began to receive complaints from residents about the heat island effect, and noise problems due to houses being very close to each other. It was this feedback (supported by warnings from design practitioners) which was the catalyst for the Council requiring climate-response to be addressed in the new Planning Scheme.

It should be noted that the above implies no criticism of Delfin. The same situation is occurring in many new developments in the region, and there are many reasons why this is the case. Some derive from lack of consideration of climate-response at lot-development stage, followed by inappropriate design of subsequent dwellings. Other reasons include the circumstances prevailing in the construction industry, the (previously) relatively low cost of electricity in Queensland combined with much reduced cost of air-conditioning systems, and the nature and level of demand in the housing market.

The nature of the market

The Townsville urban region remains one of fastest growing areas outside the south-east corner of the State. Around 2000 houses are being built each year. The population of the region is fairly mobile, with a turnover of around a 10% per annum. There are new arrivals from 'down south' who are unfamiliar with the climate, and tend to select house styles that are familiar, but not well adapted to the local conditions.

The construction industry and house prices

Due to pressure of demand, the rising cost of construction, the pressure on the construction industry and shortage of skilled construction tradespersons, the cost of housing has risen dramatically during the past 2-3 years. It is easier, and therefore cheaper, to build masonry, slab-on-ground dwellings with conventional trussed roof frames, in a limited range of options. Houses designed for the specific residential lot and responsive to climate and other constraints of the lot, will cost more. Climate-response requires design and construction skills which are in short supply. CAD/CAM (computer-aided design and manufacturing) can produce considerable varieties in roof form and wall framing, and can reproduce traditional forms, but at a cost in design time and resetting of assembly jigs.

Construction materials and techniques

Up until the 1970s the most common construction form was lightweight framing, using mostly "Maryborough" hardwood. This material is very durable; it seems to gain strength with age, and has good resistance to insect attack. Equivalent hardwoods are available, but are expensive, more difficult to work, and the logging of hardwoods is now generally deprecated. Preservative-treated machine-graded pine can be used, but is still expensive, and many practitioners (including the author) do not consider it to be a reliable substitute. Manufactured structural timber such as "Glulam" is available but not widely used. In the experience of the author, plywood box structural sections are easy to produce and have a high strength to weight ratio, but are also expensive, with an added cost that engineering certification is difficult to obtain.

Steel on the other hand has known structural characteristics and sections are dimensionally accurate and stable. Steel is currently the only common substitute for conventional timber framing, in the form of trussed roofs and stud walling.

Architects are now tending to favour the use of hot-formed RHS (rectangular hollow section) to provide the primary framing for framed houses, as a portal frame system. The primary framing if exposed is acceptable as it is in effect pre-finished. Frames are generally cut, welded and finished off-site, with limited on-site working required. The method allows the retention of features such as raked or cathedral ceilings and minimal wasted space in roof voids. Although not commonly used for residential construction in the past, portal frame systems are probably the most economical way of enclosing space.

An alternative, cheaper framing solution is to use cold-formed steel portal frame (eg 'C' sections) with secondary framing provided by 'top hat' rails – basically the form used for Class 10 structures (sheds and the like) over about 15m² in area. The author has assisted in the construction of two 'starter' homes built using this type of construction. They are 74m² in area, extendable (verandahs, bedrooms), constructed by contractors to lock-up (with slab, windows/external doors, insulation) for \$25,000 each in 2004. Internal fit-out and finish, including onsite wastewater system, is expected to be completed for a further \$20 - 25,000 each, as owner/builder projects. Design details are available as a separate document from the author's website.

Concrete block construction remains the most common. There is nothing particularly wrong with block in the tropics – provided it can be shielded from the sun. It is expensive to shield all exposed walls with verandahs, and with the trend to smaller lots and larger dwellings there is rarely enough room.

Exposed block will absorb heat from the sun and re-radiate it into the interior space. In the worst cases this can occur continually for months. The original draft of the BCA Energy Code in 2003 contained measures that would outlaw the use of standard concrete block for external walls in the tropics, for this reason. For obvious reasons, this was impracticable, and the measure has been 'deferred'. At the time of writing, there is no concrete block which has the required insulation properties AND is also capable of the required structural performance in cyclonic areas.

'Free-run' or air-conditioning?

In earlier times, it was common for dwellings to be designed for passive climate-response. Air-conditioning was expensive, and power supplies more uncertain. However, most houses still had at least one room air-conditioner (often in the main bedroom) for those times when it was hot and humid, and there was no wind. This is still the case with 'free-run' dwellings. However, most new houses in the region are now constructed with air-conditioning. Installations are more energy efficient, costs are lower, power supplies are a little more reliable, and the cost of reticulated power in Queensland (until recently) has been relatively low. The NCC (formerly BCA) Energy Code ensures that there is at least some provision for the structure to be energy-efficient. More recent (and more dense) residential development does not have the same level of exposure to cooling breezes, and the breezes themselves also seem to carry more dust and pollution.

This region is very well supplied with solar energy, but the rate of take-up for solar water-heating has, until recently, been minimal. The reason is that with the low cost of power, it took too long for the additional cost to be recovered. The use of reticulated power for water heating is capable of being measured through the off-peak tariff system. The figures are substantial, and as a result, solar- or gas-assisted water heating is now mandatory for new dwellings.

It is counter-productive if savings in energy usage from more efficient water-heating is swallowed up by greater use of air-conditioning. The deemed-to-satisfy and energy-rating provisions in the BCA may reduce the worst practices, but do little to encourage passive climate-response.

There has recently been a surge in photo-voltaic installations, due to the high price paid for feed-in tariff. The problem with this is that somewhere along the line, the inflated return has to be paid for, by every consumer; “the poor are subsidising the rich”. As a result, from 9th July 2012, feed-in tariffs in Queensland have now been drastically reduced for new installations.

Energy efficiency software

Energy Rating systems such as NatHers and Bers have been in general use for assessing energy efficiency in housing for a number of years. Most of the rating systems use the energy rating engine CHENATH, developed by CSIRO. Most systems were based on closed dwellings, and did not perform well in the assessment of the type of ‘free-run’ dwelling common in the tropics. Attempts by legislators to encourage the use of energy rating systems in the tropics were criticised by practitioners. As a result, in 2005 State and Federal agencies and the CSIRO commenced a program to develop a “Second Generation” of energy rating software, piloted by the Association of Building Sustainability Assessors, which inter alia would address the objections of tropical designers. The pilot program was based on NatHers, and the new product was NatHERS/AccuRate. Since most of the development was via the CHENATH engine, the changes would follow through to the other products using this. I participated in the pilot program, and my views on the outcome follow.

The new system is better than the old. The software is better at handling shading and the properties of materials, and can take into account the benefit of natural ventilation. However, at the time of writing there remain a number of anomalies which deter me from using NatHERS/AccuRate (or its superior rival BersPro) as a primary tool for climate-responsive design:

- The system will now produce a Star Rating (1 – 10) for cooling loads alone, rather than combined heating and cooling loads. This is important in the tropics, as measures for heating are seldom, if ever required.
- However, There still seems to be a built-in requirement for natural ventilation devices to be capable of being closed, in order for air-conditioning to work.
- While the inclusion of wind speed, direction and probability is potentially beneficial, it is easy for assessors to ‘fake’ their value, eg by assuming air movement which is precluded by the form of development.
- As far as I am aware, the system will give a much higher rating for slab-on-ground than for the same building with an elevated floor – 5 or 6 Stars compared to 2. This appears to be ‘hard-wired’ into the engine, and runs contrary to empirical evidence in this region.
- The engine cannot model some features known to be of value in tropical design, such as Bernoulli devices (high-level vents which operate under differential pressure produced by natural airflow). These will be assessed as operating under convective forces only.
- In the case of NatHERS/AccuRate at least, modelling of the building is descriptive rather than graphical, and time-consuming and prone to error even for conventional dwellings. The software is unlikely to be efficient in modelling a complex tropical-style design.
- As a result, in Queensland the most commonly used “front end” is now BersPro.

Design Guides, “Sustainability Assessment” Systems, SmartHousing and Affordability:

AMCORD and the Queensland Residential Design Guidelines

Readers are advised not to use the principles outlined in AMCORD (Australian Model Code for Residential Development). Earlier editions were seriously counter-productive where tropical design was involved. The latest version is better, but it appears AMCORD is no longer being updated. Some of the principles are incorporated in the “Your Home” Technical Manual. Amcord was replaced in Queensland by the Queensland Residential Design Guidelines, but it appears this is no longer being maintained.

Generally, design guides are only useful if they specifically relate to tropical design, and preferably, written by practitioners with experience in tropical design.

“Sustainability Assessment” Systems

A number of these are currently being promoted, and seek to assess dwellings against “triple bottom line”, life cycle, environmental issues and the like. Most originate from ‘down south’ and contain values which, again, are counter-productive if used in the tropics. In one system a 200m² house on a 400m² lot is given a positive value, whereas experience in the tropics shows that this type of dwelling is very likely to be a problem, particularly if surrounded by other similar properties. Again – not recommended unless tropical design issues are addressed.

Smart Housing

This was an initiative of the Queensland Department of Housing, and contains recommendations for a whole range of issues relating to dwellings, such as adaptability, internal layout which will allow for disability (eg wider corridors, lever door-handles), security and the like. The basic ‘list’ adds very little to the total cost of the dwelling, and should therefore be considered by even the most cash-strapped customer.

Affordability

In 2004 the Queensland Department of Housing issued an ominous report predicting major problems with housing affordability – predictions which are turning out to be accurate. There have recently been a number of exemplars for “sustainable dwellings” where the cost per square metre is double that of the main housing stock. Sustainability and climate-response have no value if the bulk of clients cannot afford the cost.

Climate-Responsive Design is about Principles, not Rules

Climate-Responsive Design includes principles such as east-west orientation, not placing habitable areas or amenity spaces on the western side, but it must be recognised that these are principles, not rules. Sites will have specific features or constraints which are more important than the principles. For example:

- The western side might have a major view, eg river, hills, etc. In this case, the view wins, and the CRD issues must be solved another way. The western elevation needs to be protected, but some consideration can be given to what exists on the western boundary or beyond it, eg dense vegetation or a two-storey building .
- The north-east airflow is considered paramount, but if there is a major highway in close proximity on the north-east side, it might be better not to capture the airflow directly.
- There is little point in aiming to capture airflow directly through doors and windows if the airflow is skimming over the top of the building. In this case, Bernoulli vents should be considered.

References

[A number of these are no longer traceable so have been omitted]

Koenigsberger, Ingersoll, Mayhew and Szokolay, Manual of Tropical Housing and Building – Part 1 Climatic Design, Longman London 1974.

[Part 1 was the only part published, and is largely the work of Steven Szokolay. Steven was one of the judges for the Design Competition mentioned above. The book has been in print for some time, but in the opinion of this author has not yet been surpassed.]

Su San Lee, PhD Thesis, Natural Ventilation and Medium Density House Forms in the Tropics, 1998, Institute of Tropical Architecture, James Cook University.

This document is referenced in the Queensland Government archive of documents and also at Townsville City Council. Part of the document exists as code in the Townsville City Council's planning scheme of 2014.

www.townsville.qld.gov.au

Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley, November 2006.

Richard Aynsley Ph.D was formerly UNESCO Professor of Tropical Architecture, and Director, Australian Institute of Tropical Architecture, James Cook University, 1993-2000. Copies of the above and related documents should be obtainable by Internet search.

An earlier version of the document you are reading has been referenced by Dr Aynsley in research commissioned by Thuringowa City Council, May 2007.

Martin Clark's website tropicdesign.net.au contains the current copy of this document and other useful resources.