PART 2

PILBARA MIX USE BUILDINGS
Many Pilbara communities are about to experience major redevelopment of their town centre in response to the anticipated industrial and population growth in the region. Hedland and Karratha have been identified as the future cities of the Pilbara region, each with a projected population of 50,000 people. This major infrastructure redesign will include higher density mix-use and residential developments close to key amenity. It will also provide a diversity in housing not currently offered in Pilbara towns.

In larger towns, most mix-use and high density residential development will be three to four storeys. Smaller towns will require higher density development of low rise buildings, so the towns can retain their existing pedestrian-friendly size. Medium to high density low rise developments are significantly more expensive to construct per square meter than their high rise counterparts. For towns, such as Onslow which is expected to triple in size in the next few years, higher density development is a critical component if they are to contain growth within a compact town scale.

The simultaneous expansion of all these towns provides an opportunity to test innovative planning and design which responds to the place of its location. We can expect high density development to become part of the urban fabric of the Pilbara. We need to prepare for this development by assessing, and being alert to, the opportunities and constraints of the Pilbara region.

Many of the planning and design strategies recommended in the other parts of the Pilbara Vernacular Handbook will be useful and should be considered in the development of mix-use buildings. This chapter provides guidance to key design and development considerations specific to medium to high density buildings. However, it can only provide overarching strategies and there are micro considerations specific to each site and town which the developer and designer need to address.

The mix-use strategies respond to the same design values as the urban realm and housing strategies in the Pilbara Vernacular Handbook.

These strategies respond to the Pilbara context. Other generic aspects of mix-use development, such as passive surveillance, signage, vehicle parking, acoustic separation, life cycle of the building are not fully addressed in this chapter and information is readily available in the BCA and local government Town Planning Schemes (TPS).

### DESIGN PRINCIPLES

- Design for shade
- Plan for Pilbara conditions
- Plan for cross ventilation
- Use building elements to create a more comfortable living environment

- Use vegetation, especially native vegetation, to create a comfortable environment
- Work with the local terrain

- Adapt for local conditions
- Design for the Pilbara lifestyle
- Acknowledge outdoor living

- Diversify through flexibility
- Provide accommodation choices
- Plan for comfortable access and movement

- Design for the life cycle of a building
- Explore new construction systems
- Embrace new technologies
The creation of a comfortable environment for pedestrians during the day is essential for successful activation of town centres in the Pilbara. Higher density buildings can contribute to this by providing shading to footpaths, open spaces and adjacent buildings. The building volume can be used as a powerful shading device if it is designed to respond to solar movement patterns.

**DESIGN FOR SHADE**

- Use the building to provide shade for pedestrians on the street below.
- Use the building to provide shade for adjacent buildings and the pedestrian spaces in front of them.
- Use the building to shade itself and its outdoor living areas.
- Cardinal orientation with a long east-west axis allows a building to have most of its openings and glazing on the north and south facades. This minimises openings and glazing to the east and west which are exposed to the early morning and late afternoon sun and are most difficult to protect from direct solar access.
- Cardinal orientation provides greater opportunity to design effective shading devices such as screens, awnings, canopies and louvres. Use vertical devices on the west and east facades and horizontal devices on the north facade.
- Outdoor living areas located on the south facade can maximise the benefits of shading from the building. Using the sun to warm the interior of a building is not a priority in the Pilbara. However, temperatures drop in the coolest months sufficient for living areas to benefit from limited direct solar access in some towns.

**REFER TO PILBARA GENERAL: RESPONDING TO CLIMATE - Minimising Conditions That Create Heat Islands**

Using a building to shade a the street and adjacent buildings is a common traditional practice. Marrakech, Morocco
Responding to CLIMATE

DESIGN FOR SHADE: CARDINAL ORIENTATION

To maximise shade in an urban environment, it is important to analyse and understand the movement of the sun so that built form can be used to control and limit direct solar exposure. Overshadowing can deliver desirable pedestrian conditions throughout the year as well as throughout the day in the public realm as well as outdoor areas within a development.

Key to effective overshadowing is working with cardinal orientation to achieve the most effective responses to solar movement patterns. This is demonstrated in the following diagrams. *

- The minimum height of a building can be calculated to determine effective overshadowing to the street and adjacent buildings. AS A RULE OF THUMB, FOR A 20M WIDE ROAD RESERVE, AN EQUIVALENT HEIGHT BUILDING IS REQUIRED FOR EFFECTIVE SHADING ACROSS THE STREET.
- Buildings on the south side of a street provide most of the street shading during the hottest months (October - March) and can significantly cool the public realm micro climate.
- Northern buildings provide shading during the cooler months (April - September) and, due to the lower sun angles, a lower height building can provide effective street shading.

OBJECTIVE:
PEDESTRIAN SHADE ON BOTH SIDES OF THE STREET FROM 7AM TO 5PM.

Road reserve: 20m
North building height: 16.5m
South building awning/overhang depth: 3m

OUTCOME:
The street and pedestrian areas are in full shade throughout the day but relies on the awning/overhang of the south building to provide shade on the south side at midday. *

OBJECTIVE:
PEDESTRIAN SHADE ON BOTH SIDES OF THE STREET FROM 7AM TO 5PM.

Road reserve: 20m
North building height: 16m
South building awning/overhang depth: 4m

OUTCOME:
The street and pedestrian areas are in full shade throughout the day but relies on the awning/overhang of the south building to provide shade on the south side at midday. *
PILBARA MIX-USE BUILDINGS

**Responding to CLIMATE**

**DESIGN FOR SHADE:**

**CARDINAL VS. NON-CARDINAL ORIENTATION**

Cardinal orientation is a benchmark from which to assess the shading effectiveness of buildings which have non-cardinal orientation. By analysing shadow patterns, we can see that beyond 15 degrees off north, a building’s ability to create maximum shade is compromised. At 10 degrees off north, the shading is significantly less compromised. The analysis provided below outlines the overshadowing effectiveness of a lot/building when its long axis is east-west and is rotated up to 10 degrees and 15 degrees off north in each direction.

**DESIGN FOR SHADE: CARDINAL VS. NON-CARDINAL ORIENTATION**

- Ensure the building orientation minimises the amount of external wall area exposed to direct solar access by orienting the long axis east-west.
- Cardinal orientation with the building's long axis east-west is the most effective orientation for blocking solar access for a maximum number of months during the hottest period of the year in the Pilbara.
- A building can be rotated off north by up to 10 degrees and still achieve the benefits of cardinal orientation. The only difference between rotation east or west is that the sun penetration is in the morning (east) or afternoon (west).

### JANUARY: SUMMER

<table>
<thead>
<tr>
<th>Objective: Maximum Street Shade</th>
<th>Cardinal</th>
<th>80' off North (+10')</th>
<th>75' off North (+15')</th>
<th>100' of North (-10')</th>
<th>105' of North (-15')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of street shade coverage from south building</td>
<td>GOOD COVERAGE</td>
<td>VERY GOOD COVERAGE</td>
<td>VERY GOOD COVERAGE</td>
<td>LOW COVERAGE</td>
<td>LOW COVERAGE</td>
</tr>
<tr>
<td>Number of hours of no shade to street</td>
<td>10am - 2pm (4hrs)</td>
<td>12.15pm - 4.15pm (4hrs)</td>
<td>11.15am - 5pm (5.45hrs)</td>
<td>8am - 2pm (6hrs)</td>
<td>7am - 1.30pm (6.5hrs)</td>
</tr>
<tr>
<td>North building shade</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### MARCH/SEPTEMBER

<table>
<thead>
<tr>
<th>Objective: Maximum Street Shade</th>
<th>Cardinal</th>
<th>80' off North (+10')</th>
<th>75' off North (+15')</th>
<th>100' of North (-10')</th>
<th>105' of North (-15')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of street shade coverage from north or south building</td>
<td>LOW COVERAGE until 7.30am: 20%</td>
<td>GOOD COVERAGE 50-60% am 35% pm</td>
<td>GOOD COVERAGE 70% am 40%pm</td>
<td>LOW COVERAGE 10% am Maximum</td>
<td>LOW COVERAGE 20% am Maximum</td>
</tr>
<tr>
<td>No shade to street - south building</td>
<td>8am - 4.30pm</td>
<td>9.10am onward</td>
<td>9.40am onward</td>
<td>Provides no shade</td>
<td>Provides no shade</td>
</tr>
<tr>
<td>North building shade</td>
<td>8.30am - 4.15pm</td>
<td>10.20am onward</td>
<td>10.40am onward</td>
<td>6am - 3pm</td>
<td>7.30am - 3pm</td>
</tr>
</tbody>
</table>
PILBARA MIX-USE BUILDINGS

Responding to CLIMATE

DESIGN FOR SHADE: USING BALCONIES TO SHADE A BUILDING

Fundamental design principles that create a more comfortable living environment in single housing are also appropriate for larger buildings.

Using a building to shade itself can have a significant effect on the comfort of internal spaces as well as outdoor living areas such as balconies and terraces.

The balcony can also be used as a shading device to protect walls from direct solar access.

In this study, we look at the depth of a balcony required to provide optimum shading to the walls behind it.

- North facing balconies need to be deep to avoid direct solar exposure to the north facing external walls and openings. (Figure 1)
- If the north facing balcony depth is 4000mm, it will prevent all winter sun falling on the rear wall. This applies a building orientated up to 15° off north in either direction.
- Balconies facing south do not need to be as deep to achieve optimum protection from the sun. (Figure 2)
- A south facing balcony will block all summer sun on the rear wall if the balcony depth is 3000mm. This applies a building orientated up to 15° off north in either direction.

REFER TO PILBARA GENERAL: Responding to CLIMATE - Control Solar Heat Gain
PILBARA MIX-USE BUILDINGS

Responding to CLIMATE

DESIGN FOR SHADE
USING BALCONIES TO SHADE A BUILDING

This study demonstrates the solar penetration to the balcony and the wall behind it during the hottest months of the year, October to March. It shows the impact on shading when an east-west axis building is rotated off north. We have worked with a 15 degree rotation in each direction at which point shading is significantly compromised.

CARDINAL (0’ long axis east-west)
75’ OFF NORTH (+15’ long axis east-west)
105’ OFF NORTH (-15’ long axis east-west)

75’ OFF NORTH (+15’ long axis east-west)
No solar penetration to the rear wall during the hottest months of the year. Significant direct solar penetration to the rear wall only occurs during June - July.

OUTCOME
Orienting a building with north facing balconies with its long axis within 15 degrees off north will not negatively impact on effective shading during the hot summer months.

SOUTH FACING BALCONY
75’ OFF NORTH (+15’ long axis east-west)
Early morning sun on wall until 6.30am, balcony is completely shaded by 9am in October. November to January solar penetration to wall progressively increases to 50% (7.45am), balcony completely shaded by 11am. In February, 30% solar penetration to the apartment wall until 7.30am, balcony in complete shade from 11am. One of the hottest months, January has the maximum solar penetration to the wall but only up to 7.30am.

105’ OFF NORTH (-15’ long axis east-west)
Late afternoon sun on wall from 5pm October and exposure progressively increases to a maximum of 50% (4.30pm) in January, reducing to 30% (5pm) in February. March, no solar penetration to the apartment wall occurs, with the balcony being penetrated from 2.30pm, to a maximum floor coverage of 45% (5pm). January, sun penetration starts from midday and increases to 70% floor exposure (4pm), with wall penetration soon after.

OUTCOME
Orientating a building with its long axis as close to cardinal as possible will minimise direct solar penetration.

For buildings with south facing balconies, the further the long axis is orientated towards 15 degrees off north, the higher the amount of direct solar penetration to the rear wall during the hottest months of the years. The only difference in the two orientations is whether the sun penetration is in the morning or afternoon.
Responding to CLIMATE

PLAN FOR PILBARA CONDITIONS

Building form and its proximity to other buildings can be used as an effective strategy in providing shade to an adjacent building’s exterior.

The three planning typologies illustrated here are appropriate to Pilbara conditions. Double loaded buildings, where rooms or apartments are accessed from a central corridor, are not an appropriate planning solution for the Pilbara because the opportunities for cross ventilation are severely restricted.

1. SINGLE LOADED COURTYARD TYPE
   - **Advantages:**
     - The building provides shade for outdoor areas within the development.
     - The building provides a built edge/frontage to the street and more privacy spaces behind.
   - **Disadvantages:**
     - Some apartments will be oriented east-west and therefore difficult to shade.
     - Cross ventilation of the courtyard area needs to be accommodated or that area can become uncomfortable
   - **RECOMMENDATION:**
     Use in town centres or where a built frontage is required.

2. SINGLE LOADED TYPE
   - **Advantages:**
     - Cardinal orientation can be optimised.
     - Passive solar heating is not a priority design strategy. Living areas can be oriented to the north or south.
     - Cross-ventilation within the unit and through the site.
   - **Disadvantages:**
     - Difficult to address the street on corner sites.
   - **RECOMMENDATION:**
     Use on sites that have either a dual north and south street frontage or a single street frontage.

3. TOWER TYPE
   - **Advantages:**
     - Visual and acoustic privacy
     - The opportunity to zone for different residential types (short stay and permanent with separate and shared amenity).
     - Layout could be designed so adjacent building either shades early morning and late afternoon
     - Easy access for all apartments to cooling breezes
   - **Disadvantages:**
     - More wall area to shade.
     - Potential increase in development cost.
   - **RECOMMENDATION:**
     Use in locations that have access to cool breezes, but avoid placing buildings within the wind shadow of another.
PILBARA MIX-USE BUILDINGS

Responding to CLIMATE

PLAN FOR CROSS VENTILATION

The variation in climate conditions across the Pilbara is usually due to proximity to the sea or elevation above sea level. Closer to the coast, cross-ventilation strategies will be more effective than inland. In areas which receive cooling sea breezes, the primary consideration is maximising opportunities for interior and exterior living spaces to have access to these breezes. For inland towns that do not receive cooling breezes during hotter months, it is crucial to maximise the shading of the building and its immediate surroundings. Correct orientation of a building can minimise solar access on the long facades using very simple shading strategies.

High level wind speeds slow down considerably over urban development. Therefore, we need to introduce planning and building design strategies which maximise opportunities for natural ventilation and good air movement.

The effect of humidity on human comfort is most noticeable when air temperatures are high and air movement is low. The coastal areas of the Pilbara experience humidity throughout the year, particularly during the summer wet season. Strategies to encourage natural ventilation and air movement can greatly enhance the comfort of residents and should be incorporated into all multiple residential and mix-use building design.

PLANNING

- In larger development sites, dividing the building into smaller blocks will improve air movement.
- For a development that requires a single volume, designing ground and upper floor void areas will enable breezes to penetrate into structure and also assist with purging of hot air.
- Use walls to assist with drawing air into the interior by incorporating air ducts, vents and wind catchers.
- Use wing walls adjacent to openings along windward walls to deflect wind into the house.
- Movable walls can be adjusted to suit wind direction, particularly adapting to seasonal changes.
- Stagger external walls to control air flow.
- Cross ventilation can easily be achieved by ensuring that there are openings on opposite sides of the building. Open plan living areas encourage air movement through all parts of the dwelling.
- Breezeways can allow air movement through the built form, cooling and assisting with air flow to the adjacent rooms and spaces that the breezeway crosses through. Breezeways can also be effective in encouraging air flow and provide shaded connections from the front to the rear of a building.
- Inland sites should be planned in response to the direction of hot winds and use walls or screens for protection.

DESIGN CONSIDERATIONS

- Protecting the interior of the building from direct solar access will reduce the load on mechanical cooling and help reduce household power costs.
- When double loaded buildings are required, they need to be designed with elements which enable cross ventilation, such as operable skylights and ducted vents. (Figure 1)
- Ceiling fans in all habitable rooms can create air pressure zones which stimulate air flow. They can work independently or in combination with mechanical air conditioning to cool indoor areas. A minimum ceiling height of 2.7 meters, with fans offset 0.3 meters below are more efficient. Offsetting fans from the centre of the room will create a more effective air movement.
- Use open weave materials, such as perforated metal mesh, timber battens and trellis, for awnings and pergolas to enable hot air to flow through, rather than be captured and directed into the interior.
- Use hinge casement windows and doors on the downwind side of buildings to deflect breezes into the interior.

Figure 1: Opportunities for cross ventilation in a double loaded corridor building.

Atrium type voids can enable air cross ventilation in rooms within a single volume building.

Screened exterior stair access - single loaded apartment
Responding to CLIMATE

PLAN FOR CROSS VENTILATION: OPENINGS
Most places in the Pilbara have sufficient clear sky days throughout the year to minimise window sizes without compromising the quality of natural light internally. Large expanses of glazing are not a good design option. Instead, thoughtful placement of smaller windows and different shapes, such as strip (ribbon) windows, skylights and long, narrow winds should be considered.

- By adjusting the size and orientation of windows, the air flow and air exchange in internal spaces can be controlled and improved. The Mahoney Tables can be used to calculate internal heat gain and loss, and recommend that openings make up only 10-20% of the wall area.
- Smaller openings on the windward side of the building and larger openings on the leeward side can create negative pressure inside which assists with cross ventilation.
- Smaller windows will help reduce heat transference from the outside without compromising light levels in interior spaces.
- Specify glazing which reduces internal heat gain, such as Low E (low emissivity), double glazing or tinted glass. The reduction in heat gain can be substantial.
- Non-glazed openings, such as timber louvre shutters or hinged timber panels will also allow air flow into internal spaces without exposing the interior to direct sun.
- By locating openings at different heights, cool air can be drawn in at lower levels and hot air expelled through higher openings.

Examples of placement of openings to enable cross ventilation in various apartment configurations.
ZONING OF ROOMS

- Consider how the occupants will use the internal spaces. Divide the spaces into zones for daytime living, nighttime living, sleep and circulation. This is particularly valuable if there are shift workers who need cool bedrooms during the day, but do not need to cool the entire house. The air conditioning system can then be programmed to suit the zoning.

- Design living areas that can be separated from the circulation spaces for more efficient use of mechanical (active) cooling systems. (Figure 1, 2)

- Seal the entry area to minimise hot air entering the unit. Non-habitable circulation spaces that are passively ventilated can be useful to mediate and control the heat entering from outside into the mechanically cooled living areas, further improving efficiency and minimising energy use. Ventilate stairwell with high operable opening such as a clerestory window or skylight. (Figure 1)
PILBARA MIX-USE BUILDINGS

Responding to CLIMATE

USE BUILDING ELEMENTS TO CREATE A MORE COMFORTABLE LIVING ENVIRONMENT

In the Pilbara, building elements which contribute to protection from the sun and improve air flow need to be at the forefront of design decisions.

- Balustrades, screens, shutters, awnings and external blinds can be used to improve the performance of the building which, in turn, helps to reduce running costs of mechanical cooling and ventilation.
- Balustrades should always be permeable in the Pilbara. Any solid component must be placed at well spaced intervals. Permeable balustrade panels such as mesh, woven wire, perforated metal and timber slats enable air flow but retain privacy and safety. (Image 1, 5, 6)
- Vertical screens are effective on east and west walls and are particularly effective for blocking early morning and late afternoon sun (Image 4)
- Permeable materials are more desirable in the Pilbara because they enable air flow but block direct solar access to the interior. (Image 1, 2, 3)
- Screens and awnings which are adjustable and operable are more beneficial than fixed elements. (Image 1, 2, 3)
- Fabric blinds are usually easier to retrofit and are replaceable (Image 1, 5).
- Natural timber slats are attractive and effective, but alternatives that are lower in maintenance are preferable. Recycled plastic and composite timber battens that reference timber qualities are an alternative to timber. (Image 2)

1. Metal mesh balustrades are permeable and also provide visual privacy. Purpose designed blinds when not in use roll into a cavity within the ceiling. This type of detail could be adapted for cyclonic regions

2. Timber-look screens avoid the maintenance demands of natural timber as well as provide privacy, shading and air flow to the interior of the building. The glass balustrade is unsuitable in the Pilbara because it is impermeable.

3. A timber slat interpretation of the traditional garage roller door offers privacy, shading and limited ventilation. The system would need to be designed to meet cyclonic standards.

4. Vertical screens are particularly appropriate for providing protection to east and west facing facades

5. Open balustrades and adjustable roller blinds are cost effective elements that address shading and ventilation

6. Balustrades and screens can be integrated into the facades of the building and do not have to be projecting ‘add-on’ elements
Responding to CLIMATE

USE BUILDING ELEMENTS TO CREATE A MORE COMFORTABLE LIVING ENVIRONMENT

Self shading building design is a traditional technique used in hot climates. The built form can provide sun protection to the facade, its openings, circulation areas - including stairwells - internal spaces and external living spaces such as balconies, terraces and courtyards.

Double skin design is also very effective in protecting walls from direct solar access and is evident in early buildings in northern Australia. The traditional Queenslander and Broome pearler's house typologies have a double skin of permeable screen of lattice or timber slats wrapped around a verandah which, in turn, wraps around a centre core. Double skin construction is an appropriate design response for higher density developments in the Pilbara. A variety of permeable systems for the outer skin, using metal, timber and synthetic materials, are available.

SELF SHADING BUILDING DESIGN
- Using the built form to shade itself is an efficient way to successfully create shade without the need for costly additional screening and projections.
- The form and depth of walls can be used to shade openings. (Image 1)
- By recessing balconies and terraces into the building volume, creates a shade zone in front of the wall opening as well as shading the balcony. (Image 3)
- Where a lot does not provide an opportunity for optimal building orientation, the upper level(s) can be orientated independent of the ground level to create shade for the ground level and more effective protection from the sun for the upper levels. (Image 2)
- Self shading materials, where the face of the element shades itself, such as segmental brick or precast concrete forms can be used when heavy mass material is required. (Image 3)

DOUBLE SKIN FACADE DESIGN
- Mechanically controlled double skin facades such as the Institut du Monde Arabe (Arab World Institute), Paris which has an external skin which respond to sun angles, is not currently financially viable in the Pilbara, but may be a consideration for the long term minimisation of energy use in high density buildings. (Image 4)
- A double skin facade design can be as simple as a second framed wall or a vertical screen (refer previous page). If used on east and west walls, it can effectively protect the inner wall from direct solar heat gain and the subsequent re-radiation into the apartments habitable rooms. (Image 5)
Responding to CLIMATE

USE BUILDING ELEMENTS TO CREATE A MORE COMFORTABLE LIVING ENVIRONMENT

Horizontal eaves, overhangs and projections which are part of the structure of the building can reduce the need for add-on shade elements such as awnings, blinds and shutters. Therefore, they can be a cost efficient response to shading north and, to a limited degree, south facing walls. These elements can be strong visual features of the building’s facade and need careful design consideration.

WING WALLS, EAVES, OVERHANGS and PROJECTIONS

- Wide eaves, overhangs and projections have been successfully employed in many of the original houses in the Pilbara and would seem an intuitive climatic response. (Image 1-4)
- Currently, no examples of mix-use climate and site responsive development exists in the Pilbara. Look to developments in Queensland which articulate these elements.
- The images on this page demonstrate a ‘form follows function’ design philosophy, whereby the defining elements of the building form perform a critical function of either shading or ventilation.
- Timber is not recommended as a building material in the Pilbara because of its susceptibility to termite attack.
- Wing walls positioned next to openings can be used to catch cooling breezes and direct them through the opening to interior or outdoor living spaces. (Image 3, 4)
- Wing walls can also be used to block prevailing hot winds. (Image 3, 4)

1. Deep eaves project over the two levels providing shade to both levels
2. Balconies partially cantilever out towards the road, large eaves provide deep shade to the top floor and integrates projecting sections into one cohesive building volume
3. Deep eaves with vertical fins that provide shade from low angle sun as well as potentially acting as blocking hot winds.
4. Providing shade to windows is a minimum requirement for any higher density building in a hot climate
Responding to CLIMATE

USE BUILDING ELEMENTS TO CREATE A MORE COMFORTABLE LIVING ENVIRONMENT:

STREET AWNINGS
Awnings with a minimum span of three metres can make a strong connection between the building and its streetscape, benefiting both.

- Deep awnings over shop fronts will shade both the glazing and the footpath, creating more comfortable conditions for pedestrians and encourage greater street activation.
- Exterior double volume awnings enable hot air to rise well above the pedestrian and also provide shading to windows, balconies and footpaths.

COVERED ENTRY
- Deep awnings can also provide protection to the entrance of the building as well as identifying the entrance.
- A shaded exterior entry acts as an important transition from the outside heat into the cooler interior of the building.
- A shaded entry will create passive cooling at the entry which can ease the load on internal mechanical cooling and help reduce running costs. Using shade for passively cooling at the entry will also assist in making interior passive cooling systems more effective. Consider an air lock entry for optimal cooling efficiency.

1. The awning is punctuated at regular intervals with fixed louvres to facilitate hot air being released through the awning. Passive design solutions that release hot air from within the awning will prevent hot air from being trapped

2. Balconies that extend into the road reserve can be integrated with the street awning. Where no provision for this has been made, setback the ground floor to enable a sufficient size awning to shade pedestrians and provide shaded seating areas

3. A shaded entry area integrated within the form of the building

4. An awning extending into the road reserve provides shade for pedestrians whilst balconies are contained within the lot boundary

5. Balconies extending into to the road reserve providing the street awning

6. An example of an attached shaded entry element, referencing the predominante construction material used in north Australia.
PILBARA MIX-USE BUILDINGS

Incorporating the NATURAL LANDSCAPE

USE VEGETATION, ESPECIALLY NATIVE VEGETATION, TO CREATE A COMFORTABLE ENVIRONMENT

Vegetation should not be underestimated as an effective building shading strategy in medium to high density developments. Vegetation, especially trees, can also contribute to effective cooling of outside areas, by screening and filtering direct solar penetration.

SHADING AND SCREENING

- Using trees in combination with other built shading strategies. Trees are a low cost shade solution for all facades and, through careful site planning and species selection, can complement built shading elements.
- Trees to the east and west, set back from the building can provide shade in the morning and afternoon when the sun is low in the sky.
- Use trees to filter prevailing hot winds.

REFER TO PILBARA GENERAL:
Responding to CLIMATE - Minimising Conditions that Create Heat Islands

CASE STUDY: HIGH DENSITY MIX USE DEVELOPMENT

This plan is an example of an appropriate planning response for a development site in a Pilbara town. An open courtyard building type, offers ground floor retail and commercial tenancies, as well as permanent and short stay apartments with private open space and at ground carpark.

The landscaped area between the carpark and building creates a cool buffer area that minimises the carpark heat re-radiation from entering the building. Trees planted within the garden area provide facade shading and street trees effectively shade the facades that have a zero (0) metre lot setback.

Figure 1. Trees to the east and west can provide effective shading at low sun angles.
Incorporating the NATURAL LANDSCAPE

WORK WITH THE LOCAL TERRAIN

Heavy rain for short intense periods is the typical Pilbara rainfall pattern. The Pindan soil in the Pilbara does not filtrate water quickly and, therefore, large volumes of stormwater require a combination of water dispersion, detention and infiltration systems to ensure safe dispersion of water and avoid flooding.

- Dispersion of stormwater into the road network and into large swales is typical in the Pilbara. Higher density buildings collect significant amounts of stormwater to the road network from their impermeable carparks and large roof areas. To ensure that on site stormwater does not flood the road system, it needs to be detained on site for a short period and the rate at which water enters the road drainage network needs to be slowed. This can be done by channelling the movement through surface flow and piping.
- Infiltration is a less effective method due to the impermeable nature of the soil, but can offer additional on site infiltration for smaller amounts of water. This has the added benefit of watering vegetation if designed appropriately.
- Due to the short bursts of high volume water, any openings in the kerb structure risk eroding loose stone mulch. Any kerb perforations need to be designed to slow water flow and, at the same time, direct it away from buildings.
- Permeable paving in carpark detention areas is a passive infiltration method that can complement detention carpark design.
- Carpark design should also avoid large single areas of carpark. Instead plan for smaller separate parking zones with vegetation between them.
- Ground floor levels need to be designed to meet the 100 year flood level as a minimum.

REFER TO PILBARA GENERAL:
RESPONDING TO CLIMATE - Minimising Conditions That Create Heat Islands
WORK TO LOCAL CONDITIONS;
ENHANCING LIVABILITY - Design for Water

CARPARK PLAN

An open courtyard type plan with ground floor retail and commercial, short stay apartments with open space and at ground carpark.

- Stormwater surface dispersion route to the road
- Piping of detained stormwater into the road network
- Concrete kerb
- Breaks in kerb BUT detail design required to avoid high volume flow
- Building
- Stone mulch garden area
- Impermeable asphalt detention basin
- Permeable paving detention bowl allows for the slow infiltration as well slow dispersion of stormwater to the road
PILBARA MIX-USE BUILDINGS

Building on the PILBARA CHARACTER & IDENTITY

ADAPT FOR LOCAL CONDITIONS

Buildings with heavy thermal mass construction can be appropriate in the Pilbara and can be effective in stabilising internal room temperatures if designed correctly.

Heavy mass walls need to be protected from direct solar access. Heat absorbed by heavy mass walls during the day is radiated into internal spaces at night, making rooms particularly uncomfortable for sleeping.

Deep eaves, building overhangs, balconies, porticos, colonnades, canopies, awnings and dense shade trees can all be used to provide shade to reduce the absorption of heat.

THERMAL MASS

- The thermal mass of masonry is 30% more effective if constructed as an inner leaf and covered with a lightweight outer leaf with insulation between. This is commonly called reverse brick veneer. The veneer surface will shade the masonry and the air gap between the two leaves will also allow for air movement which keeps masonry surfaces cooler.

LIGHTWEIGHT CONSTRUCTION

- Lightweight construction will transfer heat more quickly, but also loses heat quickly. If adequately insulated, a lightweight wall does not re-radiate heat as does heavy mass.

INSULATION

- A combination of insulation batts (low heat transfer) and aluminium foil (reduced radiation) in a wall or roof cavity will provide the best combination of insulation. The highest R-value should always be specified to help reduce the load on mechanical cooling.

- Heat gain through the roof can be mitigated by using light coloured roof cladding and a high R-value insulation together with reflective foil.

COMPOSITE MATERIAL USE

- Designs should also consider a mix of building materials which respond to the climate. For example, use light weight construction for the walls on the east and west where low angle sun is more difficult to shade and masonry for the southern and northern facing walls with large overhangs and balconies.

AN EFFECTIVE EXAMPLE OF COMPOSITE MATERIAL USE

1. Braced concrete core contains stairwell, lift, entry, bathrooms and services for each level.

2. Fixed to the core is the framed floor and walls for the dwelling living and bedroom areas, plus balconies. The inner heavy thermal mass helps stabilise the dwelling temperatures, the lighter framed exterior protects the concrete from heat build up with the additional layer of perimeter balconies adding another layer of solar protection to the dwelling living rooms.

3. Permeable shade screens and balustrade design protects balconies from direct solar penetration whilst facilitating ventilation.

REFER TO PILBARA GENERAL:

Building on the PILBARA CHARACTER & IDENTITY - Work with Pilbara xriendly Materials
Responding to CLIMATE - Work to Local Conditions
PILBARA MIX-USE BUILDINGS

Building on the PILBARA CHARACTER & IDENTITY

DESIGN FOR THE PILBARA LIFESTYLE

A consistent comment expressed by residents living in the Pilbara is their love of being able to live outside almost all year round. The provision of room size balconies in mix-use and multiple residential developments needs to be a primary consideration in ensuring that the benefits of living in a warm climate can be enjoyed in higher density developments.

At the hottest times of the day, staying inside is a sensible option. In the evening, outdoors living areas can be more pleasant, when night temperatures drop and the interior is still holding the heat from the high daytime temperatures. In areas with cooling breezes, outdoor areas will provide more exposure to these breezes.

Single houses can add these facilities after construction. However, it is more difficult to add these spaces to a multiple housing development and, therefore, careful thought needs to be given to balconies, terraces and communal outdoor spaces in the early stages of design development.

ROOF TOP SHARED TERRACE
ADVANTAGE: Residents have a very large outdoor entertaining area. Easily ventilated and ideal for evening use. Can be used for hydroponic gardens.
DISADVANTAGE: The roof area receives the maximum solar exposure and if not well designed it would be uninhabitable in a hot climate.

ROOF TOP PRIVATE TERRACES
ADVANTAGE: Provides a large outdoor space which is often left unoccupied. Needs fixed and adjustable shade and ventilation elements - can’t rely on shading from the building or balconies above. Additional drainage systems likely to be needed especially for roof gardens adding to construction costs.

CANTILEVER BALCONIES outside the building envelope
ADVANTAGE: More control in the ability to ventilate and cool. Night purging is more effective.
DISADVANTAGE: Compromises privacy because it requires residents to actively adjust the screening and roof element. More expensive construction.

ENCLOSED BALCONIES within the building envelope
ADVANTAGE: The units above provide protection from direct sun and heat build up.
DISADVANTAGE: The balcony will be slower to cool. If there are no access to cool breezes and a build up of hot air trapped under the balcony roof is likely.

TERRACES - GROUND FLOOR
ADVANTAGE: Setbacks from the street offer the ground floor unit to have a large terrace with garden, offering amenity not available in an upper unit.
DISADVANTAGE: Only ground floor units can have a terrace that can easily accommodate larger vegetation such as trees.
PILBARA MIX-USE BUILDINGS

Building on the PILBARA CHARACTER & IDENTITY

DESIGN FOR THE PILBARA LIFESTYLE
The priority for higher density buildings is usually to maximise internal space and provide the minimum requirement for outdoor living. However, in the Pilbara, medium and high density apartments must have direct access to a usable private and communal usable outdoor spaces with good amenity such as barbecues, dining tables and chairs and lighting. Balconies and terraces need to be designed with the lifestyle and comfort of the occupants clearly realised. This will enable occupants to seek out the coolest temperatures and best exposure to cooling breezes. Amenity for barbecues and eating outdoors also means that the interior is not further heated by cooking and will help reduce the load on internal mechanical cooling.

OPTIMUM SIZED OUTDOOR LIVING

ACCEPTABLE FOR SMALLER UNITS

TOO NARROW TO BE A FUNCTIONAL OUTDOOR ROOM - NOT RECOMMENDED IN THE PILBARA

BALUSTRADE (FIGURE 1)
- Materials: metal mesh, woven wire, perforated metal, timber slats or timber-look slats. Use the maximum spacing possible under building standards.
- AVOID Glass, masonry and any solid panel balustrade.

SCREENS (FIGURE 2, 3)
- Horizontal permeable screens can be used for growing creepers, for additional privacy and to personalise the living area.
- Adjustable vertical louvre maximise air flow. Can shield from direct sun throughout the day and year. Adjustable is more expensive. (Figure 4)
- AVOID solid panel screens

BALCONY ROOF (FIGURE 4, 5)
- A solid roof offers total weather protection but will trap hot air. A small opening will help alleviate this.
- Outdoor fans will provide air movement under a solid roof.
- Adjustable louvres are ideal for cantilever balconies and roof tops by offering maximum flexibility in shading, ventilation and is waterproof when required. It is also the most expensive option.
- Fixed louvres or a pergola structure with battens angled according to the building’s orientation provides shade and ventilation.
PILBARA MIX-USE BUILDINGS

Enhancing LIVABILITY

DIVERSITY THROUGH FLEXIBILITY

The Pilbara towns are under pressure to provide a range of housing to meet the needs of the existing and future workforce. Single lot houses are the dominate housing type and this will continue. However, there is an opportunity and demand for alternative residential typologies.

Mix-use development has very specific locations in which it can be developed as defined by the local government Town Planning Scheme (TPS). The influence that mix-use development type will have in meeting the housing shortage will not be overly significant.

Some people also have concerns about living in a mix-use development, such as the noise generated by commercial trucks entering the premises during the early hours of the morning, rubbish storage of commercial tenancies, operating hours of food and liquor outlets. These conflicts within mix-use developments are well documented, however, with careful planning and design can be minimised.

- Towns need a range of residential apartments from bedsits to multiple bedroom family accommodation. The diversity of accommodation options needs to be within a development as well as across various developments.
- Consider the lifestyle and work patterns specific to Pilbara residents. For example, single workers sharing an apartment might each require their own bathroom. People living away from home might want additional accommodation for visiting family and friends.
- Accommodation options need to cater for various socio-economic groups, for example, a two bedroom apartment could be 65m2 or 90m2; one or two bathrooms; one or two living areas.
- A range of fittings and fixtures also provides diversity, giving homeowners a choice of affordable to luxury fit out, and enabling the same apartment to be offered to different market groups.

SINGLE STOREY MIX USE DEVELOPMENT

ADVANTAGES:
Single storey mix-use buildings should be considered for the Pilbara and could be financially more feasible because of the high cost of multiple level construction.
In smaller towns, single level developments are sufficient to meet accommodation demand.
Small studio units can be utilised as subsidised employee accommodation to attract workers to relocate to the area.

DISADVANTAGES:
Longer term future growth could require higher density development. If all usable land area with the town centre is occupied by single storey development, the opportunity to infill with multiple level mix-use

Minimum recommended apartment sizes:
1 bed x 1 bath: 45-50m2
2 bed x 1 bath: 60-65m2
3 bed x 1 bath: 80m2
PILBARA MIX-USE BUILDINGS

Enhancing LIVABILITY

DIVERSITY THROUGH FLEXIBILITY

MULTIPLE LEVEL MULTI-RESIDENTIAL PLAN

Roof Level (Level 4) (apartment over two levels)

Level 3 (apartment over two levels)

Ground Level and Level 2

MULTIPLE RESIDENTIAL LARGE APARTMENT

3 bed x 2 bath: 160m2 offers larger living areas.

Assuming the following apartment sizes which are larger than market standards:

- 2 bed x 1 bath: 71m2
- 2 bed x 1 bath plus study: 75m2
- 3 bed x 1 bath: 83m2
- 3 bed x 2 bath: 107m2
PILBARA MIX-USE BUILDINGS

Enhancing LIVABILITY

PLAN FOR COMFORTABLE ACCESS AND MOVEMENT

The advantage of higher density development is the opportunity to provide a high volume of accommodation in close proximity to services and amenities. Higher density developments are often located close to retail and commercial centres and public open space. Residents can access these services and facilities on foot rather than driving.

In the Pilbara, the hot climate reduces the distance people are prepared to walk to access services and facilities.

- Continuous shaded pedestrian paths between buildings can provide relief from direct sun
- Compact urban planning with co-location of community and commercial services and amenities can reduce the distance that pedestrians must walk in the heat.
- Mix-use and multiple residential developments within close proximity to key open space amenity should consider reducing their private open space requirement by contributing financially towards improving the amenity of the nearby public open space. Public open spaces within comfortable walking distance of a mix-use development can used as an outdoor living area by residents. This can reduce the expectation for outdoor areas within the development. Beyond a comfortable walking distance to the public open space, outdoor amenities will be required within the development site for residents. (Figure 1)
- Pedestrian routes which reduce travelling distance should be incorporated into the planning of mix-use development sites such as diagonal paths across a site. (Figure 2)
- Increase effective usable, shaded pedestrian space along the street by setting back the ground floor. The upper level overhang and awnings can shade pedestrians and outdoor eating areas. (Figure 3)

ADVANTAGE

- Reduced maintenance costs of outdoor amenity. This could be shared with the local government
- Increased street and public open space activation contributing to a more dynamic social life of a place.

DISADVANTAGE

- If the path to the public open space is not well shaded and enticing the appeal and utilisation of the public open space is likely to be reduced.

REFERR TO PILBARA GENERAL:
ENHANCING LIVABILITY - Incorporate Access & Connections to Open Space
BUILDING ON THE PILBARA CHARACTER & IDENTITY - Consider Streetlife
MOBILISING FOR CHANGE - Town Centre Vitality
Mobilising for CHANGE

DESIGN FOR THE LIFE CYCLE OF THE BUILDING

Rapid change is occurring in the Pilbara. Currently, housing demand is greater than the demand for commercial floor space in almost every Pilbara town. Both housing and services supply will continue to grow in line with the growth of the region’s resource industries. However, there is a limit to the commercial floor space that is sustainable within each town and, in the future, this could contract as locals turn to the internet to provide retail and commercial services. Buildings need to be designed so that they can respond to both current and future demands. Fast tracking development to meet immediate demand risks creating short term solutions which do not consider how a building might adapt to future changes. Mix-use developments on the fringes of town centres can mediate between housing and commercial requirements with ground floor spaces which can be adapted to either use. The following examples are design strategies for adaptable mix-use buildings.

DUAL KEY UNITS

- Dwellings need to offer alternative living arrangements which have the ability to grow and contract with demand.
- Dual key units offer the flexibility for units to be used by one or two occupant groups. They can also be used by different demographic groups. A family can occupy the total space or singles or couples could occupy two separate units. This would seem an appropriate accommodation in the Pilbara for future residents. Improved amenity, education and services are expected to attract more long term residents. There is also the option for the homeowner of a dual key unit to live in one unit and to rent out the second unit.

ADAPTABLE DESIGN

- Design street facing and ground floor residential units so they can be adapted into commercial units once demand is sufficient.
- Design for adaptation from the beginning so that changes can be made with minimal cost and re-construction work.
EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region.

Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

EXPLORE NEW CONSTRUCTION SYSTEMS

A building site is one of the most difficult environments to achieve production efficiency and quality control. Health and safety, supply of skilled labour and materials and transportation costs are additional challenges when building in remote areas such as the Pilbara. Prefabrication can alleviate some of these problems and is a viable option for medium to high density development in the Pilbara region. Currently, prefabrication is generally specified because it is cheaper. However, this is at the expense of a standard of finish and flexibility of design which on-site construction offers.

The challenge for prefabrication suppliers is to provide a product which can be used in more diverse ways, such as prefabricated pods for wet areas, ‘flat pack’ systems and assembly options for a hybrid of off site/on site construction.

PREFACTRICATED OPPORTUNITIES IN MEDIUM TO HIGH DENSITY DEVELOPMENTS

1. Precast concrete core containing stairwell, lift, entry and bathrooms and service core for each level.

2. A combination of in-situ and prefabricated elements form the internal and external walls, floors and balconies.

3. Prefabricated balustrades, sunshades, screens and louvred panels.

1. Precast concrete core containing stairwell, lift, entry and bathrooms and service core for each level.

2. A combination of in-situ and prefabricated elements form the internal and external walls, floors and balconies.

3. Prefabricated balustrades, sunshades, screens and louvred panels.

BENEFITS OF HYBRID CONSTRUCTION

• Production cost savings
• Faster construction programme for accelerated settlements
• Reduced deliveries to site
• Reduced site supervision
• Reduced material and product tracking and movements

• Less on-site labour movements
• Reduced time spent on defects
• Enhanced cost control
• Enhanced quality control
• Reduced on site skilled labour
• Reduced cleaning and rubbish removal
• Reduced material damage and theft.

A high quality prefabricated bathroom pod in Spain (note lightweight walls instead of concrete are likely to be used in the Pilbara)

Pilbara Vernacular Handbook / Part 2-25
Mobilising for CHANGE

EMBRACE NEW TECHNOLOGIES

Mechanical cooling will always be required in high density buildings in the Pilbara. Passive cooling strategies can reduce the dependence on mechanical cooling and, in turn, reduce household power costs. Low energy technologies can further reduce power costs.

Most airconditioning in the Pilbara is refrigerant based DX systems (direct expansion of split system) which are either wall mounted or ducted into the ceiling cavity. DX systems cool the room air using an indoor fan coil unit, removing heat to the refrigerant and then rejecting the heat from the refrigerant to atmosphere at an outdoor condenser unit. Fresh air is supplied by a separate ducted system to the fan coil unit intakes.

DX systems are simple mechanical devices, are easy to install and can be provide cooling for a single room, a single house or larger commercial and residential buildings. Using ceiling fans with mechanical airconditioning can help to reduce the load on the mechanical system and, in turn, reduce power costs.

The cooling technologies suggested here are alternatives to the DX system. Some are being widely used in commercial and residential development whilst others are yet to be adopted in the wider market but offer potential for future projects.

CHILLED/VENTILATED SLABS

Ventilated floor slabs are a fan-assisted cooling and ventilation system. The hollow core of concrete floor slabs are used to distribute cooled fresh air. Air passes through the hollow core at low velocities, allowing prolonged contact between the air and the slabs. This enables a heat exchange between the supplied air and the slab which results in a stable air flow into the building.

The variation in temperature between the air entering the room and the temperature of the concrete slab is no more than 2°C.

Chilled beam systems are a very convection cooling system which is suited to large buildings. Pipes of water are passed through a heat exchange beam in the ceiling. As the beam chills the air around it and the denser chilled air falls to the floor, it is replaced by warmer air moving upwards which is then cooled, creating a constant flow of convection. Active chilled beam systems used ducts to push air towards the beams, increasing the cooling capacity.
Mobilising for CHANGE

LOW VELOCITY CEILING FANS

In warm weather, the air movement produced by ceiling fans provides cooling by increasing the rate of evaporation from the skin surface and will help to achieve a higher level of comfort at elevated temperatures.

High volume low speed fans can provide an efficient way to stimulate air flow and air exchange which helps to cool large areas such as covered outside areas, halls, community centres and shopping centres. They run at low speeds and utilise their size to move the air around at low velocity. Low velocity fans reduce energy consumption because fan energy is proportional to the square of the air velocity. An increase in velocity of two times will result in a four times energy increase.

It is recommended that ceilings are 4m or above, as the blades need to be at least 3.05m above floor level and require approximately one metre overhead clearance.
Mobilising for CHANGE

EMBRACE NEW TECHNOLOGIES

**DISPLACEMENT VENTILATION**
Displacement ventilation is an all-air system that provides cooling by supplying air at low level (either by floor grilles, low level wall-mounted grilles or bollard type) and extracting hot air at high level.
The supply air for cooling also provides internal air exchange/fresh air ventilation. Free-cooling (cooling without refrigeration) for ventilation can be used if cooling is not required.
The system works best with high ceilings greater than 3m (the higher the better)
Supply air temperature can be higher than other systems (a few degrees below room temperature) therefore the system can be more energy efficiency because it doesn’t have to produce low chilled water temperatures.

**CHILLED WATER FAN COIL UNITS**
Chilled water based fan coil units are an alternative to DX fan coil units. Chilled water is used as the heat transfer medium rather than a refrigerant pipework distribution and outdoor condenser unit.
The equipment space for indoor units is similar to the DX system, whereas the outdoor plant space depends on the heat rejection option: air cooled chiller or water cooled chiller with heat rejection via borehole.
This system is significantly less efficient than displacement ventilation and this technology would need to be refined to make it more efficient if it is to be considered.
SOLAR COOLING
Solar cooling technologies are based on the concept of using heat from solar collectors to drive a cooling system such as absorption chillers which operate by taking heat input to drive the refrigeration process rather than taking mechanical work input.
Absorption chillers are less efficient than air and water cooled chillers, the main advantage being the use of solar energy as a power source and therefore the reduction in power costs over mechanical cooling systems.
Various forms of solar collector can be used to provide heat for the absorption chiller including flat plate collectors, evacuated tube collectors, linear concentrating collectors, parabolic dish concentrating collectors or combinations these.

DISTRICT COOLING SYSTEMS
Makes chilled water at night when electric rates are low and stores it in large tanks until needed by customers.
A plant chills water to about 6°C and delivers it to buildings.
Chilled water is delivered via an insulated underground pipeline to offices, industrial and residential buildings to cool the indoor air, within a district.
Specially designed units in each building then use this water to lower the temperature of air passing through the building’s air conditioning system.
Chilled water circulates through refrigeration coils and fans cool a building’s air by blowing it across the refrigeration coils.
The output of one cooling plant is enough to meet the cooling-energy demand of dozens of buildings.
District energy systems are less expensive to implement when they are planned before new developments are built, or if the piping can be installed alongside other infrastructure.