PART B4

SUSTAINABLE DEVELOPMENT
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SECTION 1–INTRODUCTION

Bankstown Local Environmental Plan 2015 is Council's principal planning document to regulate effective and orderly development in the City of Bankstown. The LEP provides objectives, zones and development standards such as lot sizes and floor space ratios.

Part B4 of Bankstown Development Control Plan 2015 supplements the LEP by providing additional objectives and development controls for water and energy efficiency in development in the City of Bankstown.

Part B4 applies to buildings with a classification of Class 5 to Class 9 under the Building Code of Australia.

Objectives

The objectives of Part B4 of this DCP are:

(a) To have the design and operation of development incorporate water conservation measures.

(b) To have the design and operation of development incorporate energy efficient practices.

Part B4 aims to achieve these objectives by specifying development controls for water conservation and energy efficiency. Compliance with these controls will be verified either when the application for a compliance certificate is being considered, or in the case of controls that apply to larger development (those above 5,000m$^2$) through information provided with the development application and by the inclusion of relevant conditions of consent.

Developments affected by Part B4

Part B4 of this DCP specifies development controls for development. The controls may apply in the following situations:

(a) new proposals requiring a development application;

(b) extensions to all existing development that greater than or equal to 5,000m$^2$ of gross floor area; or

(c) extensions to existing development below 5,000m$^2$ of gross floor area where the development seeks to expand by an amount of 50% or more of the existing floor area.

Where extensions to existing uses are subject to Part B4, the controls apply only to that part of the building being extended.
In the case of proposals for mixed residential and commercial development and mixed commercial and industrial development, controls for the relevant components apply (i.e. commercial controls apply to the commercial component, and the industrial controls for the industrial component).

For the purposes of Part B4, retail uses have generally been included in the term “commercial development”, although there are some instances where separate controls have been specified for retail and commercial uses. Elsewhere in Part B4, it should be assumed that the same controls apply to retail and commercial uses unless stated otherwise.

Part B4 does not apply to proposals involving a change of use.

Summary of development controls

Table 1 summarises the development controls that are included in Part B4 of this DCP (refer to sections 2 and 3 of Part B4 for the exact requirements of the controls).

**Table 1**: Summary of water conservation and energy minimisation controls.

<table>
<thead>
<tr>
<th>Type of development</th>
<th>Controls that apply</th>
<th>Energy Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Conservation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New development where floor area is below 5,000m² OR An extension to an existing building below 5,000m² where the extension involves 50% or more of the existing floor area</td>
<td>W1 Water efficient fixtures must be installed</td>
<td>E1 Building must be designed to enhance energy efficiency AND E2 Energy efficient hot water systems, air conditioners and lighting must be installed OR E4 Building to achieve rating of at least 4 stars under the SEDA Greenhouse Rating Scheme (alternative for new commercial development)</td>
</tr>
</tbody>
</table>

Refer to text for advice on how to comply
| Extension or new development where floor area equals or exceeds 5,000m² | W1 | Water efficient fixtures must be installed  
AND  
A site water management plan must be prepared |
|---|---|---|
| W2 | E3 | An energy performance report must be prepared  
OR  
Building to achieve rating of 4 stars or better under the SEDA Greenhouse Rating Scheme  
(alternative requirement for new commercial development) |
| E4 | Refer to text for advice on how to comply | Refer to text for advice on how to comply |
SECTION 2–WATER CONSERVATION CONTROLS

Objectives

The objectives are:

(a) To have more sustainable use of water in development by:

   (i) increasing the efficiency of mains supply water use; and

   (ii) providing for on site collection and re use of rainwater, grey water and stormwater runoff.

Development controls

The development controls to achieve the objectives are:

2.1 Proposals for new development with a gross floor area less than 5,000m$^2$ and proposals for extensions to existing developments below 5,000m$^2$ seeking to expand by 50% or more of the existing floor area must comply with Requirement W1.

2.2 Proposals for new development or extensions with a floor area greater than or equal to 5,000m$^2$ of gross floor area must comply with Requirements W1 and W2.

Requirement W1: Use of water efficient fixtures

The following controls are mandatory and will be implemented by way of conditions of consent which will be verified when the application for a compliance certificate is being considered.

All taps, showerheads, toilet suites (cisterns, urinals) used in the development must be rated to at least 4 stars under the National Water Efficient Labelling and Standards (WELS) Scheme (refer below).

National water conservation rating and labelling scheme

The Water Efficient Labelling and Standards (WELS) Scheme is administered by the NSW and Australian Government and is designed to make more efficient use of Australia’s potable water supply.

At present, the full 6 star rated items are not readily available across all fixtures. However for basin tap ware the full 6 star rated item is available. The following star ratings are required for compliance with this DCP.

(a) shower heads 3 stars–8 litres or less per minute;

(b) basins Taps 6 stars–4.5 litres or less per minute
(c) toilet cisterns 4 stars—4 litres or less per flush.

A comprehensive list of products that meet the above water consumption requirements of this DCP can be viewed at the Australian Government website at www.waterrating.gov.au.

**Requirement W2: Site water management plan**

All proposals with an intended gross floor area equal to or greater than 5,000m$^2$ (whether multi use or single use) must submit with the development application, a site water management plan that investigates and where feasible provides for the integrated management and use of water for the proposed development.

Matters to be addressed in the water management plan include proposals for reducing mains water supply use by using other water sources including the following:

(a) preparation of an integrated water collection and recycling system for the capturing and recycling of rainwater. The system should preferably be integrated with the mains supply water system and should provide for the reuse of captured water in the development. Appropriate uses for recycled water would include car washing, dust control, watering of gardens, flushing of toilets and similar uses;

(b) proposals for capturing and reusing grey water on the site. Appropriate uses for recycled water would include car washing, dust control, watering of gardens, flushing of toilets and similar uses (refer to Appendix 1 for more information on grey water reuse);

(c) proposals for capturing and reusing stormwater from the site. The need for any treatment of stormwater prior to reuse should be considered;

(d) proposals (where feasible) of treating and reusing any process water generated by the development; and

(e) proposals for controlling the quality of waste water that is to be disposed of.

**Notes:**

The water management plan must be submitted with the development application and will be considered in the assessment of the application.

The relevant findings of the site water management plan must be incorporated into the proposed development. Conditions of consent will be included to implement this requirement.

Appendix 1 includes more information in relation to this requirement.
SECTION 3–ENERGY MINIMISATION CONTROLS

Objectives

The objectives are:

(a) To have energy efficiency in the design and operation of development proposals. This is done by:

   (i) promoting the use of energy efficient principles in the design of a facility; and

   (ii) ensuring the ongoing operations of the facility incorporates energy minimisation measures.

Development controls

The development controls to achieve the objectives are:

3.1 Proposals for new development where the total gross floor area is below 5,000m$^2$; and extensions to existing uses below 5,000m$^2$ that involve an increase in 50% or more of the existing gross floor area must comply with Requirements E1 and E2.

3.2 Proposals for new development, or extensions where the total gross floor area equals or exceeds 5,000m$^2$ must comply with Requirement E3.

3.3 Commercial development (either above or below 5,000m$^2$) elect to comply with Requirement E4 as an alternative to Requirement E1 and E2, or E3 as applicable.

Requirement E1: Energy efficient building design

The following requirements are mandatory and will be implemented by way of conditions of consent which will be verified when the application for a compliance certificate is being considered.

The following energy efficiency measures are mandatory, and must be incorporated into the building design:

(a) Measures to maximise solar access and natural lighting. The building should be designed and oriented to maximise solar access and natural lighting. This should be done by:

   (i) orientating the building so that its longest side is on the east west axis (where possible);
(ii) maximising the number of windows on the northern face of the building and minimising glazed areas on the eastern and western walls of the building (i.e. providing for most of the glazed areas on the northern face of the building);

(iii) warehouses must be fitted with skylights to 10% of the roof area; and

(iv) consider and include where feasible the following features: skylights, clerestory windows, light wells, light tubes, atriums and similar features.

(b) Measures to maximise natural heating, cooling and ventilation. The building should be designed to minimise the need for mechanical heating and cooling (air conditioning). This must be done by:

(i) ensuring that all windows are rated to at least four (4) heating stars under the Australian Windows Councils Windows Energy Rating System (windows must also satisfy Australian Standard 2047 for air infiltration performance);

(ii) incorporating external shading devices (e.g. overhangs or shutters) into the design of the building for all west facing windows;

(iii) consider and incorporate where possible other features to maximise natural ventilation, including: use of openable windows, grills or vents, use of high level ventilation to release warm air as it rises, use of fans and the use of ridge vents and cowlings on the roof; and

(iv) include appropriate insulation. Insulation should be provided that meets the following standards:
   Walls: R = 1.5 or greater;
   Floors: R = 1.0 or greater;
   Roof/Ceiling: R = 2.5 or greater.

Requirement E2: Energy efficient hot water systems, air–conditioning and lighting

The following requirements are mandatory and will be implemented by way of conditions of consent which will be verified when the application for a compliance certificate is being considered.

Energy efficient hot water systems

The development must incorporate a hot water heating system that is energy rated to at least 4 stars. The preferred system is either a gas boosted solar system, or a 5–star gas system, with appropriate insulation to the tank and pipes (refer to box for a list of different types of water heaters that have a rating of 4 stars or higher).
### SEDA rating of hot water heating in terms of energy efficiency

<table>
<thead>
<tr>
<th>Source of Energy</th>
<th>Storage</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Gas Boost (solar contribution 50%)</td>
<td>Storage</td>
<td>5 stars</td>
</tr>
<tr>
<td>Gas</td>
<td>Instantaneous</td>
<td>4</td>
</tr>
<tr>
<td>Gas–Storage</td>
<td>High Efficiency</td>
<td>4</td>
</tr>
<tr>
<td>Electric–Storage</td>
<td>Heat Pump</td>
<td>4</td>
</tr>
<tr>
<td>Gas–Storage</td>
<td>Low Efficiency</td>
<td>4</td>
</tr>
<tr>
<td>Solar Electric Boost (solar contribution&gt; 50%)</td>
<td>Continuous</td>
<td>4</td>
</tr>
<tr>
<td>Solar Electric Boost (solar contribution&gt; 50%)</td>
<td>OP2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Note 1:** The most energy efficient hot water heating system is a gas boosted solar system. A 5 star gas system is almost as energy efficient and probably less costly to install. In general, gas systems are more energy efficient than electric and also compare well with electricity systems in terms of price.

**Note 2:** The efficiency of a water heating system can be improved by positioning it close to main areas of use, such as the kitchen or the bathroom. Efficiency can also be improved by insulating the pipes and the tanks and including thermostatic controls.

### Energy efficient air conditioning

(a) Where mechanical heating and cooling (i.e. air conditioning) is required, energy efficient systems must be used. Options include:

(i) SEDA rated air conditioners (note: the SEDA rating scheme for air conditioners only applies to those up to 7.5kW. These are mainly appropriate for domestic and household use. However those uses that do use air conditioners of this capacity should select a SEDA rated appliance); or

(ii) where systems that exceed 7.5kW power output are required, air conditioning systems that comply with the Minimum Energy Performance Requirements in Australian Standard 3823.2 should be selected.

(b) Air–conditioning in new hotels should operate on a demand or room occupational basis only.
Energy efficient lighting and lighting control systems

(a) Energy efficient lighting must be used in the development. The following lighting options should be specifically considered and incorporated unless they are not suitable for the development:

(i) use of compact fluorescent or tubular fluorescent lamps, instead of standard incandescent bulbs;

(ii) use of triphosphor fluorescent instead of halophosphor fluorescent lights;

(iii) use of electronic ballast instead of magnetic ballasts in fluorescent lights;

(iv) use of compact fluorescent or low voltage tungsten halogen lights instead of tungsten spotlights;

(v) use of solar powered or metal halide or sodium discharge lamps for outside areas such as car parks;

(vi) (for industrial applications) use of high pressure sodium lamps instead of mercury vapour lamps for high intensity discharge lighting;

(vii) use of energy efficient starters.

(b) Lighting control systems should be developed having regard to energy efficiency. The following matters should be considered and incorporated unless found not to be feasible:

(i) designing lighting systems to match the level of lighting that is required; (for example, warehouses with skylights installed in the roof should also link the lighting to photoelectric dimming devices);

(ii) use of lighting controls to ensure that lights are used only where and when they are needed. For example, timed switches or occupancy detectors in areas with only sporadic uses, and that switch off after hours;

(iii) use of reduced voltage lighting systems.

Requirement E3: Submission of energy performance report (developments in excess of 5,000m²)

All proposals for new development and extensions to existing uses for buildings greater than or equal to 5,000m² must submit with the development application an Energy Performance Report (EPR) prepared by a suitably qualified energy consultant. The EPR should propose a strategy for ensuring that the development minimises its energy use. It should include the following:
(a) Design issues: The EPR should demonstrate how the building has been designed to minimise energy use. This must address all of the design principles included in the Design Guidelines for Development (refer to Appendix 2).

A copy of these Design Guidelines must be obtained from Council, and the Design Report that is required to satisfy Requirement E3 should address the objectives of each of the Design Elements specified in the Design Guidelines.

(b) Lighting, air conditioning and hot water: The EPR should also address the energy efficient lighting, air conditioning and hot water requirement specified in Requirement E2 above.

(c) Operational energy: The EPR should consider the energy requirements for the operation of the proposed facility and show how energy minimisation measures will be incorporated. This should include:

(i) estimate the intended energy use of the facility (including the intended use where possible) in MJ/square metre per annum, and review this projected energy use against existing industry benchmarks and best practice guidelines where these are available;

(ii) results of consultation with SEDA and their publication entitled “The Energy Smart Toolbox–Energy Savings Manual”. The EPR should outline how the comments of SEDA (and the publication referred to above) have been considered for inclusion in the development;

(iii) outline other steps that have been taken to minimise energy use in the operation of the building/facility. This should (inter alia) identify how energy efficient plant and equipment has been incorporated in the development; and

(iv) ongoing energy management of the facility. The EPR should consider the need for an energy management system for the building/facility.

Requirement E4: Greenhouse rating of new commercial buildings (alternative requirement to E1, E2 or E3 for new commercial buildings)

As an alternative to complying with Requirement E1 and E2 (development below 5,000m²) or Requirement E3 (development above 5,000m²), proposals for new commercial development can elect to have the proposed building Greenhouse Rated under the Sustainable Energy Development Authority’s Greenhouse Rating Scheme.

The applicant will then agree to enter a commitment based agreement under the Scheme to obtain a rating of 4 stars or better for the operation of the building. This will then be made a condition of development consent and subject to monitoring.
For development involving a mixed commercial industrial development that elect to have their building rated under this scheme, the four star rating needs to be obtained for the floor area that is occupied by the commercial component (note: there is no Greenhouse Rating Scheme presently operating for industrial developments).

**The SEDA greenhouse rating scheme**

Commercial buildings in Australia generate around 35 million tonnes of CO$_2$ as a result of the energy they consume. These emissions are expected to almost double by 2010. The Building Greenhouse Rating Scheme is a program for office buildings, designed to identify the potential of a building to reduce greenhouse emissions.

The ratings incorporate a “star” system, and are based on energy related greenhouse gas emissions, adjusted to account for climate and how the building is used. The more stars, the better the performance.

The star rating is derived from the actual amount of energy consumed by the building in a year, and determining the buildings “greenhouse impact”. A 4 star rating would indicate excellent energy performance due to design and management practices or high efficiency systems and equipment and low greenhouse intensive fuel supply.

The scheme identifies the potential for reducing greenhouse emissions, for example, by identifying energy efficiency improvements (such as the installation of energy star office equipment), and the use of “Green Power”.

APPENDICES

Appendix 1–Additional information about Requirements W2 and E3

The following information has been included as some additional background information about Requirements W2 and E3.

Requirement W2: The preparation of a site water management plan

The site water management plan is intended to ensure that large developments consider the capture and reuse of water from rainwater, stormwater, grey water and process water. In preparing the site water management plan the following matters should be considered:

(a) Rainwater capture devices

In preparing the site water management plan, it may be recommended that water tanks (or other rainwater capture devices) be installed to provide for the capture and the reuse of water. In installing tanks or other rainwater capture devices, the following principles should be borne in mind:

(i) plumbing the tanks into the mains water supply system: it is far more preferable for water tanks to be plumbed into the system and water piped directly to the toilets for flushing, rather than for them to be used for more passive uses such as garden watering;

(ii) plumbing connections: Sydney Water requires that tanks and similar devices keep their water entirely separate from the existing water supply system. A backflow prevention device will also need to be installed to ensure there is no direct connection to water mains supply, and (for tanks that are plumbed into the system), a valve is needed to allow switching between the tank and mains supply water. Contact Sydney Water for further information;

(iii) taps: any taps from these devices should be marked so as to prevent use of water that is collected being used for human consumption;

(iv) materials: rainwater tanks can be made from galvanised steel, polyethylene, fibreglass, concrete or masonry, and can be designed in shape and colour to blend with building design;

(v) location: location of rainwater capture devices should be done so as to minimise their visual impact;

(vi) structure: matters to be considered include: ensuring an appropriate support structure and foundation, ensuring child proofing, including covering and contaminant screens;

(vii) noise: any pumps installed in association with the tanks should comply with all relevant noise control standards;
(viii) overflow: any overflow water should be piped preferably into a stormwater detention pit and made available for reuse. It may be possible to pipe the overflow into the stormwater drainage system. It should not be piped to the sewerage system.

Consideration should be given to the following documents in the design, installation, operation and maintenance of rainwater tanks: NSW Ministry of Health Guideline GL2007_009 titled “Use of Rainwater Tanks where a Public Supply is Available”; Enhealth document titled “Guidance on the Use of Rainwater Tanks 2010”; and Australian Guidelines for Water Recycling “Managing Health and Environmental Risks (Phase 2): Stormwater Harvesting and Reuse (July 2009)”.

(b) Grey water recycling

The following matters should be considered when considering a grey water reuse scheme:

(i) grey water often requires separation and treatment before it can be reused;

(ii) all applicants should consult with NSW Health (the responsible Government authority on grey water recycling, and ensure that any comments made by NSW Health are incorporated into the site water management plan for grey water reuse;

(iii) The NSW Health website (www.health.nsw.gov.au) also provides useful information about grey water recycling.

The reuse of grey water for non–potable purposes may need to be licensed by the NSW Independent Pricing and Regulatory Tribunal under the Water Industry Competition Act 2006 or approved by Council under section 68 of the Local Government Act 1993.

Consideration should be given to the following documents in the design, installation, operation and maintenance of grey water reuse systems: Australian Guidelines for Water Recycling “Managing Health and Environmental Risks (Phase 1) 2006”; and NSW Department of Primary Industries: Office of Water “Interim NSW Guidelines for Management of Private Recycled Water Schemes”.

(c) Reuse of stormwater

The reuse of stormwater for non–potable purposes may need to be licensed by the NSW Independent Pricing and Regulatory Tribunal under the Water Industry Competition Act 2006.

Consideration should be given to the following documents in the design, installation, operation and maintenance of grey water reuse systems: Australian Guidelines for Water Recycling “Managing Health and Environmental Risks (Phase 1) 2006 and “Managing Health and Environmental Risks (Phase 2): Stormwater Harvesting and Reuse (July 2009)”. 
Requirement E3: preparation of an energy performance report

The requirement for an Energy Performance Report (EPR) has been included for larger development to ensure that they address the issue of energy use on an ongoing basis, from the planning and design stages, and through to the ongoing operation of the facility.

The matters that will need to be addressed will depend upon the size and the nature of the operation. Some large development (such as warehouses) could have a relatively low energy requirement in comparison to some industrial processing operations. In such cases, the EPR could be relatively brief. Some general guidance concerning the compliance with this requirement, and the matters that should be addressed in the EPR are shown below.

Energy efficient design

The total energy use of a building can be significantly affected by the way it is designed. It has been estimated that careful attention to passive design can reduce the total energy consumption of a building by about 50%. The aim of passive design is to get maximum value out of the building elements–making the building itself, rather than additional systems do the work of keeping the occupants comfortable. Good passive design can eliminate or substantially reduce the load on heating, cooling and ventilation systems, thus providing savings in operational energy and reductions in greenhouse emissions.

It is a requirement of Part B4 of this DCP that all development over 5,000m² prepare a Design Report that explains how design considerations have been incorporated into the building to enhance its energy efficiency. To assist applicants in preparing the Design Report, Council has commissioned the preparation of a set of Design Guidelines by the consulting firm Team DES.

Appendix 2 contains a copy of these Design Guidelines, and the Design Report that is required to satisfy Requirement E3 should address the objectives of each of the Design Elements specified in the Design Guidelines.

Operational energy

Some uses will naturally use a significant amount of energy during their operation. The EPR should look for opportunities for minimising energy use during the operation of the facility. Matters that the EPR should address are as follows:

(i) estimate of total energy use: the purpose of this is to help engender a proactive approach towards energy use during the operation of the development, and to serve as a benchmark from which a consideration of energy reduction measures can be considered. The EPR is also asked to compare uses against industry benchmarks. Government Authorities such as SEDA, and the Australian Greenhouse Office can provide assistance in providing information on typical amounts of energy used by different uses, although in many cases this information may not be available;
(ii) consultation with SEDA. Applicants are encouraged to use plant and equipment that is energy efficient, where of course this does not affect their operations. The EPR should detail what steps will be taken to ensure that the most energy efficient equipment has been used. In this regard, applicants are required to consult with SEDA (NSW Sustainable Development Authority) and to review their publication entitled the “Energy Smart Toolbox” and particularly the Energy Savings Manual. This manual provides handy hints about the use of energy saving equipment for a range of different applications. Please list the recommendations from this manual that have been incorporated into this development.

The requirement for consultation with the NSW Sustainable Energy Development Authority (SEDA) is to ensure that advice from the State Government regarding energy efficiency can be incorporated where feasible. SEDA, as the States leading Government authority on energy efficiency prepares numerous publications on enhancing energy efficiency. The advice of SEDA should be obtained, and its findings incorporated where possible.

**Ongoing energy management**

The need for an energy management system should be considered to help minimise energy use during the life of the facility. This will be applicable mainly for high energy use facilities.
Appendix 2–Design guidelines for development

1 Background information

1.1 Introduction

These design guidelines supplement Part B4 of this DCP.

In particular, it is intended that they be used by larger development (in excess of 5,000m² of gross floor area) to comply with the controls of Part B4 of this DCP.

The guidelines outline the basic design principles that need to be taken into account before submitting a development application for development where the gross floor area of the development exceeds 5,000m².

Council is not asking applicants to conform to every design concept described in these guidelines. The concepts that apply will vary according to the nature of the site and the activities that are proposed to occur. However, Council does require that all proposals for new buildings, or extensions to existing buildings larger than 5,000m² of gross floor area, submit a Design Report that demonstrates how the concepts addressed in these guidelines have been considered in the design of the proposed development.

The guidelines were prepared for Council by the consulting firm Team D/E/S, with some minor amendments being made by Council.

1.2 Principles of passive design

The aim of passive design is to get maximum value out of the building’s elements making the building itself, rather than additional systems, do the work of keeping occupants comfortable. Good passive design can eliminate or substantially reduce the load on heating, cooling and ventilation systems, thus providing savings in operational energy and reductions in greenhouse emissions.

Passive design involves the use of siting, orientation, form and fabric (the main construction materials) of a building to create comfortable internal conditions that eliminate or reduce the need for mechanical systems of heating, cooling and ventilation. A key principle of passive design involves exposing or shading a building’s thermal mass to solar radiation and moving air across it according to seasonal conditions.

For winter, passive design strategies are used to minimise heat loss and maximise heat gain. In summer the aim is to minimise heat gain and maximise heat removal.

Correct orientation, use of windows to receive winter sun where appropriate but which are shaded in summer, incorporating appropriate amounts of thermal mass into the right parts of the building, the use of insulation and provision for natural ventilation are important passive design strategies for heating and cooling.
These approaches are appropriate for dwellings, but need to be modified for non-residential buildings. For example, direct sunlight penetration into workplaces is generally undesirable for safety reasons. This limits the use of internal thermal mass for solar heat gain. On the other hand, passive approaches to lighting—substituting diffused or indirect daylight for artificial lighting is important for workplaces as they generally consume large amounts of energy for lighting.

Passive design requires making the right design decisions from the very beginning of a project, with careful consideration of:

(a) building orientation and siting to maximise daylighting;
(b) building form, shape and footprint: to optimise solar access, daylighting and natural ventilation thermal mass to minimise summer heat gain and winter heat loss;
(c) building layout to group activities with similar heating, cooling and ventilation needs;
(d) building envelope and insulation for roof, walls, windows and floors to be designed and specified to minimise summer heat gain and winter heat loss;
(e) natural ventilation and cooling: to maximise opportunities and reduce building energy uptake;
(f) daylighting to reduce the need for artificial lighting;
(g) shade and sun control to shade or expose thermal mass and windows as appropriate and to prevent glare problems; and
(h) landscape design to complement other passive strategies, especially for shading and cooling and evaporative cooling as a possible extension of landscape design.

There is no single passive design solution that can be applied to every situation. Appropriate solutions are many and vary according to the circumstances of each site and the functional requirements of the building.

1.3 The Design Report

The purpose of the Design Report is to consider the passive design principles that could be used in the design of the building, with due regard to the type of land use being proposed (for example photographic processors who depend upon darkrooms will clearly have a problems with the delivery of daylight).

The Design Report with appropriate diagrams that should present design strategies in the following areas:

(a) building orientation and siting;
These aspects of passive design are described in more detail in the following pages.
2 Matters to be addressed in the Design Report

The following matters should be addressed in the Design Report:

2.1 Building orientation and design

Objectives

The objective is to have the building’s orientation and siting optimised for passive design strategies that will reduce the need for artificial lighting, mechanical heating, cooling and ventilations systems, and thus contribute to energy conservation.

Development controls

Explain (with use of a Site Analysis Diagram) how the building’s orientation and its position on the site will take best advantage of solar access and microclimatic conditions (such as prevailing summer breezes).

Concept

A building should be placed on its site so as to maximise solar access between 8.00am and 4.00pm at the mid–winter solstice. The north wall and roof should not be shaded by other buildings or by vegetation in mid winter (this is called ‘north wall access’).

If a building is orientated so that the major areas of glazing are facing solar north (Figure 1) this maximises winter sun penetration (because the sun is at a lower angle in winter) and assists in shading in summer when the sun is at a higher angle (Figure 2).

For workplaces, sun penetration needs to be kept away from task areas, but may be able to be utilised for winter heat gain in non-critical areas (e.g. staff canteens, reception areas)—this needs to be designed in relation to thermal mass (refer to Item 3). East and west facing glazing should be avoided because it can be difficult to shade and cause heat gain in summer.

Building orientation and siting also needs to take account of local microclimate. For example, knowing about the direction and intensity of prevailing winds means that the building can be sited to exclude cold winter winds or to take advantage of summer breezes. The effect of adjacent buildings on airflow needs to be considered also (Figure 3).

Glazing on the north facade of a building takes advantage of the sun’s higher angle in summer, requiring less shading. The lower sun angle in winter can be utilised to allow sunlight to penetrate into non–crucial work areas, and thus contribute to the building heat gain.
2.2 Building form and footprint

Objectives

The objective is to have the building’s shape and form maximise the opportunities for passive design strategies that will reduce the need for additional lighting, heating and cooling systems, and thus contribute to energy conservation.

Development controls

Explain in the Design Report (with a diagram if possible) how the building’s form will contribute to energy conservation.

Concept

The shape of a building influences its energy performance according to prevailing climate. The desirability of maximising north wall solar access and having the largest area of glazing on the north façade, while minimising glazing on east and west walls, suggests that a rectangular building along an east–west axis is preferable. This also maximises daylight.

Example: For a 3,200m² two storey building, a rectangular shape of 80m x 20m (providing 80% daylight access) is preferable to a square building of 40m x 40m (with only 40% daylight access).
This is important because lighting can account for up to 50% of total energy consumption in some office buildings. There are of course other alternatives to square or rectangular buildings for providing effective daylight.

Where the site itself prevents the most desirable building orientation and shape (for example a small site hemmed in by tall buildings on three sides), other strategies for achieving energy demand reduction such as daylight, natural ventilation and cooling, will need to be given more attention.

**Related concept**

A building’s form also crucially influences the movement of air around and through it (see natural ventilation and cooling in Section 2.6 and Figure 4).

**2.3 Thermal mass**

**Objectives**

The objective is to have the building’s thermal mass utilised most effectively so as to reduce the need for additional heating and cooling systems, and thus contribute to energy conservation.

**Development controls**

In the Design Report explain how thermal mass will be used in the building to contribute to energy conservation.

**Concept**

Thermal mass refers to the heat storage capacity of materials. Dense materials like stone, brick and concrete have high thermal mass. They absorb heat from surroundings during the day then radiate it when the air temperature cools down. Thermal mass stabilises the inside temperature of a building by acting as a heat sink and source as well as providing a time lag in equalising internal and external temperatures.

The most effective use of thermal mass is to have it in direct contact with the ground, because the temperature below the ground does not fluctuate as much as the air temperature. Thermal mass enhances solar heat gain through north facing windows in winter, absorbing the heat and re-radiating it slowly to warm the internal space.

In summer, thermal mass needs to be shaded to minimise heat gain. Summer cooling can be assisted by directing air over thermal mass that has been pre-cooled by ground contact (also see natural ventilation and cooling). There are also propriety products such as a hollow core concrete slab system through which ventilation air is passed so as to regulate its temperature before it enters the room.
2.4 Building structure and layout

Objectives

The objective is to have the arrangement of internal spaces complement overall passive design strategies, thus minimising energy needed for ventilation, heating, cooling and lighting.

Development controls

In the Design Report, explain how the internal layout of the building has been designed to enhance energy conservation.

Concept

The structural design of a building will influence the possibilities offered for passive design. A structural system that allows for large clear spans and high ceilings can facilitate daylight and airflow, but also requires careful design for heating and cooling.

One favoured method, for example, is to combine concrete slabs with a steel frame, high ceilings and brick infill. This delivers several advantages: a high volume of thermal mass, with clear spans that reduce the need for internal structural walls or piers. This, together with high ceilings and large north facing windows allows for deep daylight/solar penetration. Additionally, such structures afford good end-of-life materials recovery that can offset the structure’s high embodied energy.

The arrangement of the internal areas of the building should complement passive design strategies. This involves careful consideration of location of internal wall and partitions to take best advantage of daylight and natural ventilation. The more walls or partitions, the more complicated it becomes to naturally ventilate and to ‘daylight’ a building. Another way of saving energy is to group together activities into zones with similar heating, lighting, ventilation and acoustic requirements.

2.5 Building envelope and insulation

Objectives

The objective is to have the energy efficiency of the building envelope maximised through appropriate design, choice of materials and insulation.

Development controls

Specify the R–value (thermal resistance value) of the building envelope. The recommended R–value for the building envelope is:

(a) external walls R 1.5; or

(b) external walls and windows (averaged) R 0.4 m$^2$;
(c) floors R 1.0 m²; and
(d) roof R 3.0 m².

**Concept**

Building envelope refers to walls, roof and floor—the building’s external ‘wrapping’, which must be designed to maximise energy efficiency. This involves effectively controlling heat loss and gain using measures such as:

(a) appropriate window to wall ratio (WWR) noting that windows are a major source of heat gain and loss;
(b) selecting windows and glazing with the appropriate light, solar heat gain and heat transfer properties;
(c) thermally appropriate construction materials, appropriate shading systems; or
(d) insulation of wall cavity, roof and window seals.

The building envelope’s thermal performance can be calculated by adding up the R–values of its elements: walls, ceiling, windows, floors and insulation materials. R–values are a measure of thermal resistance. The higher the R–value, the higher the thermal resistance, thus the greater insulating ability of the material or combination of materials.

**Insulation**

Insulation reduces the flow of heat into a building in summer and out of a building in winter. Insulation does not store heat in the way that heavy thermal mass construction materials like brick and concrete do, it just makes it harder for heat to pass through.

There are basically two types of insulation (bulk and reflective).

Bulk insulation reduces heat flow via conduction and convection, it consists of layers of lightweight fibres of particles that trap air. Types available are:

(a) batts or blankets made of rockwool, acrylic fibre or wool;
(b) loose fill cellulose fibre; and
(c) rigid lightweight boards such polystyrene or strawboard.

Bulk insulation is used in walls and ceilings.

Reflective insulation reduces heat transfer by reflecting radiant heat and is usually used under roofs where it effective in resisting downward heat flow from the sun. Composite bulk and reflective insulation is also available; this is often used for flat or raked roofs.
Areas of a building requiring insulation, in order of importance are:

(a) roof and ceilings—where most heat is gained or lost;

(b) walls, which while often having important thermal mass are generally poor insulators;

(c) floors, which only require insulation in cold climates where slabs are exposed to low ground temperatures;

(d) windows, which are very good conductors of heat and are an often neglected area of insulation. Ways of doing this include external shutters, tinted or reflective glass, ‘low e’ (low emittance) glass or double glazed units; and

(e) window frame materials vary in their heat conducting properties with aluminium being high (thus a poor insulator) and timber being low (thus a good insulator).

Note on roof insulation

Studies of low–rise commercial buildings show that significant savings in capital and operating costs can be achieved by using roof insulation.

For example, a review of a new building design proposal showed that savings of $440,000 on heating/cooling plant and $14,000 on annual energy costs could be made by installing $28,000 worth of insulation. The 5,440m$^2$ metal roof and sided building comprised offices, workshops, warehouse, dispatch facilities and amenities (NSW Public Works).

Note on wall insulation

<table>
<thead>
<tr>
<th>Insulated and uninsulated wall assemblies</th>
<th>R–values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity brick wall</td>
<td>0.5</td>
</tr>
<tr>
<td>Cavity brick with double sided reflective insulation</td>
<td>1.5</td>
</tr>
<tr>
<td>Brick veneer/plasterboard</td>
<td>0.46</td>
</tr>
<tr>
<td>Brick veneer/plasterboard with reflective foil in cavity</td>
<td>1.48</td>
</tr>
<tr>
<td>Cavity wall: hollow cement blocks (90mm each)</td>
<td>0.6</td>
</tr>
<tr>
<td>Cavity wall: hollow cement blocks + R 1 foam board</td>
<td>1.6</td>
</tr>
<tr>
<td>Earth construction 300 mm thick (see also ’Berms’ in glossary)</td>
<td>2.4–4</td>
</tr>
</tbody>
</table>

Note on glass

The performance of glass is often measured in terms of heat transmission values or ‘U values’, which are the inverse of R values (thermal resistance). The lower the U value, the less heat is transmitted through the glass. Approximate values depending on type and brand are as follows:
<table>
<thead>
<tr>
<th>Type of window</th>
<th>U–values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glazing, clear 6mm glass</td>
<td>6</td>
</tr>
<tr>
<td>Single glazing, low e glass</td>
<td>4</td>
</tr>
<tr>
<td>Double glazing, low e coating argon–filled gap (argon is a harmless low conductivity gas)</td>
<td>2</td>
</tr>
<tr>
<td>Insulated wall (for comparison)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Low–U value glazing is used where heat gain is not wanted. Where windows are to be used as part of a passive heating strategy, the reverse is required—the glass needs to have a high solar heat gain coefficient, (this measures the percentage of solar radiation passing through the glass, which for 3mm glass is 88%), and the gain needs to be more than the outflow of heat from inside that has been stored in the thermal mass.

Double glazing and other special glass products cannot by themselves be effective in preventing unwanted heat gain if other design factors have been neglected, such as appropriate size and placement of windows (larger glazed areas on north and south facades, less or none on east and west), shading devices and assessment of daylight needs. It should also be noted that reflective and to a lesser extent low ‘e’ glass also reduce transmission of light.

2.6 Natural ventilation and cooling

Objectives

The objective is to have a comfortable, healthy indoor environment by using forms of ventilation not dependent upon fossil fuel derived energy (and thereby reduce greenhouse emissions).

Development controls

In the Design Report, indicate which basic natural ventilation strategies will be used and why they are appropriate for the proposed building, particularly in terms of energy savings. Also, demonstrate that advanced natural ventilation strategies have been adequately evaluated and implemented where feasible. Indicate the percentage of floor space to be naturally ventilated (Figure 4).

Concept

Ventilation is essential for the health of building occupants: fresh air needs to be inducted; stale air and CO$_2$ need to be expelled. By carefully managing airflow through a building, comfort conditions can be improved, and in summer, a cooler indoor environment can be created. This requires understanding and designing in relation to several factors:
Designing to assist airflow

Managing airflow for ventilation requires:

(a) knowing about how air moves across the site: the influence of prevailing winds, topography, nearby buildings and vegetation. These factors as well as solar access and local rainfall make up the ‘micro-climate’;

(b) taking into account how building form directs air movements. In general:

(i) airflow over a building creates positive and negative pressures, which can affect how air moves through a building;

(ii) sharp edges cause eddies and suction effects; and

(iii) roof form is critical (with flat roofs having the highest wind shadow).

This means taking external air movement and air pressure (such as prevailing winds) into account when determining the size and locations of the building’s ventilation openings (Figure 5).

Qualification 1: In all cases the ventilation scheme has to be designed in conjunction with, and in compliance with fire regulations.

Qualification 2: The induction of external air into a building during the day and night has to be based on the quality of this air being good. If doubts exist it should be tested.

Qualification 3: Close proximity to external noise can limit opportunities for natural ventilation.

Figure 4: Applicants must indicate the percentages of their building to be naturally and mechanically ventilated (i.e. air conditioned). The aim is to minimise air-conditioned spaces.

Figure 5: Roof shape affects how air flows over and around a building. Positive pressures are created on the windward side and negative pressures on the leeward side. Flat roofs have large wind shadows and can be subject to suction. When making decisions about roof form, building site conditions need to be taken into account so as to avoid creating unwanted situations like wind tunnels, eddies and suction effects, and to benefit from cooling summer breezes (see also natural ventilation and cooling and Figure 9).
Designing to assist cooling

Managing airflow for ventilation and cooling requires all of the above, plus:

(a) understanding the nature and the disposition of the building’s thermal mass; and

(b) having information about differences in temperature: externally and internally; between day and night; between different parts of the building.

With this information, passive ventilation systems can be designed to move ambient cooler air to where it can be most effective. For example, air can be pre-cooled before entering a building by directing it across shaded thermal mass that is at a lower temperature than outdoors.

Another example is night cooling. Here, the colder night air is drawn in through low level intakes (such as grills) and exhausted through high level vents to flush the building of warm air that has accumulated during the day, to make the building more comfortable at the start of the day.

This is particularly appropriate for offices with large numbers of computers and other equipment that give off a lot of heat during the day. More sophisticated night cooling techniques involve utilisation of a building’s thermal mass, such as directing air through the centre of a custom designed slab or through plenums.

Basic natural ventilation

Cross-ventilation

This is the simplest of measures and just requires an appropriate sized and positioned building openings (windows, vents) and an internal layout that allows for free air movement for prevailing or managed air currents (Figure 6).

In many commercial buildings (e.g. shops with store rooms at rear) openable windows may not be desirable for security reasons. Instead, grills and vents should be employed—appropriately sized and positioned to facilitate cross ventilation (Figure 7).
Cross ventilation can be supplied by appropriately positioned openable windows and/or vents. This is easier to achieve for freestanding buildings with access to good quality air and where external noise is not a problem. Where conditions are not optimal, care needs to be exercised in positioning air intakes, so as to minimise the building occupants’ exposure to externally generated air or noise pollution. Effectively designed cross ventilation can reduce the need for air conditioning and fans, and thus save on energy costs.

**The stack effect**

The ‘stack effect’ refers to the draught that is created by warm buoyant air as it rises in a tall confined space. This could be a chimney, stairwell, atrium or lift shaft. The stack effect can be taken advantage of to improve internal comfort conditions in various ways.

**High level (window) ventilation**

High–level windows (such as clerestory windows) are effective for removing hot stale air. Combined with lower level air intake (windows or vents) on the opposite side of a space, they can be used for night cooling (see cooling above). Used in the same way during the day, high–level windows can increase comfort in hot weather, while not actually lowering the indoor temperature.

**Cowlings**

These are roof–mounted vents designed to catch wind. They need to be appropriately sized and positioned in relation to roof profile and air movement.

**Rotary ridge ventilators**

These are usually mounted on roof ridges and rotate according to wind direction to draw air out of internal spaces.
Ridge vents

These can be of several types. For example linear ridge vents run along the length of the roof ridge and are generally used just to ventilate the roof space, so as to avoid moisture build up. Ridge vents that are operable (able to be opened and closed) are also available.

These can be used more ambitiously as part of a passive strategy to ventilate room space in a building with pitched roof and raked ceilings. Depending on the configuration of the space, the stack effect (see below) could be utilised to assist airflow.

Solar fans

Fans driven with a small electric motor powered, during good daylight, by a small photovoltaic cell (instead of mains electricity). Ridge or chimney mounted solar fans can assist hot air extraction in roof spaces in premises.

Advanced natural ventilation

For buildings over $2 million

Increasingly stack–assisted ventilation is being favoured by environmentally aware engineers as a way of moving air through a building instead of using powered fans. The ‘stack effect’ refers to the draught that is created by warm buoyant air as it rises in a tall confined space. This could be a chimney, stairwell, atrium or lift shaft. The stack effect can be taken advantage of to improve internal comfort conditions in various ways.

Atriums

An atrium is a tall internal courtyard with a glazed roof. It can assist air movement in a similar way to a chimney, as well as provide capacity for other internal spaces to induct and exhaust air. Atriums also deliver natural light and can improve the aesthetic appeal of internal spaces (Figure 8).
**Figure 8:** The main use of atriums is to bring daylight into the core of buildings, but they can also be designed to enhance natural ventilation, and thus reduce or eliminate the need for air conditioning.

**Figure 9:** The stack effect, where warm air rises and is displaced by cool air at lower levels, can be used for natural ventilation and cooling. A chimney (or other tall narrow spaces such as a stairwell) enhances this by accelerating the airflow. The diagram shows a sophisticated stack ventilation system for multi-storey buildings, with different kinds of chimney openings to modify the action of wind pressures. The use of chimneys and similar spaces as a means of natural ventilation and cooling needs to be incorporated at the early stages of building design and should take local wind conditions into account (see also building orientation and siting and Figures 4 and 5).

### Chimneys

To create an efficient stack effect in a chimney the critical factors are its height, dimensions, the position and size of openings, air pressures and desired rates of air change. Additionally, the introduction of a material at a higher elevation to heat or to expose to solar radiation can increase the efficiency of the draw, particularly important if low-level air is being inducted for cooling. The design of such structures requires computer modelling, and while this and their construction are a considerable project expense this has to be offset against the cost of air handling plant and operational costs. For large scale projects this method and those below should be reviewed (Figure 9).

### Shafts, service conduits, stairwells

These building elements can be designed to manage airflow, providing air induction and expulsion is appropriately managed and that large openings (i.e. doorways) and other apertures are kept in the open or closed position that the system requires to function.

### Double facades

A double facade effectively acts as an airway in the same way as an atrium, but with a very shallow depth. It can also be designed to shade external walls and be used to group services instead of having separate service shafts (Figure 10).
A double facade acts as an airway in the same way as an atrium, but with a very shallow depth. It also shades the external wall and can be used to group building services externally.

Figure 10: A double facade acts as an airway in the same way as an atrium, but with a very shallow depth. It also shades the external wall and can be used to group building services externally.

The concrete’s thermal mass stores heat or cold, according to the design parameters.

The stable temperature of a concrete slab can be utilised as part of a heating or cooling strategy. The space between the slab and a suspended ceiling or between the slab and a platform floor can function as a plenum by directing air across the slab, allowing it to circulate and come in contact with the slab’s stable temperature. Pipework is sometimes introduced into the slab. It may be used to carry either pre-cooled or pre-heated water or air. The concrete’s thermal mass stores heat or cold, according to the design parameters.

Figure 11: The stable temperature of a concrete slab can be utilised as part of a heating or cooling strategy. The space between the slab and a suspended ceiling or between the slab and a platform floor can function as a plenum by directing air across the slab, allowing it to circulate and come in contact with the slab’s stable temperature. Pipework is sometimes introduced into the slab. It may be used to carry either pre-cooled or pre-heated water or air. The concrete’s thermal mass stores heat or cold, according to the design parameters.

Plenum utilisation and other means to facilitate airflow

A plenum is normally introduced as a designed feature of the building fabric. It allows hot or cool air to pass below the thermal mass of a slab to heat or cool it. It is an appropriate device in both a naturally ventilated building as well as an alternative to ducting in a mechanically serviced (air-conditioned) building.

There are proprietary products that can be used to effectively retrofit an existing slab so that it performs as if had been fabricated with a plenum. For example, a rigid sheet with a profile that forms air channels and can be installed between a false ceiling and slab or a pedestal floor and slab to draw in air. Additionally there are design solutions and products that provide alternatives to the obstruction of thermal mass by false ceilings, such as permeable ceilings that allow air to pass through them.

Ceilings in commercial buildings are generally suspended grids into which acoustic backed ceiling tiles fit. This prevents air from coming into contact with the thermal mass of the concrete slab above. In retrofitting a building, it would be advantageous to substitute this with an open grid ceiling or permeable tiles (without acoustic backing). This would allow rising warm air created by people and equipment to pass through the ceiling to the cooler underside of the slab, which would act as a ‘heat sink’ (Figure 11).

2.7 Daylighting

Objectives

The objective is to have an increased ratio of daylight to artificial light without unduly increasing the building’s heat load, and therefore to reduce energy uptake and greenhouse emissions.
Development controls

All applicants are required to develop a daylighting strategy. The Design Report should include a diagram indicating methods for maximising daylight penetration into the building (Figure 24).

Concept

Daylight consists of direct and reflected sunlight and skylight. Daylighting should be an integral part of the overall design of a building. Well–designed daylight can deliver a direct reduction of energy use because it reduces the need for artificial lighting. On the other hand poorly designed daylighting can increase the heat load in summer, leading to more energy being used for cooling.

Compared to other building materials, glass, when exposed to sunlight, lets in much more radiant heat into a building. Also, heat generated inside a building is lost much more rapidly through glass than through other materials when the outside temperature is lower. Therefore it is very important that daylighting, heating and cooling should be designed in relation to each other to achieve the most energy efficient outcomes. This is why on large projects computer modelling of different design options is often done.

When designing and managing daylighting systems it is important to eliminate glare. Window orientation and geometry, the type of glazing used and the reflectance of walls and other surfaces and shade structures can eliminate unwanted glare. The type of glazing, types of windows, window angle, the use of reflective materials and paints, plus a range of design strategies and off the shelf products can all affect the quality and management of daylight entering a building.

Related concept

A rectangular building with a narrow floor plate, oriented east–west will optimise daylighting opportunities. The type of structural grid is also a factor (see building orientation and building form).

Daylighting methods

Side lighting (conventional windows)

These provide adequate daylight in a building’s perimeter zones, but illumination levels fall off rapidly with distance from the window wall. A typical limit is 4 to 6 metres depending on the height of the window.

Clerestory windows

High–level windows often arranged in strips. Used in conjunction with reflective surfaces they enable deep penetration of indirect light, thus avoiding glare. If openable, they can also double as high level air vents (see natural ventilation and cooling). South facing clerestories admit the most even light (Figure 12).
Skylights

These admit more daylight per square metre of glazed area than vertical windows, but they also collect more heat, which needs to be controlled. Off the shelf products with double glazing and heat reflective coating on one side (low emission or low e glass) are available. Skylights can be fixed or openable, the latter providing good high level venting (see natural ventilation and cooling—Figure 13).

Interior treatments

Reflective materials, mirrors, reflective colours and surface treatment are all important to consider for achieving the best daylighting performance.

**Figures 12–15:** Different approaches to daylighting.

- A clerestory window and reflective surface to bounce light deeper into a room.
- A skylight set into a roof with no ceiling cavity (the roof should be insulated).
- A light well cutting through roof and floor plates to bring light deep into a building.
- A light tube brings light through the ceiling cavity.

Special Glazing

There are types of glass and off the shelf insulating glass units that are designed to allow light transmission while reducing heat transmission. Some, such as tinted or mirror glass, also reduce light transmission, compared to clear glass. Most effective for daylighting and heat insulation is double glazing (which has the added bonus of significantly reducing external noise penetration). It is also more expensive. To prevent glare, frosted or sandblasted glass panels could be used instead of clear glass (e.g. upper panels) in situations where visual comfort is critical (such as premises with large numbers of computers).
Related concept

Glazing options needs to be assessed at the same time as overall insulation needs (see building envelope and insulation).

Light wells

These perform a similar function to atriums but rather than being a void space around which functional spaces are disposed, a light well is a dissection through the floor plates (Figure 14).

Light tubes

Light tubes are used to bring light from a roof or wall through an intermediate space (like a roof cavity) into a room. Sometimes they have a highly reflective inner surface to intensify light penetration, usually combined with a translucent ceiling fixture to evenly diffuse the light delivered to the interior (Figure 15).

Atriums

An atrium is a void intersecting all building levels that brings light into the building core. Atriums need to be carefully designed so as to manage light penetration without creating areas of glare. Atriums can also be designed to facilitate natural ventilation (see natural ventilation and cooling—Figure 16).

Figure 16: Atriums bring light into a building and can also be used as part of the natural ventilation strategy (natural ventilation and Figure 8).

Figure 17: Light shelves are horizontal solid structures with a highly reflective surface used to bounce daylight off the ceiling making it penetrate deeper into the interior space than by a window alone. Their performance varies according to ceiling height and the height of the light shelf from the floor. Light shelves can increase uniformity of illumination between work areas near and far from windows.

Figure 18: A light shelf can be positioned inside the window, half inside/half outside or outside only. The position chosen affects the shadow area created underneath the shelf as well as the depth of light penetration. Light shelves need to be carefully designed in terms of height and positioning, as well as in relation to the dimensions of the space they will serve.
Prismatic panels

These use refraction or reflection to redistribute daylight and sunlight away from a window and further into a room (for example they are often used in conjunction with a skylight to create more even, usable light). They eliminate glare and solar gain, increase depth of light penetration but require careful setting.

Light shelves

Light shelves provide indirect light deep into an interior space, while reducing solar gain and glare. Their effectiveness depends upon window height, room height and depth; the dimensions, surface finish and positioning of the light shelf, as well as the interior colour scheme, lighter colours have higher reflectance (Figures 17 and 18).

Other optical devices, especially light control panels that use non–imaging optics and reflective materials are under development and used in specialist contexts.

2.8 Shade and sun control

Objectives

The objective is to have the protection of buildings from unwanted seasonal heat gain, to reduce glare to internal spaces and to minimise external ‘heat islanding’, and thus to reduce energy uptake and greenhouse emissions.

Development controls

If glazing is used on east or west facades, it must be shaded (preferably by external shading devices) from penetration by summer sun.

In the Design Report explain the shade strategy to be used for the building.

Concept

Provision of shade in the right places and at the right time of the year, appropriate to the building, its site and the kind of activities to be carried out in it, is an important part of passive design. Reasons for providing shade are:

(a) to control solar radiation entering a building (especially through glass) when it is not wanted (e.g. in summer);

(b) to manage glare (especially to stop sunlight falling directly on task areas);

(c) to manage the heat gain of external thermal mass and to reduce heating islanding caused by reflected heat; and

(d) to provide protection from ultra–violet light radiation in external areas used by a building’s occupants (such as recreation areas, around canteens).
External shade structures such as overhangs and awnings assist in preventing heat transmission through glass as well as cutting out glare. Therefore where the aim is to control heat gain, external treatment is always preferable to internal devices such as blinds that affect light transmission only. External shade structures are also preferable to blinds because they allow visual connection with the outside, which is more pleasant for building occupants.

For facade design and in determining the shading requirements of windows, both the vertical and the horizontal shadow angles need to be considered. Qualified building designers such as architects or engineers use shadow protractors with regional Sun Charts or computer programs for this purpose (Figure 19).

![Figure 19](image-url)

**Figure 19:** In determining the shading requirements of windows, both the vertical and horizontal shadow angles need to be considered. Qualified building designers such as architects or engineers use shadow protractors with regional Sun Charts or computer programs for this purpose. The vertical shadow angle is used to determine the cut–off line for shade structures roughly parallel to the ground (like awnings). The horizontal shadow angle is used when considering the shading effect of an irregular facade or of vertical shade elements (like fixed vertical louvres).

**Facade design**

Shade provision of shade should not be a last minute ‘add–on’, but an integral part of facade design. Given that sunlight and daylight penetrate buildings differently according to building orientation and season, it is very unlikely that an energy efficient building would have identical fenestration and shading treatment on all facades.

**Building shade structures**

The addition of eaves, overhangs, awnings, verandas or colonnades should be considered at an early stage of building design. Shade needs will be determined by factors such as orientation, location of thermal mass, of windows and the building’s likely patterns of use.

**Louvres**

These can be exterior or interior; vertical or horizontal; fixed or operable. Operable louvres can be manual or mechanical; user activated or operated by a sun tracking system. Options should be selected according to building orientation, window size and design, room use and occupancy levels.
Blinds and shutters

These can be interior or exterior and should be selected according to building orientation, window size and design, room use and occupancy. External shade devices such as louvres are available with either horizontal or vertical slats. If they are to be fixed, sun angle calculations need to be done carefully. Otherwise adjustable louvers can be used, angling them as needed to cut out early morning and late afternoon sun. On east and west windows this will also block the view (Figure 20).

2.9 Landscape design

Objectives

The objective is to have landscape elements that provide shading and cooling to enhance the building’s thermal performance and thereby reduce energy uptake and greenhouse emissions.

Development controls

In the Design Report demonstrate how the landscaping strategy will contribute to building energy performance.

Figure 20: External shade devices such as louvres are available with either horizontal or vertical slats. If they are to be fixed, sun angle calculations need to be done carefully. Otherwise adjustable louvers can be used.

Figure 21: Earth berms are mounds of earth in direct contact with an external wall. They are used to stabilise internal temperatures by reducing the exposure of the thermal mass to variations in air temperature. They also reduce noise transmission.

Figure 22: Building grassing works on the same principle as a berm, but protects a larger area of the building envelope against external heat gain and internal heat loss. It also insulates against sound, as well as advantaging surrounding areas by reducing ‘heat islanding’ i.e. heat given off from large structures, that collectively contributes to increasing temperatures of built–up areas compared to less developed surrounding areas.
Concept

Landscape design is not just about making an industrial or commercial development look good. It can also be a passive means of contributing to thermal performance and daylighting.

Trees

Trees can provide seasonally appropriate shading to thermal mass, windows and external areas. Some pre–cooling effects can be achieved by allowing air to pass through trees or shrubs before entering a building. There are also psychological benefits for people working in a building where there are visual and tangible connections to trees.

Trees need to be selected and planted extremely carefully in relation to building function and siting. Their growth pattern and growth rate, mature size, canopy density and whether they are deciduous or evergreen should all be appropriate to the nature of the site. Species native to the City of Bankstown (derived where possible from locally sourced seedstock) should be used wherever possible as their water requirements are most likely to less than imported species and they will contribute to maintaining local biodiversity.

Berms

These are mounds of earth in direct contact with an external wall, used to alter the ratio of heat gain and loss by reducing exposure of thermal mass to solar radiation (Figure 21).

Building grassing

This is an established way to add external insulation, reduce solar heat gain and loss. It also reduces ‘heat islanding’ and thus urban thermal mass temperature increase (Figure 22).

Roof gardens and planters

These are also established ways to add external insulation, reduce solar heat gain and loss. It also reduces ‘heat islanding’ (and thus urban thermal mass temperature increase).

Evaporative cooling

This is an old method that can be used when designing landscape or building envelope. It is based on the principal of pre–cooling air by passing it through or across water. It does this in three ways.

Still/running water/fountains as part of landscaping can reduce external air temperature as latent heat is removed during evaporation.
Spray mist systems increase the rate of evaporation and seek to spatially manage the water vapour and air movement.

Note: the water used in evaporative cooling system should be collected roof water. If stored in underground tanks its cooling capability will be enhanced and pumping should whenever possible be from a solar pump.

**Figure 23:** As part of the Design Report that all applicants must submit with their development application, a site analysis must be included. This must indicate existing structures, adjacent buildings or features; slope, drainage, prevailing seasonal winds; vegetation and site features; environmental constraints and opportunities (e.g. proximity to a water way or a sensitive area of vegetation).

**Figure 24:** As part of the Design Report that all applicants must submit with their development application, a site diagram indicating the footprint and orientation of the proposed building must be included.

**Figure 25:** As part of the Design Report all applicants must indicate the percentages of their building to be naturally and mechanically ventilated (i.e. air conditioned). The aim is to minimise air-conditioned spaces.
DEFINITIONS

The following terms used in these guidelines are defined:

Air flow means the movement of air outside and inside a building.

Atrium means a void intersecting all building levels that brings light (and sometimes air) into a building core.

Berm means soil piled against the length of a wall at an angle to reduce the exposure of surface area to solar radiation and to assist in the maintenance of equilibrium between subsoil ground temperature and the building’s thermal mass. Berm also provide insulation against noise.

Building grassing means the use of grass as external insulation and as a means to reduce exposure of the building surface to solar radiation. This approach also provides insulation against noise.

Clerestory means a high level window used for daylighting.

Daylighting means a range of techniques used to introduce sun and sky light into a building.

Embodied energy means the accumulated energy used to manufacture and maintain a material or product from the extraction of raw materials to the end of its useful life, disposal and/or recycling. Embodied energy is distinct from operational energy. The measurement of embodied energy is an important part of environmental Life Cycle Assessment. A distinction is often made between Process Energy required (e.g. for extraction, manufacturing) and other energy inputs e.g. for product transportation or for periodic maintenance.

Evaporative cooling means various techniques of using evaporated water (water vapour at a lower than air temperature) to cool air.

Light tube means a device for bringing light through a cavity to an interior space without diffusion.

Light shelf means a means of deflecting light onto an internal reflective surface to increase the depth of light penetration into an internal space.

Natural ventilation means a range of techniques that combine natural airflow with building design characteristics to induce fresh air into a building and exhaust stale air. Natural ventilation is also sometimes used as a means to reduce the temperature of a building’s thermal mass.

Night cooling means the induction of cool night air into a building to reduce the temperature of its thermal mass.
**Plenum** means a space in which air can pass horizontally, either between a concrete slab and suspended floor or between the underside of a slab and a ceiling.

**Permeable ceiling** means a false ceiling that allows air to come in direct contact with a slab above it.

**R-value** means a measure of the thermal resistance of a material or building element.

**Solar fan** means a roof or ridge fan used to induct or extract air from a building that is driven by a photovoltaically produced electric power (electricity generated by sunlight).

**Solar radiation** means the heat and light created by the combination of all the sun’s rays (ultra–violet, infrared, electromagnetic waves) plus high energy charged particles.

**Shade audit** means a quantification of all source of available and needed shade for a specific site.

**Stack effect** means the tendency for warm air to rise in a tall confined space, creating a draft and thereby drawing in cooler air at a lower level.

**Stack ventilation/solar chimneys** means the use of the stack effect as a means of naturally ventilating and cooling a building. An example would be the use of a building element such as a stairwell or shaft, with a top vent, air movement across this vent and high temperature at or above roof level, all which would work together to extract hot air out of a space and induct in ground level cool air.

**Thermal mass** means the thermal mass of a building refers to the capacity of materials to store heat or cold. Materials with a high thermal mass are dense, such as brick, concrete, stone.

**U-value** means the measure of a material’s overall thermal transmittance.