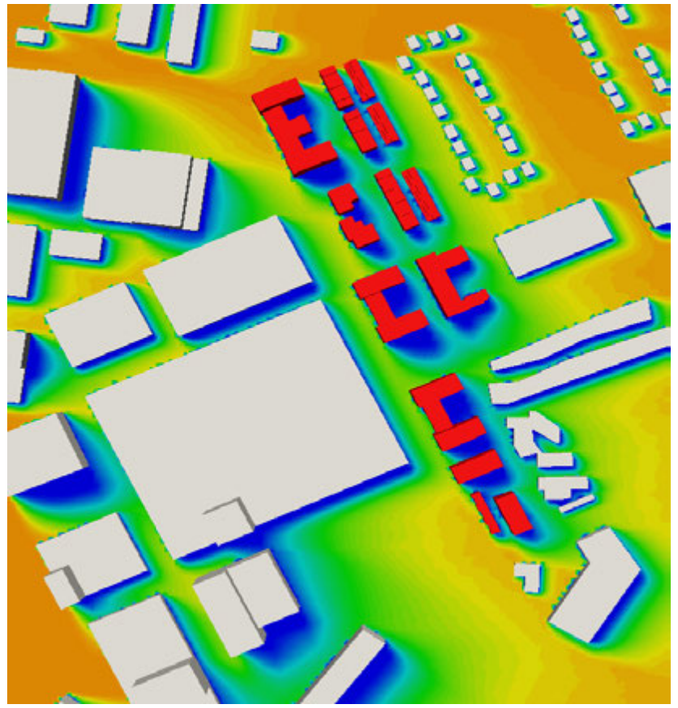

ACT Community Services Directorate
ACT Braddon and Reid Master Plan

Sustainability Benchmarking Plan

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ARUP

ISSUE

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EXECUTIVE SUMMARY

Arup has been commissioned by the ACT Community Services Directorate (CSD) to develop a sustainable benchmarking document and microclimate study as part of the proposed Master Plan for Sections 52 and 57 Braddon and Section 7 Reid, ACT.

The sustainability strategy for the proposed Master Plan hinges on two approaches—Base Targets and Active Targets. The **Base Targets** concern the overall orientation, massing and proposed layouts of the buildings on the site to encourage solar access; natural ventilation; renewable energy generation potential; and high indoor and outdoor environmental quality for residents. The **Active Targets** concern the green building and energy ratings targets; building services efficiencies; water, ventilation and material strategies; and landscape initiatives. While the Base Targets inform the proposed Master Plan and are incorporated into the architectural model developed by Cox Humphries Moss and Purdon, the Active Targets remain open to further refinement during the design, construction and operation of individual buildings.

This report includes an overview of the existing site performance, followed by a series of urban residential case studies with energy data, including annual heating and cooling energy consumption, and a table of key sustainability strategies incorporated in the development. Each case study has been selected for at least one or more of the following reasons:

- Availability of energy consumption data;
- Independent, third-party certification of sustainability strategies;
- Accessibility of design documentation within Arup; and
- Relevance to the proposed Braddon and Reid Concept Master Plan.

The annual heating and cooling energy of these case studies was then compared in order to establish an average NatHERS rating that could be used to gauge performance for Canberra. NatHERS is a regulatory rating that quantifies the thermal performance of residential units based on façade construction, orientation, and heating and cooling loads. The average rating in the case studies was 6.5, therefore the proposed Master Plan recommends a nearly 17% improvement to the average for a targeted **NatHERS rating of 7.0 for the dwellings** in Braddon and Reid, which would represent a **40-60% reduction to energy consumption** for cooling and heating when compared to the existing development. In addition, the proposed Master Plan encourages **10% renewable energy generation on-site** and otherwise green power from grid sources.

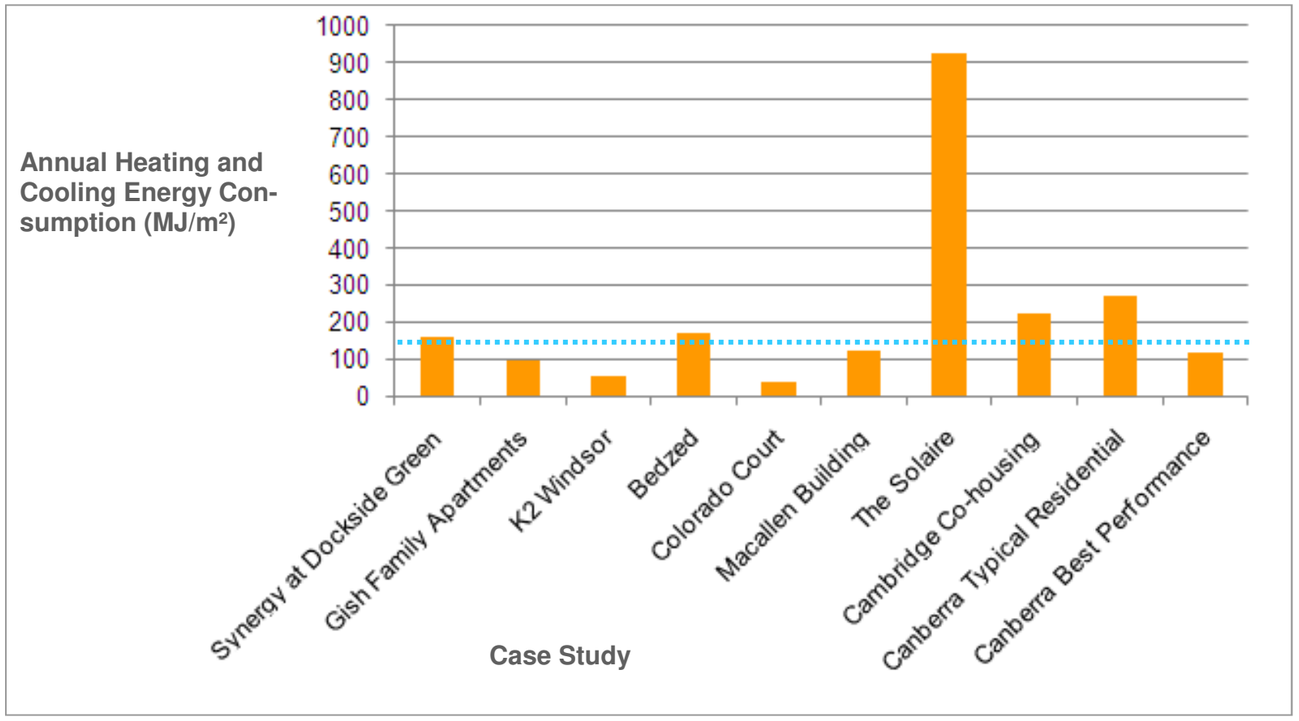

FIGURE I This graph is included in Section 4.0. It represents the combined annual heating and cooling energy consumption for the case studies presented in Section 3.0, as well as the BCA compliant residential requirement for Canberra and the proposed "best performance" target we recommend. The dotted blue line represents the average, which is approximately 140.5MJ/m2 for all case studies, excluding the Solaire. The Solaire was excluded since we felt it did not adequately represent a similar project type to what will be built in Canberra. Current practice in Canberra would be nearly twice the average energy consumption for similar developments worldwide, while the proposed best performance rating of 7 Stars NatHERS would represent a nearly 17% improvement over the average.

The next section includes an overview of the application of the Green Star Multi Unit Residential v1 rating tool, including a projected cost of initiatives required for achieving both 5 Star and 6 Star Green Star Design and As Built ratings. Green Star is a voluntary, holistic green building rating tool used to measure the sustainability of buildings. The proposed Master Plan recommends a target of 6 Star Green Star Design and As Built ratings for all residential buildings eligible.

This is followed by a benchmarking section that responds to the sustainability categories established for the case studies, setting clear performance targets for energy, water, waste, materials, land, natural environment, transport, passive design, adaptability, and community and social criteria. The water target represents **a 50% reduction in per dwelling water consumption** compared to the existing site. These targets are drawn from a range of sustainability guidelines and tools, including Green Star Multi Unit Residential v1, LEED for Neighbourhood Development V1, and best practice sustainable neighbourhood design based on industry guidelines and Arup experience.

In the Appendix, a microclimate study has been undertaken to gauge the effects of solar access, wind, and overall comfort for the proposed Master Plan site and surrounding precincts. The primary conclusion is that there will be some impact to the existing Block H precinct (refer to Figure 1.1 for the site on the next page) in terms of comfort conditions, but that impacts to surrounding residential and commercial developments will be negligible. The key summary findings from the microclimate study are included on the next page.

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MICROCLIMATE EXECUTIVE SUMMARY

FIGURE II Microclimate analysis summary; this is based on the model used for the microclimate and may not represent the final layout of the proposed Master Plan by Cox Humphries Moss and Purdon.

A microclimate analysis of the proposed Master Plan was undertaken by Arup on behalf of CSD and Purdon Associates in response to the architectural model developed by Cox Humphries Moss as of 12 August 2011. The analysis considered solar access, wind effects, and comfort (in terms of Standard Effective Temperature). The study incorporates results for the public space within the proposed Master Plan, as well as its impact on the surrounding precincts.

From a high level, the public spaces are expected to function suitably for a range of activities throughout the year, including sitting, resting or walking. The main impacts are the following, as keyed to the model shown at left:

1. The courtyards create a sheltered and pleasant space which will be protected from frequent winds coming from the Northwest during most seasons. The building shape could be optimised to increase the solar radiation in winter, when the spaces will often be shaded, by increasing density along Cooyong Street and on the South side of each block. Block VI's low-rise elements function quite effectively in creating high levels of thermal comfort in the resulting courtyard.
2. In Summer months, there is the potential for Blocks I and VIII to restrict cooling winds from the adjacent low-density residential area to the East. This area will also experience a slight reduction in solar access during the other seasons due to shadows cast by Blocks VII and VIII.
3. Due to tunnelling effects, there will be some increase to wind speed along Cooyong Street, but it otherwise operates similar to other parts of Canberra's Civic precinct.
4. The landscaped island in Ainslie Avenue will experience some overshadowing and during Spring there will be some high wind speeds, but for the majority of the year, the eastern end of the avenue will be comfortable for sitting or standing activities.
5. The large buildings in Block IV and the northern building in Block V causes an increase in wind speeds as air drops after passing across the top of the buildings. This will impact the comfort conditions of public space in this area.

1.0 INTRODUCTION

Arup has been commissioned by the ACT Community Services Directorate (CSD) to develop a sustainable benchmarking document as part of the proposed Master Plan for Sections 52 and 57 Braddon and Section 7 Reid, ACT.

The proposed master plan, as developed by Cox Humphries Moss and Purdon, dated August 2011, corresponds to a parcel of existing development located adjacent to the Canberra city centre. The proposed Master Plan sets out a redevelopment strategy for implementing inner city residential units in a variety of densities and configurations. A key project aim is to ensure these residential projects are developed in an environmentally and socially sustainable manner, particularly in regards to energy efficiency and sustainability reporting through various rating tools and government programmes.

Sustainability Approaches for the Proposed Master Plan

The proposed Master Plan is based on three approaches to sustainable design for residential development in Canberra.

The first is an improvement over minimum regulatory requirements currently mandated for Canberra. This improvement is based on the Nationwide House Energy Rating Scheme (NatHERS), which concerns the thermal performance of residential construction. A target of 7 Stars NatHERS has been established for the buildings in the proposed Master Plan; the Building Code of Australia (BCA) and ACT requirements would result in a 4 Star NatHERS rating (refer to Section 4.1).

The second approach is through the use of a voluntary green building rating tool, the Green Star Multi Unit Residential v1. The use of this tool ensures that a number of sustainable metrics, not only for thermal performance, are incorporated into the proposed Master Plan. These include initiatives for management and operation, indoor environmental quality, energy, water, waste, transport, community and social benefits, land use and natural environment, and materials, and are presented as Base and Active Targets. Initiatives from other sustainability guidelines are also included in these Targets to expand on the sometimes limited scope of the Green Star tool. A target of 6 Star Green Star has been established for the buildings in the proposed Master Plan. Both NatHERS and Green Star, as well as the use of other sustainability guidelines, are explained in later sections of this report.

The third and final approach is based on a survey of residential case studies throughout the world that represent innovative approaches to design, construction and operation of similar developments. These case studies are presented in the next section.

Benchmarks

FIGURE 1.1 (ABOVE) The Braddon and Reid Master Plan proposed by Cox Humphries Moss and Purdon includes twenty new structures and the retention of five existing structures. These structures represent both low– and medium-rise residential development. (Source: Section 52 & 57 Braddon Section 7 Reid Concept Master Plan by Cox Humphries Moss and Purdon, 12 August 2011)

Based on the case study review, this document sets key performance benchmarks to improve upon mandates, such as BCA Section J and NatHERS (Nationwide House Energy Rating Scheme), as well as voluntary ratings like Green Star Multi-unit Residential. Benchmarks will be set for the categories shown at right.

Within these categories, individual outcomes are benchmarked to provide clear, measurable and comparable performance criteria for the development of the project. Thus, for the energy category, benchmarks address building mechanical systems, renewable energy generation strategies and energy-efficient appliances. Initiatives are divided between precinct-level opportunities and those corresponding to individual buildings and/or individual units. Development teams shall respond to each of the initiatives included in this Benchmarking Plan in coordination with CSD and other relevant authorities to ensure the intent of the proposed Master Plan is implemented in the project.

In conclusion, guidance is provided to ensure these ambitious sustainable development targets can be met in a cost-effective manner with flexibility in the development, design and construction process for multiple ways to achieve the desired performance outcomes.

FIGURE 1.2 (ABOVE) The Braddon and Reid precinct is immediately adjacent to Canberra's Civic Centre precinct, which makes it especially convenient for access to public transport and daily amenities. (Source: Section 52 & 57 Braddon Section 7 Reid Concept Master Plan by Cox Humphries Moss and Purdon, August 2011)

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1.1 EXISTING SITE PERFORMANCE

The Community Services Directorate (CSD) provided Arup with data from the existing development in order to put the sustainable performance benchmarks for the proposed Master Plan in context. CSD provided energy consumption for two periods (2007-2008 and 2008-2009) and quarterly water consumption (since the fourth quarter of 2006) for the Allawah Court, Bega Court and Currong Apartments developments. That information can be summarised as the following:

Bega Court

Average water consumption (per quarter): 2420 kL

Average water consumption per unit per day: 250 L

Average electricity demand per unit (per year): 7200 kWh

Currong Apartments

Average water consumption (per quarter): 11,231 kL

Average water consumption per unit per day: 365 L

Average electricity demand per unit (per year): 3360 kWh

Allawah Court

Average water consumption (per quarter): 11,231 kL

Average water consumption per unit per day: 365 L

Average electricity demand per unit (per year): 7200 kWh

Please note that these values are indicative, at best, since averages were taken for the total number of units and common areas are included. An analysis taking into account each apartment type and use was not undertaken (i.e. private residence versus student housing, since most of the Currong Apartments are used by university students).

Water Efficiency

The proposed Master Plan sets a baseline daily water consumption level for each unit of 150 L. This can be reasonably achieved through available technology and is based on the case studies reviewed in Section 3.0 and achievements for similar developments in Melbourne and elsewhere in Australia. As such, this target would equate to a nearly **50% reduction in water consumption** per unit for the proposed Master Plan when compared to the existing development.

FIGURE 1.3 The Currong Apartments of Currong Street (Photo courtesy Cox Humphries Moss and Purdon, from the proposed Master Plan).

FIGURE 1.4 The Allawah Court apartments looking South (Photo courtesy Cox Humphries Moss and Purdon, from the proposed Master Plan).

Electricity Consumption Reduction

Based on a typical unit size of 60m² and the average electricity demand per year of a Bega Court or Allawah Court unit, the existing development's typical unit is operating at 120 kWh/m² per year or a 2.5 Star NatHERS rating (refer to Section 4.0 for details on NatHERS). NatHERS does not include domestic white goods and most tenant electricity demands, focusing instead on cooling and heating loads. Therefore, in all likelihood, the existing development is operating at a higher NatHERS rating, more in the realm of 3 to 3.5 Stars NatHERS.

This relatively low performance is expected for a development of this age and can be attributed to poor façade and glazing performance, inefficient and aging equipment and operation, the use of inefficient domestic white goods, as well as potential for buildings to operate less effectively due to lack of commissioning and tuning of systems. Please note that these conclusions are based solely on the low energy efficiency performance of the existing site and not based on on-site inspections and conditions reports of equipment or individual units. If the energy targets outlined in the proposed Master Plan and included here in Section 6.0 are implemented, the project would aim to achieve a **40% to 60% reduction to energy consumption** associated with heating and cooling demands based on NatHERS and when compared to the existing development. This can be confirmed by undertaking a comprehensive energy model for the project once in design.

Renewable Energy

The proposed Master Plan also sets a target of supplying 10% of the base electricity demand with on-site solar photovoltaic installations. In terms of the existing average unit (assumed to be 60m²), this would equate to approximately 2.5m² of photovoltaics on the roof for each unit. This is based on a solar insolation of 5.48 kWh/m² per year, which provides 296 kWh per year per m² of photovoltaics installed (based on a PV operating efficiency of 17% and a standard monocrystalline unit currently available in Australia). It can be assumed that the efficiencies of solar photovoltaics will continue to improve in the coming years during the implementation of the proposed Master Plan and that, coupled with the Plan's proposed energy efficiency targets, will result in much less area per unit required for solar photovoltaics. This should be taken into consideration as part of building design, based on electrical demand load calculations undertaken by qualified consultants.

2.0 SUSTAINABILITY METRICS

In order to establish benchmarks based on improvements over best practice design, we have set the following metrics for recording the details of each case study included in this report.

The case studies represent quantitative information on sustainable performance for key metrics, where available or within the public domain, that are directly measurable and comparable to the proposed Master Plan development for Braddon and Reid.

EVALUATION CRITERIA		DESCRIPTION
1	Energy	Energy efficiency, use of renewable energy generation technology (off-site, on-site, green power), and conservation of energy to minimise greenhouse gas emissions.
2	Water	Integrated water management, including rainwater harvesting, recycling and reusing grey/black water, stormwater detention/retention, water sensitive urban design measures, and efficient water use.
3	Waste	Reducing, reusing and recycling waste during design, construction and operation.
4	Materials	Minimise building materials during design and construction, use materials with low embodied energy, recycled or recyclable content, locally sourced from sustainable suppliers, low toxicity for the health of people and/or the environment.
5	Land	Site location relative to key facilities, appropriate utilisation of site and minimise disturbance to topography.
6	Natural Environment	Protect and enhance the natural environment and biodiversity values.
7	Transport	Promote the use of public transport, provide more sustainable options for private transport (electrical vehicle infrastructure, cycling and walking facilities), and car pooling/sharing amenities.
8	Passive Design	Design to reduce dependency on active means of heating and cooling, maximise passive lighting and ventilation.
9	Adaptability	Design adaptable spaces for different uses, allow for easy construction, deconstruction and reuse of parts.
10	Community and Social	Enhance community inclusion and interaction, provide recreational and open spaces for health and well-being, provide safe (crime prevention), clean and hazard-free living environments able to be accessed by all ages and abilities, as well as provide educational resources about how to maximise efficiency and live in a sustainable way.

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3.0 CASE STUDIES OVERVIEW

CASE STUDY: SYNERGY AT DOCKSIDE GREEN

LOCATION: Victoria, B.C., Canada

GROSS AREA: 16,570 m^2

COST: $50.2 million

COMPLETED: March 2008

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 178.6 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 45kWh/m^2 (162MJ/m^2)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): No cooling installed

ANNUAL CARBON FOOTPRINT (PREDICTED): 3.3 kg CO_2/m^2

RATING: LEED-Canada New Construction V1—Platinum

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• 40% to 50% more energy efficient than the Model National Energy Code; • 100% fresh air system with heat recovery ventilator; • Energy Star Appliances: refrigerators, dishwasher, hood fan, washer and dryer; • High-efficiency, zoned, occupancy-controlled lighting in parkade and common areas; • Independent commissioning agent and extensive post-occupancy building tuning to improve performance;
Water	• Potable water use is 65% lower than standard; • Rainwater storage tanks on most balconies that collect water from the roof and enables reuse for watering plants; no potable water will be used for irrigation or flushing toilets; • Native and adaptive plants will be used on the site to reduce irrigation needs;
Waste	• Majority of construction waste will be recycled and 100% of sewage treated on site;
Materials	• Engineered hardwood floors (in main living areas) provide zero emissions and are manufactured with sophisticated pollution-controlled technology; • Rapidly renewable bamboo butcher ´s block countertop; • 30% recycled content glass tile backsplash in kitchens and 30% recycled custom glass tile accents in ensuites; • Selection of superior low or no VOC, eco-friendly materials contribute to superior air quality; • Non- urea formaldehyde composite wood products and MDF; • Premium carpet (in bedrooms) is made from environmentally friendly, recycle-linked, precision cut, stain-resistant, colour-fast materials and comes with a CRI Green Label™ rating for indoor air quality; • 40% Fly ash in concrete mix reducing C02 emission associated with concrete use with added benefit of a stronger cement;
Land	• Developed on formerly industrial use land;
Natural Environment	• 400 trees were planted throughout the community using indigenous or adaptive species; green roofs recycle water by directing overflow water into rain cisterns and to the naturalized creeks and ponds on-site; • Cutting-edge landscape design incorporates natural water features, communal roof decks, hanging gardens, lush landscaping and numerous green spaces to create a socially and ecologically responsible open space network;
Transport	• Implementing transportation strategies such as a car-share program, a community transit service, added walkways and improvements to the Galloping Goose bike trails; secure bike storage; and close distance to public transit;
Passive Design	• External shading on south and west windows minimizes heat gain in summer but allow for daylight (on most suites);
Adaptability	• N/A
Community and Social	• Historical, aboriginal and environmental signage; community advisory group; and community-based resources like interactive site maps, event calendars, meeting notes, and community blogs;

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CASE STUDY: GISH FAMILY APARTMENTS

LOCATION: San Jose, California, USA

GROSS AREA: 6,689 m^2 (35 units)

COST: $16.8 million

COMPLETED: June 2007

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 51.1 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 10.6 kWh/m^2 (38.3 MJ/m^2)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): 16.6 kWh/m^2 (4.6 MJ/m^2)

ANNUAL CARBON FOOTPRINT (PREDICTED): 14 kg CO^2/m^2

RATING: LEED for New Construction V2—Gold and LEED for Homes V2—Gold

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• 30kW rooftop photovoltaic system provides 20% of the electricity for common use areas (42,500kWh per year, or 21.9MJ/m^2 per year); • Double-glazed, openable windows to reduce the need for air-conditioning in 95% of the building; • 75% of the building is daylit; • GreenPower purchase contract for 100% of electricity consumption for first two years of operation; • Energy efficiency measures lead to 34% reduction in annual energy consumption compared to a standard, code-compliant building;
Water	• Dual-flush toilets, low-flow faucets and showerheads to reduce water consumption;
Waste	• On-site recycling facilities; • Used reusable formwork in the construction process as part of a comprehensive construction waste management plan;
Materials	• A focus on indoor air quality by including materials with low– or no-VOCs, including paints, carpets, adhesives and sealants; no urea-formaldehyde in wood products; use of natural linoleum floors in kitchens; • 20% of all materials were sourced within 800km of the site, with 50% of those materials harvested locally;
Land	• Drought-tolerant landscaping with sub-surface irrigation systems; • Brownfield site redevelopment; • Mixed-use provided on-site with convenience store and hair salon;
Natural Environment	• No smoking enforced in indoor and outdoor spaces within the project site;
Transport	• Located adjacent to a light-rail station, also within close proximity to major bus lines;
Passive Design	• Minimised exposures on the east and west reduce the solar heat gain;
Adaptability	• Designed for a 100-year life, using durable materials such as concrete, metal and stucco;
Community and Social	• Public display of renewable energy generation on a monitor in real-time in common use areas; • Development aimed toward low-income residents priced out of the existing housing market; • “Eco-passes” provided to all tenants provide free transit on county bus and light-rail lines; • Financial literacy, job training and after-school tutoring programs offered to tenants; • 35% of apartments are set aside for tenants with developmental disabilities;

CASE STUDY: THIN FLATS

LOCATION: Philadelphia, Pennsylvania, USA

GROSS AREA: 1,858 m^2

COST: $3.8 million

COMPLETED: November 2008

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 103.6 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL CARBON FOOTPRINT (PREDICTED): 35 kg CO_2/m^2

RATING: LEED for Homes V1—Platinum

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• 50% less energy than a standard baseline requirements per code; • Central home automation and monitoring system that reduces lighting and energy use; • Solar thermal systems installed on the roof to reduce hot water energy consumption; • High efficiency radiant floor heating systems;
Water	• 23,000L cistern collects all rainwater from the roof for reuse in irrigation systems; • 50% reduction in potable water use over baseline requirements with low-flow faucets and showers and reduced-flush WCs;
Waste	• 90% of all construction waste was recycled and diverted from landfill;
Materials	• Forest Stewardship Council-certified wood flooring in all units; low-VOC paints and carpets; • Rapidly renewable bamboo plywood shelving and stair treads; • All fencing consists of 100% recycled steel; all drywall made of recycled material; • 30% fly ash content in all concrete mixes; • Recycled wood composite exterior siding;
Land	• 100% pervious site ensures that stormwater can be filtered effectively into the ground, reducing runoff and the impact to local stormwater systems; • Intensive green roof further reduces stormwater runoff and reduces the urban heat island effect;
Natural Environment	• Drought-tolerant, native, non-invasive plantings;
Transport	• Located in close proximity to established public transport links, including bus and rail; • Electric vehicle charging points in all garage spaces;
Passive Design	• "Row" home structure was designed so that natural ventilation and lighting would reduce the need for artificial lighting and mechanical heating and cooling;
Adaptability	• N/A
Community and Social	• Envisaged as an educational tool as the first LEED-rated duplex/row house development in the USA;

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CASE STUDY: NEAR NORTH

LOCATION: Chicago, Illinois, USA

GROSS AREA: 4,260 m2 (96 units)

COST: $12.5 million

COMPLETED: March 2007

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 177.2 kWh/m2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL CARBON FOOTPRINT (PREDICTED): 100 kg CO2/m2

RATING: LEED for New Construction V2.1—Silver

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• Rooftop wind turbines provide 8% of the total building electrical demand; • Rooftop solar photovoltaics further offset building electricity consumption; • Solar thermal panels located on the roof supply 30% of the building's hot water demand;
Water	• Rooftop rainwater collection stored in a 5,700L cistern and used for on-site irrigation; • Grey water system that recirculates filtered water from showers and lavatories back into toilet flushing, saving approximately 170,000L of water per year;
Waste	• On-site facilities for recycling;
Materials	• N/A
Land	• Brownfield location; • Close proximity to existing urban amenities, such as grocery stores, post office, government services offices;
Natural Environment	• Stainless steel cladding and reflective roof have a high albedo to reduce urban heat island effects;
Transport	• Located within an existing urban context with good public transport options, including bus and metro;
Passive Design	• Increased solar exposure to the north and south, with minimised east and west exposures to reduce solar heat gain;
Adaptability	• N/A
Community and Social	• Provides housing for homeless people in an historically underprivileged neighbourhood;

CASE STUDY: K2 WINDSOR

LOCATION: Melbourne, Victoria

GROSS AREA: 6,480 m^2

COST: $32.3 million

COMPLETED: February 2007

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 101.5 kWh/m^2

ANNUAL HEATING HOT WATER ENERGY LOAD (BASED ON SIMULATION): 15.9 kWh/m^2 (57.2 MJ/m^2) (Includes domestic hot water, since the heating system is hydronic)

ANNUAL COOLING ENERGY LOAD: No cooling

ANNUAL CARBON FOOTPRINT (PREDICTED): 150 kg CO2/m2

RATING: Not rated

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• Photovoltaic (PV) will provide about 10% of the base building energy, PV's mounted on each unit roof will produce 25 MWh of electrical energy per year, helping to reduce the energy bill for unit occupants; it is estimated the PV panels will reduce CO^2 emissions by 620 tonnes annually; efficient appliances combined with effective resident education are expected to further reduce emissions by 500-800 tones annually; • External roof mounted solar collectors will collectively heat more than 50 per cent of the domestic hot water for the development each year; • The requirement for unit air-conditioning has been removed through the optimisation of building orientation, external solar shading and natural ventilation; • Supplementary heating will be available to all units via hydronic heating using hot water generated from rooftop solar collectors;
Water	• 75% reduction in water use over conventional development; • Rainwater collected from unit roofs will provide approximately 20 per cent of the domestic water for the development each year; • Average water consumption in a Melbourne home is about 650 litres/day; the K2 design brief called for a 50 per cent reduction to about 325 litres; it's estimated the design will cut that to about 138 litres/day; • The 130m^2 rooftop catchments will collect 2.2 mega-litres of water annually or 6,000 litres daily, almost half the total daily requirement of the complex; it will be stored, sterilised and pumped to two domestic hot water plants to supplement the building's hot water supply; a further 4,000 litres is recycled 'grey' water, to be treated and used for irrigation and toilet flushing;
Waste	• N/A
Materials	• 25-50% fly ash replacement for cement; recycled steel for reinforcement; plantation timber used for all non-load-bearing internal and external walls;
Land	• Located close to public transport, schools, employment opportunities and the full range of urban services;
Natural Environment	• Courtyards and gardens are prominent with a "green spine" linking the buildings;
Transport	• The project design ensures pedestrians have priority over motor vehicles, with good separation between car parks and open space areas and close to the CBD and public transport links, with car parking has been limited to 52 vehicles;
Passive Design	• The buildings are orientated east-west to give each unit's living room northern solar access to capture maximum solar energy, with all units having this direct solar exposure; cross-flow ventilation encourages cooling breezes; combined with passive shading and effective insulation there is little need for summer cooling; • The design also facilitates "night purging" in summer, the natural process of night-time heat loss; in winter the design allows for structurally stored daylight warmth to be radiated back at night; limited window areas on the south, east and west reduce heat loss potential.;
Adaptability	• Core structure designed to last 200 years, with infill 'soft' components that can be readily replaced as future technologies yield more efficient materials; structural maintenance requirements have been reduced, with reviews at 10, 20, 50 and 100 years;
Community and Social	• The prominent location of PV panels ensures that they are 'on display' to both residents and the wider community, raising awareness of conservation issues while demonstrating the creative application of technology in a social housing development; • 50% of the apartments are designed for people with disabilities;

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CASE STUDY: BEDDINGTON ZERO ENERGY DEVELOPMENT (BEDZED)

LOCATION: Hackbridge, London, United Kingdom

GROSS AREA: 14,849 m2

COST: $26.1 million

COMPLETED: 2002

ANNUAL PURCHASED ENERGY USE (BASED ON SIMULATION): 0 kWh/m2

ANNUAL ENERGY USE (IN OPERATION): 34.4 kWh/m2

ANNUAL HEATING AND HOT WATER ENERGY LOAD (BASED ON SIMULATION): 48.0 kWh/m^2 (172.8 MJ/m^2)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): No cooling

ANNUAL CARBON FOOTPRINT (IN OPERATION): 14.4 kg CO2/m2 (without the contribution of the biomass cogeneration plant, which would reduce this below zero)

RATING: Not rated

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• The development uses 100% renewable energy sources to achieve zero net carbon emissions in use and incorporates a renewable energy supply (a bio-fuel 135 kW wood fuelled combined heat and power plant (CHP)); CHP waste heat supplies domestic hot water; • Part of the heat output from the Biomass CHP is used to dry the woodchips before they are fed into the gassifier, hence the ratio of remaining heat output to electricity is approximately 50:50; • The dwellings are heated solely by a combination of solar and casual gains (heating gained through activities such as cooking and using electrical appliances);
Water	• Water meters installed in occupant readable permanent position, with flow restrictors installed on all water outlets and low volume flush toilets; • Rainwater and greywater recycling for irrigation use and indoor use; on-site blackwater treatment; • Surface water features such as porous landscaping to allow vertical rather than horizontal water movement, with site treatment of contaminated surface water;
Waste	• Recycling household and domestic waste at source through a three bin system; the BedZED specification sets a target of a 60% recycling rate, with the average household disposing of about 1 tonne of waste per year; • Building waste was segregated on site and sent for recycling, with on-site processing of green waste;
Materials	• BedZed targeted 50% recycled or reclaimed materials including kerbs/paving, structural steel, majority of internal carpentry and joinery package, including doors, joists, floorboards, studding to partitions, cover strips and skirting; • FSC certified timber was used where new timber was necessary; • Construction materials sourced within a 35 mile radius of BedZED included 50% of concrete, concrete blocks, bricks, 80% of timber (excluding window frames), plasterboard, topsoil for skygardens;
Land	• 100% of site was previously used for sewage treatment; site is located close to shops, health care facilities, day care facilities, cafes and bars and schools;
Natural Environment	• Skygardens have 300 mm of topsoil, allowing raised beds if desired by residents for growing food;
Transport	• Pedestrian mews with sky gardens, covered pedestrian/cycle arcade, 117 bike spaces, and 20 non-allocated electric vehicle charging points; • Close to railway station and bus routes;
Passive Design	• The ventilation wind cowls developed specially for BedZED to provide a small amount of supply and extract ventilation to both dwellings and workspaces; • All buildings have a high thermal mass, reducing the need for central heating and all dwellings face south to maximise the opportunity for passive solar gain;
Adaptability	• Design life of 120 years for principle structural elements;
Community and Social	• Demonstration project, with a commitment to make information available to the industry;

CASE STUDY: COLORADO COURT

LOCATION: Santa Monica, California, USA

GROSS AREA: 2,800 m2

COST: $4.8 million

COMPLETED: April 2002

ANNUAL PURCHASED ENERGY USE: 122.5 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 0.133 kWh/m^2 (0.481 MJ/m^2)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): 10.8 kWh/m^2 (39.2 MJ/m^2)

ANNUAL CARBON FOOTPRINT: N/A

RATING: LEED for New Construction V2.0—Gold

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• A 30kW photovoltaic (PV) system is integrated into the building facade and rooftop, which produces more electricity during the daytime peak hours than needed by residents (7.5kWh/m^2 per year); during non-daylight hours, when the PV system does not operate, electricity will be generated by a 28kW natural-gas-powered turbine with cogeneration (waste heat recovery) system, which also provides 100% of the building's domestic hot water needs; • Shading for south-facing windows, minimal glazing on the west façade; double-pane, low-E, krypton-sealed, high-efficiency glazing; reflective roof finish; • Compact fluorescent, low-mercury bulbs with indoor and outdoor motion sensors for lighting; • Compact, energy-efficient, non-CFC refrigerators; • Energy-efficient heat pump with ozone-friendly refrigerant;
Water	• Drought-tolerant plantings, including native plants and ground cover, with drip irrigation system with seasonal adjustment; • Permeable gravel alley and underground stormwater retention system retains 95% of the site's stormwater runoff (and 100% of the entire block's alley runoff) to allow its gradual absorption into the groundwater;
Waste	• Construction site waste recycling and permanent recycling bin storage area;
Materials	• Recycled-content carpet; • Low-VOC paint, formaldehyde-free MDF for cabinetry, natural linoleum instead of vinyl flooring;
Land	• Existing palm trees retained on site;
Natural Environment	• Parking spaces located underneath building to reduce heat island effect;
Transport	• Bicycle racks and storage area; parking spaces for tenant vanpool vehicles;
Passive Design	• Operable windows and transoms for natural cross-ventilation; • Natural daylighting through courtyard design and window placement;
Adaptability	• N/A
Community and Social	• The 44 single bedroom units are designed to be affordable for people on lower incomes;

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CASE STUDY: CHRISTIE WALK

LOCATION: Adelaide, South Australia

GROSS AREA: N/A (27 units)

COST: N/A

COMPLETED: December 2006

ANNUAL PURCHASED ENERGY USE: N/A

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): N/A

ANNUAL CARBON FOOTPRINT: N/A

RATING: Not rated

EVALUATION CRITERIA	KEY SUSTAINABILITY FEATURES
Energy	• All dwellings have solar hot water with electrical backup heating, with a shared system with banked solar panels and a single pump and backup heater; • Photovoltaic panels set on pergolas over the apartments' roof garden will generate electricity for sale to the local energy utility;
Water	• Low water use shower heads and in-line flow restrictors control the water supply; • All water shed by the roofs, balconies and other impervious surfaces is collected for use on site in two 20,000 litre underground tanks situated beneath the carports; after filtering, the water is used for irrigation and toilet flushing thus reducing total water importation to the site;
Waste	• Companies with a recycling program were favoured when specifying appliances;
Materials	• 'Earthcrete' walls place additional thermal mass between the townhouses and assist in noise reduction between dwellings; • Non-toxic construction and finishes are used throughout with a policy of avoiding formaldehyde and PVC; • Timbers are plantation (*Pinus radiata*) or recycled (typically, oregon); • All concrete in slabs and mass walls contains the maximum percentage of fly ash that the engineers and suppliers (Pioneer Concrete) would allow, while paving, carports and feature elements incorporate bricks, stone, steel and timber retrieved from demolition of pre-existing structures on the site; • Recycled content in windows and insulation;
Land	• Brownfield site;
Natural Environment	• Productive community garden and rooftop garden, with low water use plantings with native and indigenous species and on-site water recycling;
Transport	• Pedestrian friendly spaces, inner city context for reduced car dependency, with key amenities close to site; • Full public transport options available, with decreased car parking allowances on site;
Passive Design	• Each house works as a 'thermal flue' allowing controlled release of warm air whilst drawing in filtered, cooled air from the vegetated, landscaped surroundings, the apartments rely on good cross-ventilation and high thermal mass for cooling with the roof garden adding a thermal buffer to the upper floor apartments; • Heating, cooling and humidity control using breezes, sunlight and vegetation; • The overall strategy was to use high internal mass within highly insulated skins with multiple user-controlled ventilation options and thermal flues, vegetation and outdoor spaces were designed to be integral with the house designs as part of the passive design approach; the passive cooling strategy requires windows to be open much of the time but the baffling effect of vegetation and absence of smooth hard road surfaces contribute to relatively good noise control;
Adaptability	• The planned life of the buildings is in excess of 100 years during which time the shells, made from mined materials, are expected to remain much the same while internal partitions, doors and windows, made mostly from renewable materials, may be changed;
Community and Social	• A range of dwelling types are represented in the project with differing configurations, orientations and construction systems to demonstrate the efficacy of environmental design for various conditions and lifestyles;

CASE STUDIES: ENERGY DATA ONLY

THE MACALLEN BUILDING

LOCATION: Boston, Massachusetts, USA

GROSS AREA: 32,500m² (140 units)

COST: $78 million

COMPLETED: April 2007

ANNUAL PURCHASED ENERGY USE: 170.3 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 16.5 kWh/m^2 (59.4 MJ/m²)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): 18.1 kWh/m^2 (65.2 MJ/m²)

ANNUAL CARBON FOOTPRINT: N/A

RATING: LEED for New Construction V2.1—Gold

THE SOLAIRE

LOCATION: New York, New York, USA

GROSS AREA: 33,100m² (293 units)

COST: $128 million (excluding land)

COMPLETED: August 2003

ANNUAL PURCHASED ENERGY USE: 383.3 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 191.7 kWh/m^2 (690 MJ/m²)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): 65.5 kWh/m^2 (236 MJ/m²)

ANNUAL CARBON FOOTPRINT: N/A

RATING: LEED for New Construction V2.1—Gold

CAMBRIDGE CO-HOUSING

LOCATION: Boston, Massachusetts, USA

GROSS AREA: 5,850m² (41 units)

COST: $7 million

COMPLETED: January 1998

ANNUAL PURCHASED ENERGY USE: 108 kWh/m^2

ANNUAL HEATING ENERGY LOAD (BASED ON SIMULATION): 58.9 kWh/m^2 (212 MJ/m²)

ANNUAL COOLING ENERGY LOAD (BASED ON SIMULATION): 2.5 kWh/m^2 (8.98 MJ/m²)

ANNUAL CARBON FOOTPRINT: N/A

RATING: Green Building Challenge

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4.0 REGULATORY REQUIREMENTS

The ACT Government was the first to mandate reporting on the energy efficiency of homes through its ACT House Energy Rating Scheme (ACTHERS). This scheme relies on independent inspection and certification of residential property. For new property, compliance can be demonstrated through modelling according to the requirements of the NatHERS scheme outlined in the next section.

New residential development must also, as part of the ACTHERS/ NatHERS program, comply with the requirements of the Building Code of Australia.

4.1 NATHERS

The Nationwide House Energy Rating Scheme (NatHERS) is administered by the Australian Government's Department of the Environment, Water, Heritage and the Arts. NatHERS establishes a standard approach to rating the thermal performance of houses throughout Australia in an effort to improve energy efficiency and reduce the country's greenhouse gas emissions. NatHERS assigns a star rating, from 0 (poor) to 10 (excellent), to the house's thermal performance. For example, a 10 Star NatHERS rating would suggest an entirely passively cooled and heated house with minimal energy demands.

The star rating is based on the total energy load, as well as the location of the house to account for climatic differences. The rating takes into account the layout of the home; the construction of its roof, walls, windows and floor, the orientation of windows and shading to the sun's path and local breezes, and how well these suit the local climate. Energy consumption by hot water systems, lights or household appliances is not part of the rating because those fittings are usually replaced several times during the life of the building. Therefore, the total energy loads in NatHERS cannot be compared on a one-to-one basis with the energy loads provided in the case studies section unless we have noted cooling/heating loads as a separate metric.

Canberra's climate is considered cool and temperate and has been classed as climate region 24 under the NatHERS scheme. The star rating criteria for Canberra is indicated in Figure 4.1 at right.

STAR RATING	ENERGY LOADS (MJ/ M2 PER YEAR FOR CONDITIONED AREA)	ENERGY LOADS (kWh/ M2 PER YEAR FOR CONDITIONED AREA)
0.5	957	266
1	792	220
1.5	657	183
2	547	152
2.5	458	127
3	387	108
3.5	330	92
4	284	79
4.5	247	69
5	216	60
5.5	189	53
6.0	165	46
6.5	142	40
7.0	120	33
7.5	99	28
8.0	77	21
8.5	56	16
9.0	35	10
9.5	17	5
10.0	2	1

FIGURE 4.1 NatHERS Star ratings for Canberra, with attendant energy consumption figures (Source: "Procedure for Accrediting Software under the Nationwide House Energy Rating Scheme," April 2007)

4.1 NATHERS (CONTINUED)

Case	Heating (MJ/m2/ annum)	Cooling (MJ/m2/ annum)	Total (MJ/m2/ annum)	Star Rating
Minimum rating in Canberra	240	30	270	★★★★☆☆☆☆☆☆ 4 STARS
Proposed rating for Braddon and Reid Master Plan	115.6	4.4	120	★★★★★★★☆☆☆ 7 STARS

FIGURE 4.2 This chart shows the BCA requirements for residential construction in Canberra, which would indicate a 4 Star NatHERS rating currently. Based on best practice in design, construction and operation, and a review of international case studies, this Plan proposes a requirement for the proposed Braddon and Reid residential Master Plan of achieving a 7 Star NatHERS rating at a minimum.

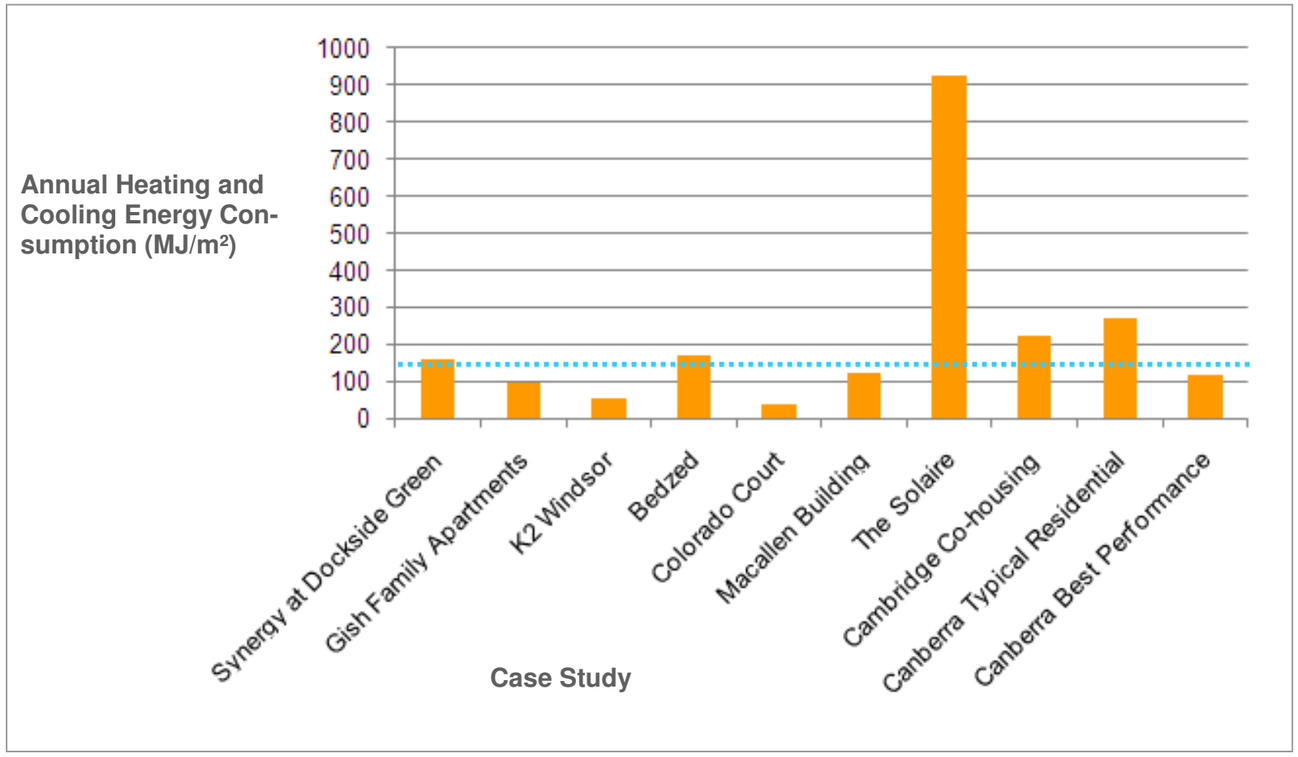

FIGURE 4.3 This graph represents the combined annual heating and cooling energy consumption for the case studies presented in Section 3.0, as well as the BCA compliant residential requirement for Canberra and the proposed "best performance" targets recommended here. The dotted blue line represents the average, which is approximately 140.5MJ/m2 for all case studies, excluding the Solaire. The Solaire was excluded since it did not adequately represent a similar project type to what will be built in Canberra. Current practice in Canberra would be nearly twice the average energy consumption for similar developments worldwide, while the proposed best performance rating of 7 Stars NatHERS would represent a nearly 17% improvement over the average.

4.2 NATHERS ASSUMPTIONS

Achieving a 7 Star NatHERS rating will depend on the Braddon and Reid development achieving a number of energy efficient performance criteria and design strategies. These include opportunities like well-insulated facades, high-performance glazing systems, solar sun shading, and energy efficient equipment. The performance criteria are elaborated as benchmarks in Section 6.0.

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5.0 VOLUNTARY RATING TOOLS

5.1 GREEN STAR

Background

Environmental benchmarking for multi-unit residential buildings is less common than for commercial buildings in the Australian marketplace. While there are several rating schemes for measuring the environmental performance of a residential building, none have reached the same level of public brand recognition as Green Star. Green Star's Multi-unit Residential V1 rating is currently available to the Australian market for use; therefore the proposed Master Plan did not consider non-Australian voluntary rating tools such as LEED or BREEAM.

Depending on how the proposed Master Plan is implemented, either individual buildings or multiple buildings of the same design approach can be certified using the Green Star residential tool.

Target

Each building in the development shall be designed to achieve a 6 Star Green Star Multi-unit Residential V1 Design and As Built rating.

The proposed Master Plan takes into account a number of passive strategies to ensure that such a target is achievable for the development; these are included as Base Targets. A set of Active Targets are also included in the proposed Master Plan, which draw not only from Green Star requirements but other sustainability rating schemes and guidelines in use throughout the world. These initiatives are further explained in the Sustainability Benchmarking Plan included in the Appendix.

Figure 5.1 lists the environmental strategies that are assumed for each of the three Green Star schemes, with the potential points scores included in Figure 5.2.

Base Green Star This scheme is assumed to represent the current proposed Master Plan, including all of the high-performance passive design features included as Base Targets and several of the Active Targets, such as building commissioning, cyclist facilities, and low-voc coatings.

Five Star Green Star Extras This scheme includes strategies that are required to ensure a 5 Star Green Star rating is achievable, such as electricity and water sub-meters, covered (as opposed to uncovered) bicycle facilities, rainwater collection, and high-efficiency appliances.

The 6 Star Green Star Extras This scheme includes points that are necessary to bring the 5 Star Green Star scheme up to a 6 Star

Base Scheme (4 Stars)	5 Star Extras	6 Star Extras
Building commissioning and tuning	All low-VOC coatings	Smart metering
Building users guide	Electrical mub-metering	Additional façade acoustic attenuation
Environmental management	*Covered* cyclist facilities	Photovoltaic system
Waste management plan	Rainwater collection	Shutoff system for apartments when unoccupied and occupancy sensors for public spaces
Natural ventilation (operable façade + dual aspect design)	Water meters	Ultra-efficient appliances
Passive design	PVC minimisation	Additional PVC minimisation
No mechanical cooling	Recycled materials used for 30% in-situ concrete, 20% for precast concrete, and 15 for stressed concrete	Sustainable timber
Daylight and views		Communal garden facilities
Noise insulation for building services		Centralised stormwater treatment system
Mostly Low-VOC coatings and materials		Post-occupancy evaluations
Formaldehyde minimisation		
Appropriate light levels		
Parking allocation for fuel efficient transport		
Cyclist facilities		
Water-efficient fixtures		
High-efficiency appliances		
Landscape irrigation sourced from non-potable water or xeriscaping		
Fire system water recycling		
Recycling waste storage		
Exposed concrete floors		
Universal design		
Zero-ODP/GWP refrigerant		
Zero-ODP insulation		
Eliminate light pollution		

FIGURE 5.1 This table includes sample initiatives that would be required to achieve the desired Green Star rating. This Plan recommends new residential buildings target a 6 Star Green Star Residential V1 rating as a minimum.

5.1 GREEN STAR (CONTINUED)

Green Star building. This includes smart metering (for displaying energy and water consumption to tenants), a solar photovoltaic system, a stormwater treatment system, and a shut-down system for unoccupied apartments (among others).

Current Green Star Advice

The Base and Active Targets included in Section 6.0 correspond to many of the credit requirements needed to achieve a Green Star rating. However, it is the responsibility of the consultant to provide advice based on the most recent applicable Green Star tool available for the project. While this proposed Master Plan is based on the Green Star Multi Unit Residential v1 tool currently available, the Green Building Council provides continuous updates and revisions via credit changes or credit interpretation requests. Each credit should be verified prior to adoption. In addition, some technologies, such as on-site black water treatment plants, are currently unavailable in the ACT. Consultants should confirm the viability of all technology prior to adopting in design.

Costs

Cost estimates were provided for each point on a per-square-meter basis, where available. Costs were not provided for some points due to lack of information or owing to the specific nature of the initiative in relation to building design and optimisation. Please note that all costs are indicative only for the Canberra market; professional cost advice should be obtained during implementation of the proposed Master Plan and for each building project to ensure Green Star and other sustainability strategies are effectively weighted and compared based on best available information.

Indicative cost comparisons are included in Figure 5.2. The base scheme assumes a small premium for some initiatives, but that otherwise the costs are included as best practice design and construction approaches. The large cost difference between a 5 Star and 6 Star Green Star schemes can largely be attributed to the need for renewable energy generation, such as solar photovoltaics, and stormwater treatment systems. It is likely that these costs could be reduced given the size of the Braddon and Reid project and the likelihood of centralisation of some services, especially the stormwater treatment systems.

Some initiatives could also be phased in as the project develops or when costs become less prohibitive. For example, the structural roofs could be designed with green roofs and solar photovoltaic systems installed in the future.

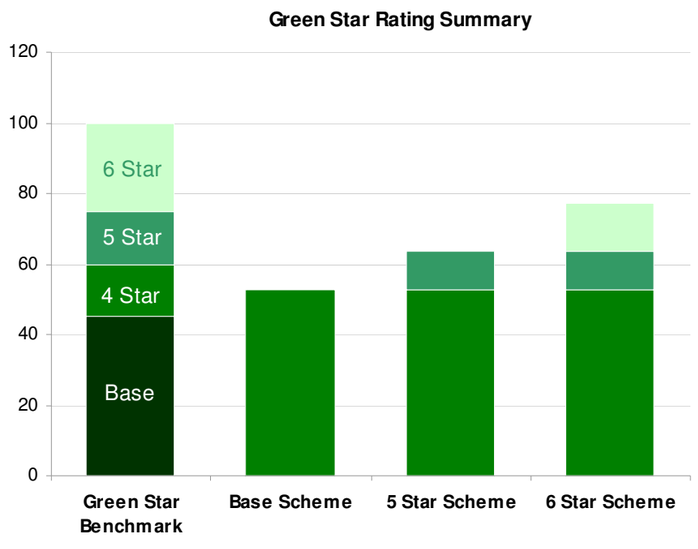

FIGURE 5.2 A preliminary Green Star Multi-unit Residential V1 rating tool strategy was developed to determine the requirements for extending a base scheme to achieve 5 Star or 6 Star ratings.

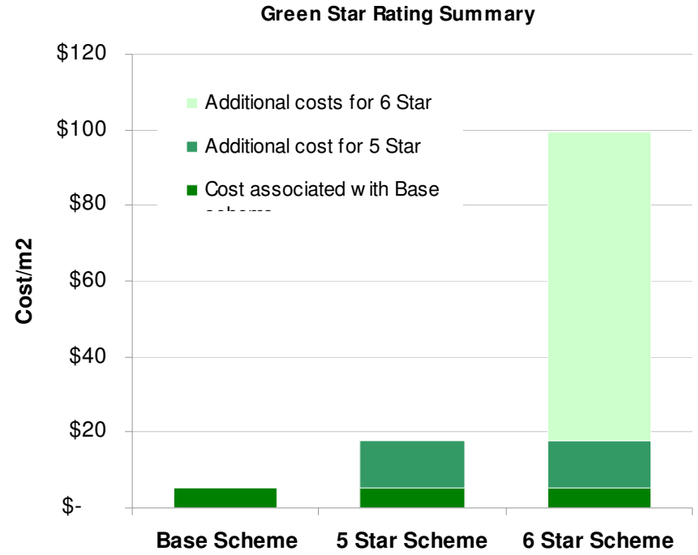

FIGURE 5.3 The initiatives developed for each scheme were then quantified for cost to determine the additional cost for targeting each Green Star rating. This cost is shown based on an area weighting. All figures should be understood as preliminary and for information only.

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6.0 SUSTAINABLE BENCHMARKS: BASE AND ACTIVE TARGETS

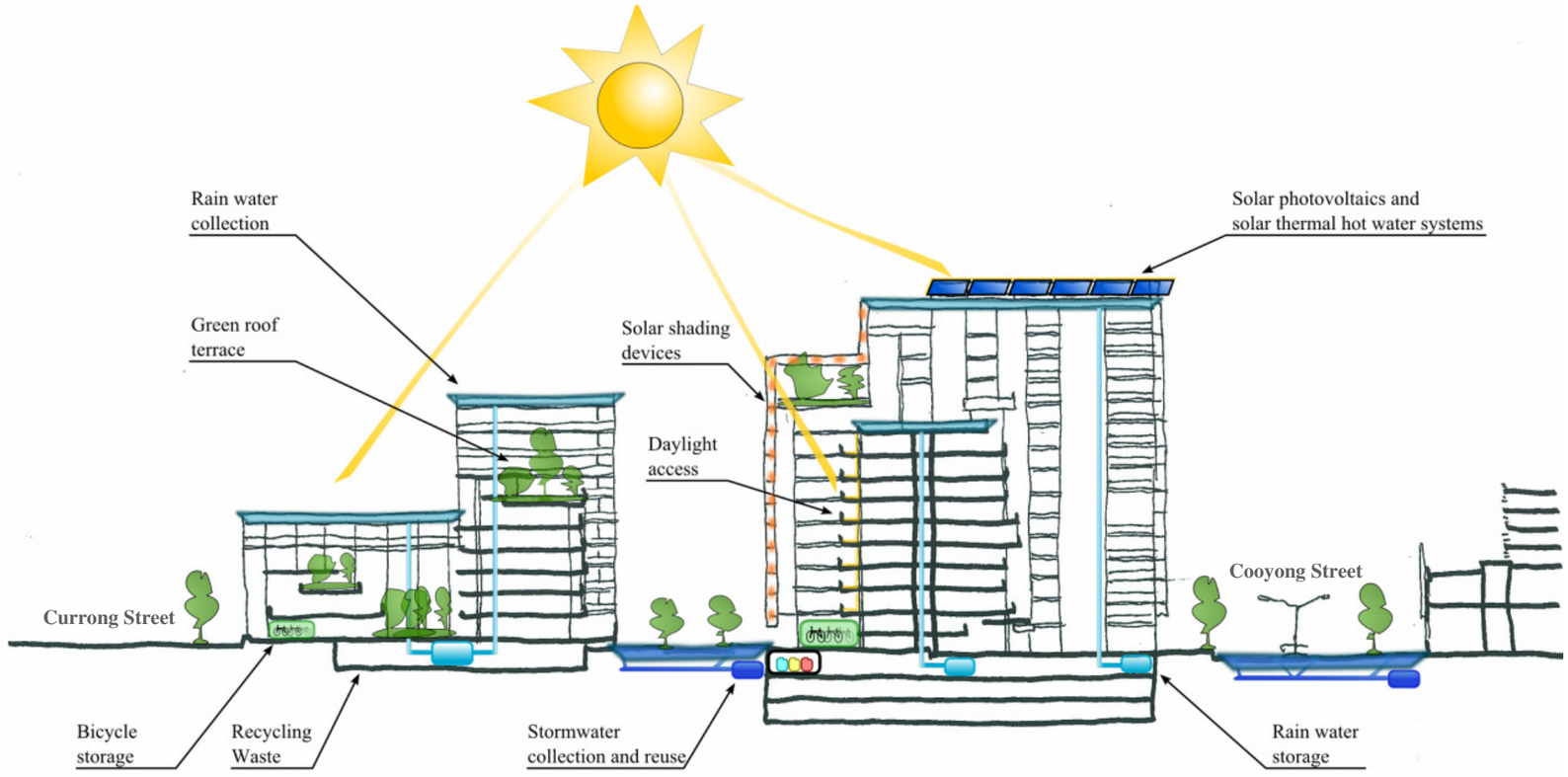

FIGURE 6.1 The Base and Active Targets for sustainability in the proposed Master Plan encourage best practice approaches to planning, design, construction and operation of the Braddon and Reid development. This encompasses a holistic approach to sustainability that takes advantage of the entire site and its surfaces.

Introduction

The following sustainability targets have been developed for the proposed Braddon and Reid Concept Master Plan based on the case study overview presented in Section 3.0, the tenets of the Green Star Multi Unit Residential v1 rating tool, the LEED for Neighbourhood Development v1 rating tool, and best practice guidelines from numerous industry sources and Arup experience.

The sustainability strategy for the proposed Master Plan hinges on two approaches—Base Targets and Active Targets. The **Base Targets** concern the overall orientation, massing and proposed layouts of the buildings on the site to encourage solar access; natural ventilation; renewable energy generation potential; and high indoor and outdoor environmental quality for residents. The **Active Targets** concern the green building and energy ratings targets; building services efficiencies; water, ventilation and material strategies; and landscape initiatives. While the Base Targets inform the proposed Master Plan and are incorporated into the architectural model developed by Cox Humphries Moss and Purdon, the Active Targets can remain open to further refinement during the design, construction and operation of individual buildings.

Both passive design strategies and active technologies are included in this plan, to ensure that resource consumption is first reduced to minimum levels before technologies are incorporated into the development to further reduce environmental impact. Priority should be given to passive strategies that can be “designed into” the development to improve operational efficiency and environmental quality.

These benchmarks should be discussed and agreed as part of an integrated design process for each building within the proposed Master Plan, as well as the overall site. The entire project team delivering the implementation of the proposed Master Plan shall be responsible to ensure these benchmarks are addressed in design, construction and handover.

Targets

1. Implement an environmental management plan for the proposed Master Plan development based on Section 3 of the NSW Environmental Management System Guidelines (2007);
2. Ensure the proposed Master Plan contractor maintains a valid ISO 140001 Environmental Management System accreditation prior to and during the entire project contract duration;
3. Achieve 6 Star Green Star Multi Unit Residential v1 Design and As Built ratings for the development.

6.1 BASE TARGETS

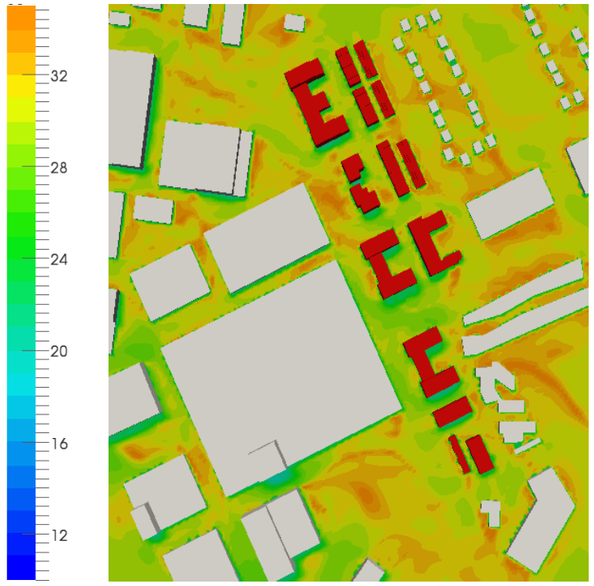

FIGURE 6.2 (LEFT) The results of the microclimate study, included in the Appendix, indicates that through proper site orientation and massing, comfortable conditions can be maintained in the public spaces in the proposed Master Plan. This image illustrates the Standard Effective Temperature for a Summer day around noon—this is the temperature that a person would "feel" if they were in the space (refer to the temperature key at far left). There is, however, the potential to impact the adjacent residential development to the North-Northeast of the site, since the new development will effectively shield Summer winds. However, this will have a minimal effect, as this image illustrates the "worst case" scenario; the typical conditions will be much milder. Refer to the microclimate study in the Appendix for more details.

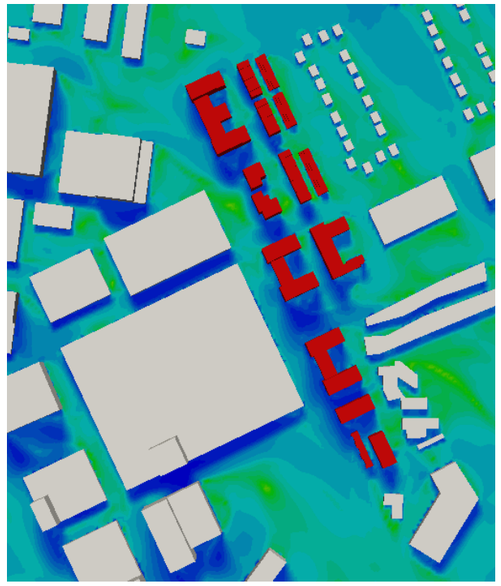

FIGURE 6.3 (LEFT) This image illustrates the Standard Effective Temperature for a Winter day around noon—this is the temperature that a person would "feel" if they were in the space (refer to the temperature key at far left). During Winter, it is likely that Block H (at the Southern end of the site) will experience colder conditions due to overshadowing and wind effects. Refer to the microclimate study in the Appendix for more details.

The Base Targets have been used to inform the development of the proposed Master Plan in terms of spatial planning and building orientation. These targets ensure best practice design is used to ensure residential units are efficient and environmentally sensitive, while also leading toward healthy and pleasing outcomes for residents.

1. Refer to the Arup microclimate study in the Appendix of this Plan to provide best practice microclimate design for exterior spaces using methodology and passive means for the following key factors:

   Wind: based on the Lawson criteria for a 5% exceedance applied to an acceptable velocity of 4m/s for outdoor play, picnic and gathering areas on the site and 8m/s for areas dedicated to walking and circulation; for areas identified in the microclimate study, consider providing vegetation or other baffles to break the wind in areas for leisure or sedentary activity;

   Solar Access: ensure that at least 25% of all outdoor communal space shall be shaded by the sun through either natural or artificial means at any given time;

   Thermal Comfort: use the standard effective temperature (SET) analysis provided in the microclimate study to identify thermal comfort issues and appropriate mitigation strategies for exterior spaces;

2. Individual dwelling units shall be designed to provide cross-ventilation capability, with openable windows from at least one or more rooms to at least two separate exposures or with openable, secure exposure to floor-by-floor winter gardens as common lobby shared space with openable windows or louvers equivalent to at least 5% of the lobby floor area; at least 95% of all common lobby floor area shall be naturally ventilated in this manner;

3. Provide openable windows capable of allowing natural ventilation for lounge rooms, kitchens, dining areas, bathrooms and bedrooms in each dwelling; where openable windows cannot be provided, use trickle ventilators for outside air according to the requirements of the Green Star Multi Unit Residential v1 rating tool IEQ-21 credit;

4. Provide high albedo roof materials, with a Solar Reflectance Index (SRI) no less than 78, and hardscape surfaces, with a SRI no less than 29, to reduce the Urban Heat Island (UHI) effect; refer to the Active Targets for requirements for green roofs, which will also act to decrease UHI effects;

5. Ensure that building orientation and sun-shading schemes are designed to allow for a daylight factor of 2.5% in kitchen areas and 1.5% in living areas as measured at the floor level under a uniform sky;

6. Provide private external space for at least 90% of the dwellings in the proposed Master Plan according to the criteria outlined in the Green Star Multi Unit Residential v1 rating tool IEQ-20 credit;

7. Ensure that all dwellings are within 0.4km from at least 15 of the following pedestrian destinations or land uses: bank; childcare facility; community/civic centre; convenience store; hair care; hardware store; health club; laundry/dry cleaner; library; live-work housing; medical/dental office; park; chemist; place of worship; police/fire station; post office; restaurant; school; senior care facility; supermarket; transit/bike shop.

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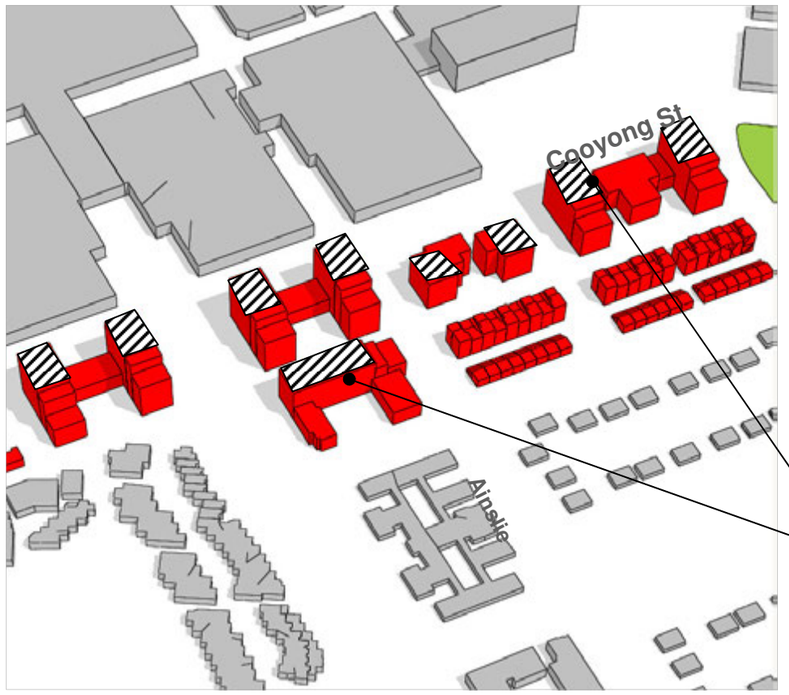
6.2 ACTIVE TARGETS

The Active Targets have been developed to be applied in design, construction and operation of the implementation of the proposed Master Plan. The Targets are arranged according to the metrics explained in Section 2.0 and analysed with the case studies in Section 3.0, including the following:

- Energy
- Water
- Waste
- Materials
- Natural Environment
- Transport
- Adaptability
- Community and Social

In some cases, these Targets are given a reference to a code, standard, or a credit within the Green Star Multi Unit Residential v1 rating tool. As such, implementing these Targets are part of the proposed Master Plan's strategy for targeting a 6 Star Green Star rating in Design and As Built. As part of a Green Star process, it's the responsibility of the design, construction and client team to determine appropriate strategies within the given cost plan and building requirements. In that light, these Targets should form the basis for a discussion in design prior to adopting each one. Stakeholder consultation, which is also proposed as a Target in the Community and Social category, is a key part to achieving best practice sustainability results for the proposed Master Plan implementation.



Upper rooftops have been identified for both solar photovoltaic and solar thermal hot water system installations. These rooftops allow for an ideal north-facing orientation and no obstructions; in addition, there are no view lines down to these surfaces.

Energy

1. Achieve 7 Star NatHERS ratings for all residential units to exceed the thermal performance requirements of the ACT;
2. Generate a minimum of 10% peak power demand for the residential components from on-site solar photovoltaic installations;
3. Implement a Green Power purchase contract for 100% of all grid-source power supply as part of the leasing agreements for the development;
4. Document the greenhouse gas emissions reduction to a baseline as outlined in the Green Star Multi Unit Residential v1 rating tool Ene-1 credit;
5. Provide a building management system for each building and connected across the development to monitor energy, water and other systems operation;
6. Install smart meters for each dwelling so that occupants can determine real-time consumption for electricity, water and gas, as well as peak demand pricing (if feasible), to future-proof the development for the Australian adoption of smart grid infrastructure; the system shall allow occupants to quantify consumption on an hourly, daily, monthly and annual basis; connect this metering system to the building management system for the site;
7. Install energy meters for all electrical loads in the building greater than 100kVA; connect these meters to the building management system for the site;
8. Provide leasing agreements and body corporate requirements to ensure that all refrigerators, dishwashers, clothes dryers and clothes washers shall be within one point of the highest MEPS rating available;
9. External clothes drying lines and/or hoists shall be provided for each dwelling, with a total line length of no less than 7.5m;
10. Heating systems shall have a Coefficient of Performance no less than 3;
11. Cooling and/or air-conditioning systems shall have a Coefficient of Performance no less than 3;
12. Pre-commissioning, commissioning, quality monitoring, and building tuning shall be implemented during design, construction, completion and post-occupancy according to the CIBSE Commissioning Codes as outlined in the Green Star Multi Unit Residential v1 rating tool; the implementation of post-occupancy evaluations shall be undertaken by the building owner or body corporate as a component of the building lease

6.2 ACTIVE TARGETS

agreement, with results of evaluations provided to all building residents; this will also be undertaken for public housing components of the proposed Master Plan and made available to tenants;

13. Install a ceiling fan in at least one room in each dwelling;
14. Install an over-ride switch for all dwelling mechanical and lighting systems at the main entrance;
15. Provide occupancy sensors for lighting and mechanical systems for unoccupied, non-dwelling spaces in each building;
16. Install automatic controls for mechanical and lighting systems in non-dwelling areas of each building;
17. Ensure that a minimum of 300 lux is achieved on the surface (900mm above the floor level) of the kitchen sink, cooktop or stove, and the vanity basins in bathrooms or ensuites;
18. Provide dedicated and separated extract fans for kitchen ventilation for at least 90% of residential kitchens;
19. Install rooftop solar thermal systems to supply all domestic hot water requirements for each building; if heating systems are to be installed, size the system to accommodate the potential for a hydronic heating system in each dwelling;

Water

1. Individual dwellings shall be designed to use less than 150L/day per unit through efficient fixtures as indicated below;
2. All bathrooms shall have 6 Star WELS-rated bathroom and kitchen taps and water closets, as well as 3 Star WELS-rated showerheads;
3. Ensure that building outflows to the sewerage system due to building occupants' usage is reduced by at least 50% when compared to benchmarks used in the Green Star Multi Unit Residential v1 rating tool; treated water shall be used on-site for non-potable water needs, such as sub-surface irrigation, toilet flushing, and, if required, heat rejection; if black water treatment plants are allowed under ACT regulations, consideration should be given to reducing outflows to the sewerage system by at least 90%;
4. After the establishment of landscaping, dedicated irrigation shall be provided for no more than 20% of plants and trees within the site;
5. Install a domestic cold water meter in each dwelling and provide a connection to a development-wide building management system infrastructure so that water consumption rates can be tracked;
6. Install water meters on all significant water loads in each building; these meters shall be connected to the building management system of each building so that water loads can be monitored by the building owner or body corporate to reduce water consumption in operation;
7. All irrigation water and toilet flushing demand shall be supplied with rainwater collection and storage systems located on the site;

Waste

1. Dedicated recycling waste collection, sorting and storage areas shall be included in each residential building and shall be accessible to both residents and recycling waste handling companies;
2. Where waste chutes are provided, include both waste and recycled waste chutes and provide them so they are accessible on each floor;
3. Provide 1m³ for every 500m² of landscape space for dedicated food and yard waste composting areas as part of the site landscape design and shall be accessible to all residents and landscape personnel to provide organic material for use in on-site gardens and landscaping; design of the composting area should meet best practice guidelines and ensure leaching does not infiltrate adjacent stormwater or other such systems; as an alternative, dedicated compost collection areas can be nominated to allow for the off-site composting of the development's organic materials according to the requirements of AS4454 (2003) for Composts, Soil Conditioners and Mulches;
4. Communal space shall be set aside within the overall development for the collection of over-sized personal goods or furniture that can be publicised for the reuse by other occupants;
5. Develop a waste management plan for use during the construction of the proposed Master Plan, which also incorporates an erosion and sedimentation plan for ensuring runoff from the entire project site during construction does not pollute surrounding areas;
6. Recycle or reuse a minimum of 90% of all construction and demolition waste, including reuse on the site as aggregate for footpaths and other similar landscape feature;
7. Provide precinct-wide exterior waste and recycling bins at each building entrance and at least one such bin at diagonal corners of street intersections within and bordering the site; such bins shall be maintained and managed by adjacent building managers subject to agreement by the Department of Territory and Municipal Services;

Materials

1. Source at least 20% of all construction materials from the local area (within a 1,600km radius of the site, if feasible);
2. Source at least 1% of the building materials using recycled content (by cost);
3. All wood shall be certified as sustainably harvested by either the Forest Stewardship Council or PEFC;
4. At least 20% of all concrete aggregates shall be from recycled sources;
5. All PVC use shall be from suppliers who can demonstrate compliance with the Green Building Council of Australia's *Best Practice Guidelines for PVC in the Built Environment* ;
6. Maintain the existing structural components and façade for reuse in buildings identified in the proposed Master Plan for refurbishing;
7. Undertake a hazardous materials survey for the site prior to demolition of existing buildings and deal with such materials according to Occupational Health and Safety legislation;
8. Comply with the VOC limits for paints, carpets, flooring and adhesives and sealants according to the Green Star Multi Unit Residential v1 credit IEQ-8;
9. Use timber products that contain no added urea-formaldehyde;
10. All fencing shall contain either 100% recycled metal or wood materials;
11. Renewable materials, such as bamboo, shall be used for cabinet works and timber floors in all buildings;
12. Kitchen floor material shall consist of linoleum where vinyl is proposed (or otherwise another material);

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6.2 ACTIVE TARGETS

Land

1. Separate all topsoil from construction debris or infill so that at least 95% of all topsoil by volume on site retains its productivity and is reused so there is no net change in topsoil on site;
2. Provide deep soil planting areas with a minimum depth of 1500mm for at least 75% of on-grade landscaped areas to ensure flexibility for the landscape regime;
3. Green roofs shall include a soil depth of at least 300mm to accommodate agricultural production and diversity of landscape;
4. At least 25% of all on-grade landscape areas shall be designed to enable active play;
5. Lighting installed in trees or to shine onto trees shall be avoided to ensure the biodiversity of the site and that native fauna habitat is not disturbed;

Natural Environment

1. Provide trees, with a calliper of at least 0.6 metres, at intervals between 4.5 and 9 metres along footpaths with no overhead utility lines;
2. Tree planting schemes shall ensure that 50% of all footpaths are under the tree canopy at tree maturity;
3. Exterior lighting fixtures shall not exceed a base allowance of 24,000 lumens with an allowed initial 35.5-45 lamp lumens/m² to conform to the dark sky requirements of the International Dark Skies Association; further, exterior light fixtures shall not have an upward light output ratio greater than 5% and shall comply with AS4282;
4. All new landscaping plants and trees to be native species that are regionally appropriate;
5. All pest and weed control chemicals used on site shall be biodegradable and non-toxic;
6. Use no HVAC refrigerants for mechanical cooling, provide no mechanical cooling, or ensure that all HVAC refrigerants have a Global Warming Potential of 10 or less and an Ozone Depletion Potential of zero;
7. All thermal insulants shall not include ozone-depleting substances;
8. Install stormwater systems to ensure that peak stormwater flows are not increased for rainfall events of up to a one-in-two year storm;

FIGURE 6.4 A Better Place has proposed to make Canberra a test city for the implementation of an electric car infrastructure roll-out in Australia. By incorporating car charging infrastructure into Braddon and Reid, even if only provided as future-proofing infrastructure, will place the development at the forefront of sustainable living in the ACT (Photo courtesy A Better Place).

9. All stormwater leaving the site shall be treated in accordance with either the *Urban Stormwater Best Practice Environmental Management Guidelines* (CSIRO 1999) or the Australian and New Zealand Environment Conservation Council's *Guidelines for Urban Stormwater Management,* as well as all applicable ACT requirements at a minimum;
10. Provide bio-retention rain gardens for individual residences with yards with perennial vegetation, organic and sand-amended topsoil, above a gravel drainage layer, for at least 10% of the roof area of the dwelling;
11. Provide bio-retention swales along the edge of large paved areas or medians; swales to be planted with perennial vegetation, organic and sand-amended topsoil, above a gravel drainage layer, for at least 10% of the adjacent impervious area;
12. Use paving designed to allow water to pass through the surface, using porous asphalt or concrete or interlocking concrete permeable pavers, for footpaths, driveways, alleys and streets to ensure groundwater recharge during storm events;

Transport

1. Provide dedicated parking spaces, 5% of total, for car share program vehicles and infrastructure to support electric car charging outlets in the on-site parking facilities;
2. Provide small car parking spaces and dedicated moped and/or motorbike parking according to the requirements of the Green Star Multi Unit Residential v1 rating tool Tra-2 credit;
3. Provide dedicated pedestrian crossing zones at each street intersection within and bordering the site to encourage resident access to adjacent sites as part of a comprehensive urban pedestrian design strategy;
4. Cyclist facilities shall be developed for each building based on the ACTPLA *Bicycle Parking Guidelines*; at a minimum, one secure bicycle rack, locker or cage shall be accorded to each dwelling and 300 visitor bicycle racks in sign-posted, well-lit, accessible areas shall be provided throughout the site development according to the requirements of the Green Star Multi Unit Residential v1 rating tool Tra-3 credit; bicycle racks or lockers under cover or internal to the buildings, either in a cage or in dedicated space, or dedicated individual resident storage space suitable for bicycles shall also be provided for at least 50% of dwellings in lieu of bicycle racks;
5. At least 10% of visitor bicycle parking spaces at each building shall be set aside for bicycle share schemes for residents; the share scheme shall either be administered by the building owner or body corporate or included as part of a city scheme or outside contractor provision;
6. Provide connections from each dwelling/building such that public transit facilities (i.e. bus stops) are within a 0.4km distance for residents;
7. Dedicated bicycle lanes shall be provided for streets within the development, with connections to established bicycle lanes on streets surrounding the site subject to agreement by TAMS;
8. Provide at least one shower and change room for the retail and commercial component of the site, considering a threshold of up to 100 new workers on site and providing at least one more shower and change room per every 150 workers thereafter;

Adaptability

1. Ensure that building services equipment is designed to respond to expected climate change conditions within the next 40 years by undertaking a risk assessment of temperature increases in Canberra; consideration should be given to expected average temperature increases and the occurrence of more extreme days in both winter and summer;

6.2 ACTIVE TARGETS

2. Design commercial and retail components of the site so that they may be adapted for different uses in the future, with flexible floor plates and façade components;
3. Consideration shall be given to live/work arrangements for residential units, with flexible floor plans to enable multiple uses;

Community and Social

1. The building shall achieve a 6 Star Green Star Multi-Unit Residential Design and As Built rating from the Green Building Council of Australia;
2. Ensure that at least 25% of the total site area is developed as outdoor communal facilities, comprising of at least nine facilities that could be a combination of either composting facilities, garden plots, worm farms, playgrounds, swimming pools, open landscaped play areas, sun-shaded areas, outdoor dining or seating, or barbeque areas as described elsewhere in this proposed Master Plan and according to the requirements of the Green Star Multi Unit Residential v1 rating tool; a maintenance plan for each facility shall also be developed and provided to the building owner or body corporate;
3. Provide at least 10% of all dwellings for public housing purposes or for otherwise identified low-income and eligible residents;
4. For retail and commercial components of the development, CSD will work with operators toward identifying and employing vulnerable persons as defined by the ACT Government's *Canberra Social Plan* or by other relevant authorities as agreed with CSD;
5. Provide dedicated, centralised interior communal space for community events, meetings and education opportunities;
6. Set aside a minimum of 20% of all green space, either on-grade or on the roof, for gardens for food production; ensure the gardens are accessible to residents;
7. For universal basic access, provide one zero-step entrance on an accessible route for each building or individual residence;
8. To ensure that residential units can be occupied by residents with special needs or physical demands, provide all main floor units or individual residences with one usable half-bath (or full bath);

FIGURE 6.5 ACTPLA's Bicycle Parking Guidelines, from 2006, recommend a significant amount of cyclist facilities for residential developments. These have been incorporated into the proposed Master Plan Active Targets in order to reduce emissions and other environmental impacts associated with car transport, while also encouraging a healthier lifestyle for residents.

9. Interior doors to be provided or designed for adaptation to ensure passable access for all people, including those in wheel chairs, for at least 10% of all units;
10. Provide footpaths no less than 1.8 metres in width with no barriers or furniture in the clear walk area; for retail areas, increase the width to 2.4 metres;
11. For 90% of all new building frontage, provide a principal entry on the front façade to face a public space, but not a parking lot, and connect to a footpath or equivalent provision for walking;
12. All footpaths shall be provided for public use and not gated;
13. A building users guide shall be provided to all new tenants upon occupancy throughout the life of the building, including changeover of tenants within a single unit; the guide should address building systems operation, intended environmental performance and benchmarks, community resources and amenities, and guidelines for accessing and maintaining shared public spaces; the guides should be developed according to the requirements of the Green Star Multi Unit Residential v1 rating tool;
14. Develop a community outreach and involvement plan that incorporates community meetings, official public hearings, and on-going communications strategies to relay project information and solicit feedback from community members, government representatives, and local stakeholders during design, construction and handover of the project; upon occupancy, consider implementing this established process as part of the body corporate for each building;
15. Implement a construction noise management plan consistent with the NSW Department of Environment, Climate Change and Water (DECCW)'s *Interim Construction Noise Guideline 2009* and the ACT Government's *Environment Protection Act 1997* and its accompanying *Environment Protection Regulations 2005*;
16. Comply with the internal noise levels for residential units as set forth in the Green Star Multi Unit Residential v1 rating tool credit IEQ-7;

APPENDIX

Figure A1.1.1: Canberra, ACT. Proposed Master Plan Location

Figure A1.1.2: Braddon and Reid area, Proposed Master Plan Location

Figure A1.1.3: Canberra, ACT. Proposed Master Plan.
3D model for the Microclimate Study.

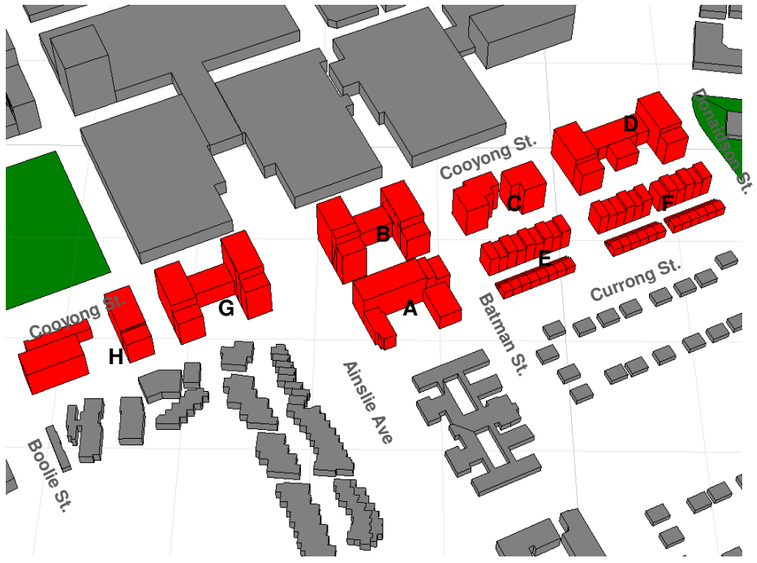


Figure A1.1.4: Canberra, ACT. Proposed Master Plan.
3D model for the Microclimate Study.

A1 MICROCLIMATE ANALYSIS

Introduction

A microclimate analysis of the proposed Master Plan was undertaken by Arup on behalf of CSD and Purdon Associates in response to the architectural model developed by Cox Humphries Moss as of 12 August 2011. The analysis considered solar access, wind effects, and comfort (in terms of Standard Effective Temperature). The study incorporates results for the public space within the proposed Master Plan, as well as its impact on the surrounding precincts.

The purpose of this study is to provide a model for the development teams that will implement the proposed Master Plan to consider the effects of building design on the surrounding environment in order to lessen the impact on the existing Canberra urban fabric. The existing site is a residential development surrounded by retail and office development on the West and residential, education or park land development on the other exposures. In some instances, the scale of the new development does not change significantly from what is existing on site (such as Blocks VIII), while other Blocks are significantly denser.

Methodology

The microclimate review combines two advanced assessments, wind and solar access, to derive a single criterion for estimating comfort conditions.

Both assessments have been completed using numerical methods to assess annual comfort conditions.

Computational fluid dynamics (CFD) has been used to predict the local wind climate and ray-tracing methods have been used to determine solar access.

The numerical methods use 3D models of the proposed development and surrounding buildings, which have been included to a distance of approximately 500m from the site.

Model

The model is based on the information received from Cox Humphries Moss Architects on 12 August 2011.

A1.1 SOLAR EXPOSURE

Methodology

The process for assessing solar access at the pedestrian level is as follows:

- Calculate the position of the sun at each hour of the day for selected time periods.
- For each hour, determine whether each part of the site is in sun or shade.
- Combine results for all hours to determine percentage of hours when the site is in sun.

Results

The majority of the new area of the proposed Master Plan receives direct sunlight for most of the specified hours, with better exposure in the courtyards in the mornings. In general, the denser residential blocks tend to overshadow the streets, where solar access is reduced, particularly given the heights of some buildings in the proposed Master Plan.

During Autumn, Winter and Spring afternoons the shadows cast by Blocks VII and VIII reduce solar access to the residential development East of the site by less than 25%. During afternoon hours throughout the year, Block V casts shadows over the adjacent existing buildings, causing approximately 50% reduction in solar access.

The higher density buildings could be concentrated and oriented along Cooyong Street and along the South sides of each block. Lower rise buildings could be concentrated along the North sides. This would improve the solar access to more apartments (preventing Northside towers from overshadowing Southside towers) and concentrate overshadowing along the streets.

However, the level of solar access illustrated in this study would be found acceptable for higher density urban environment and is consistent with other parts of Canberra's Civic precinct. In addition, given the proximity of the proposed Master Plan site to adjacent park lands, residents will have access to full sunlight and recreation when needed.

Generally, best sustainable design practice suggests that in mid-Winter, dwelling units should experience at least 3 hours of sunlight during the day (see NSW Planning's *Residential Flat Design Code*, 2002, as well as the Green Star Multi Unit Residential v1). There are exceptions to this, especially given site constraints in dense urban locations. Generally, the proposed Master Plan addresses solar access well for individual dwellings (this is not specifically addressed in this microclimate study).

Summer

- There is high solar exposure site wide during summer months.
- Courtyards receive good solar access throughout the majority of the day, with a slight reduction in the afternoons which is expected.

Mid-Seasons

- Solar access during mid-seasons is acceptable.
- Internal courtyards have low solar access in the afternoon.

Winter

- The main roads, sidewalks and public spaces remain well-exposed to daylight during Winter months.
- Internal courtyards are often quite shaded throughout the entire day, with some receiving no access to daylight at all.

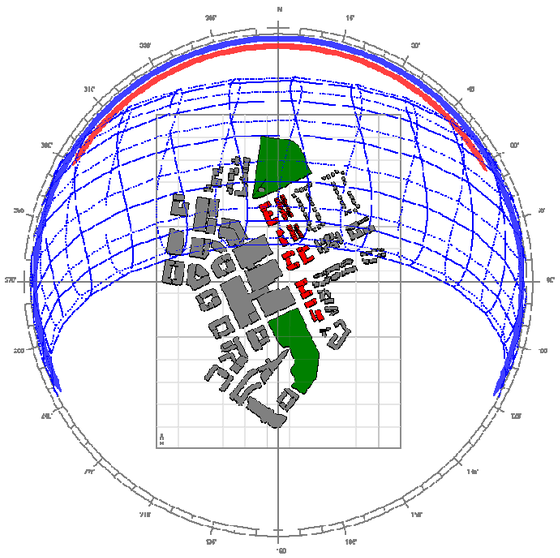


Figure A1.2.1: Annual Solar Path. Top View

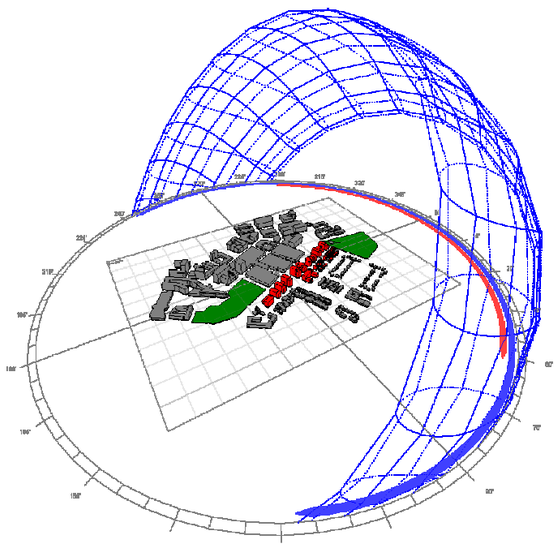


Figure A1.2.2: Annual Solar Path. Perspective View

ISSUE

A1.1.1 SOLAR EXPOSURE ANALYSIS

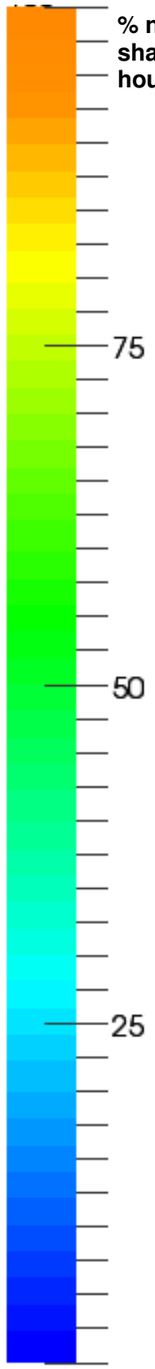


Fig. A1.4.1 Summer Morning

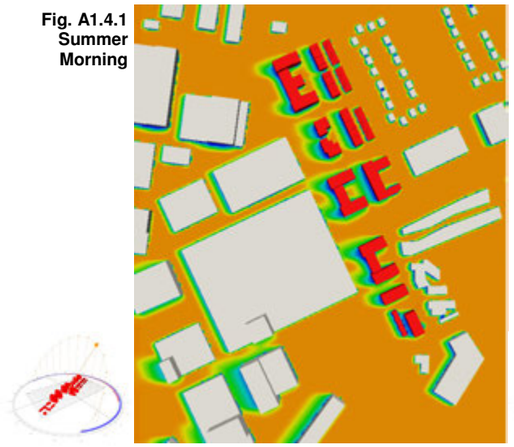


Fig. A1.5.1 Autumn Morning

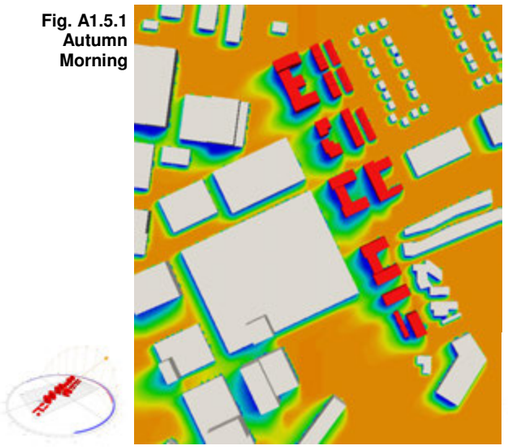


Fig. A1.6.1 Winter Morning

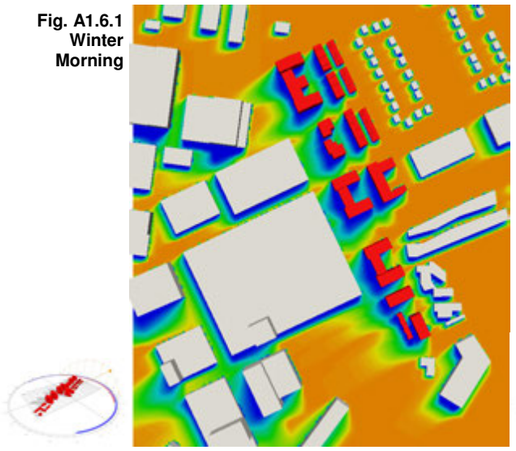


Fig. A1.7.1 Spring Morning

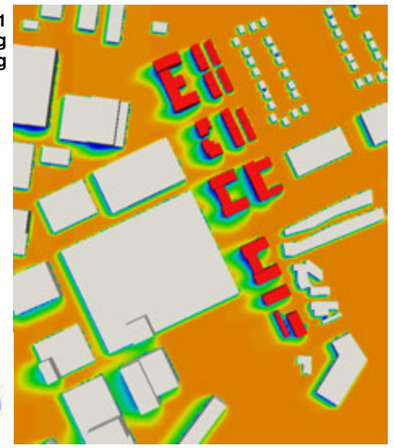


Fig. A1.4.2 Summer Midday

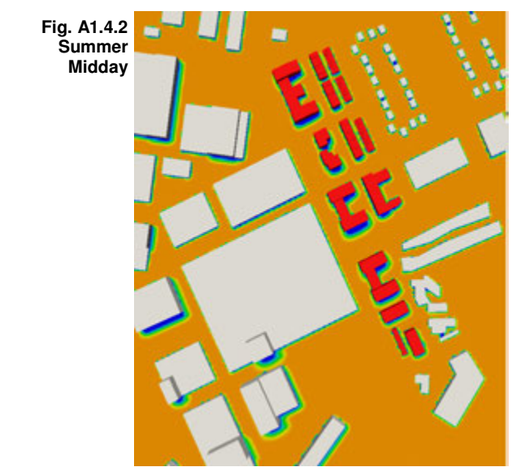


Fig. A1.5.2 Autumn Midday

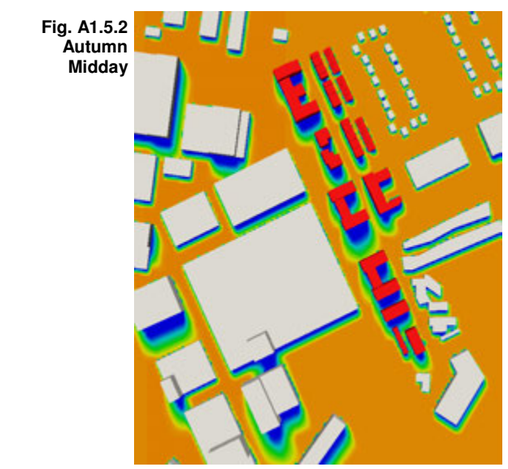


Fig. A1.6.2 Winter Midday

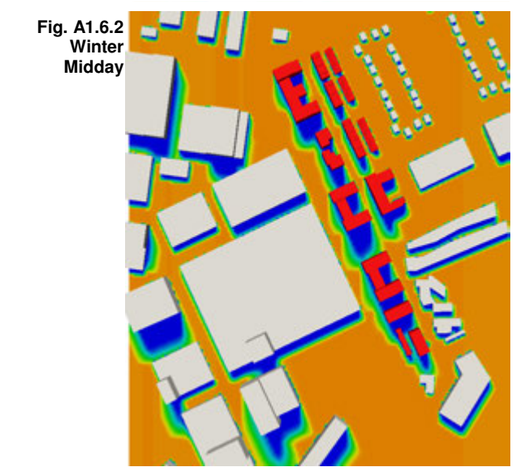


Fig. A1.7.2 Spring Midday

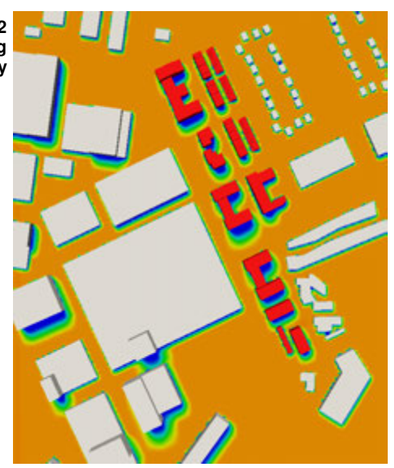


Fig. A1.4.3 Summer Afternoon

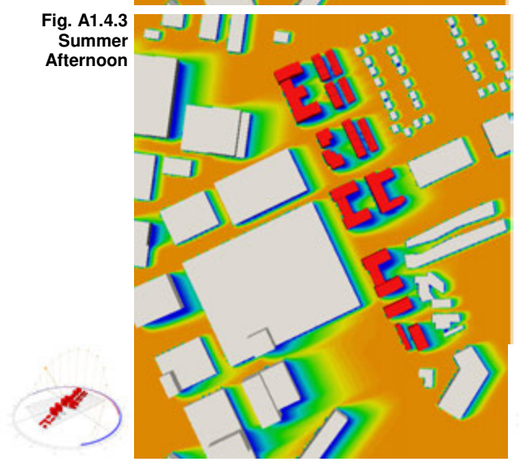


Fig. A1.5.3 Autumn Afternoon

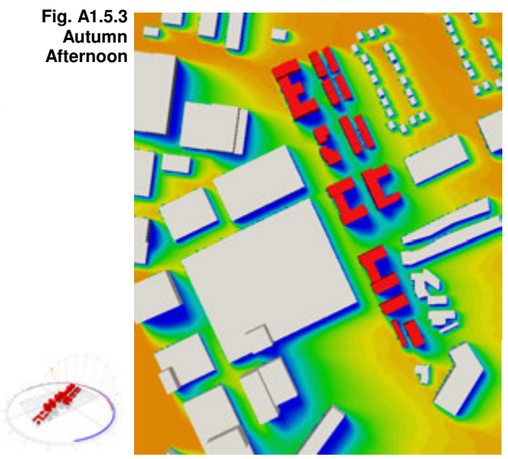


Fig. A1.6.3 Winter Afternoon

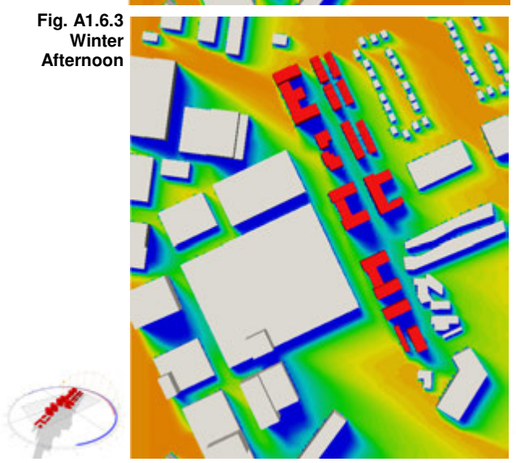
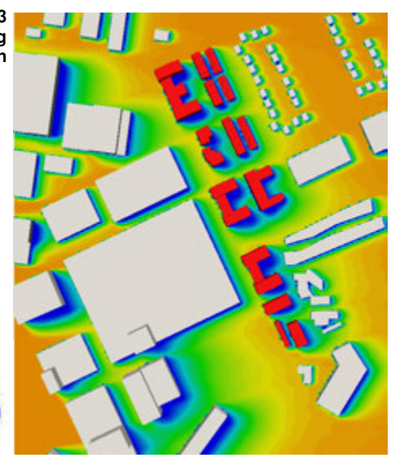


Fig. A1.7.3 Spring Afternoon



ISSUE

A1.2 WIND EFFECT ANALYSIS

Wind is a key contributor to perceived pedestrian comfort. In Summer months, a strong wind can aid physiological cooling, where a person 'feels' cooler due to air movement. In Winter months, however, a cold wind will significantly increase discomfort, especially when combined with rain. In this analysis, wind speed and directional probability are analysed to determine where discomfort or unintended effects could potentially occur.

Methodology

The basis for assessing wind conditions at the pedestrian level is founded on a well-established analysis process explained as follows:

- Undertake a statistical analysis of historical wind data to establish the Weibull parameters. The Weibull parameters describe the probability and strength of wind approaching the site from each wind direction.
- Use CFD to predict the local wind conditions at pedestrian level for each wind direction, for a reference wind speed and atmospheric boundary layer profile.
- Combine the Weibull parameters with the results of the CFD analysis to calculate the mean wind speed for particular times of the day or year associated with a probability of exceedance of 5%.
- Compare the predicted mean wind speed with desirable targets known to be compatible with wind comfort. For the purpose of this assessment, we have used the interpretation of the Lawson criteria established by BMT in the UK, which are regularly used in the UK for assessment of wind comfort [*Outdoor Human Comfort and Assessment*, American Society of Civil Engineers, 2003]. The threshold criteria for this study has been set at 10m/s with a probability of exceedance of 5%, which corresponds to sites that are appropriate for "fast or business walking". Greater than 10m/s indicates wind discomfort. See the table at right.

Results

Results from the wind analysis are shown on page 32 for each season of the year in three different periods of the day: Mornings (starting at 8am until before midday), 12pm and Afternoons (just after midday and until 6pm). From this, critical areas were further analysed and summarised on pages 33.

Lawson Criteria for Wind Acceptability	Threshold
Uncomfortable for all uses	
Fast or business walking	5% > 10m/s
Strolling or window shopping	5% > 8m/s
Short periods of standing or sitting	5% > 6m/s
Long periods of standing or sitting	5% > 4m/s

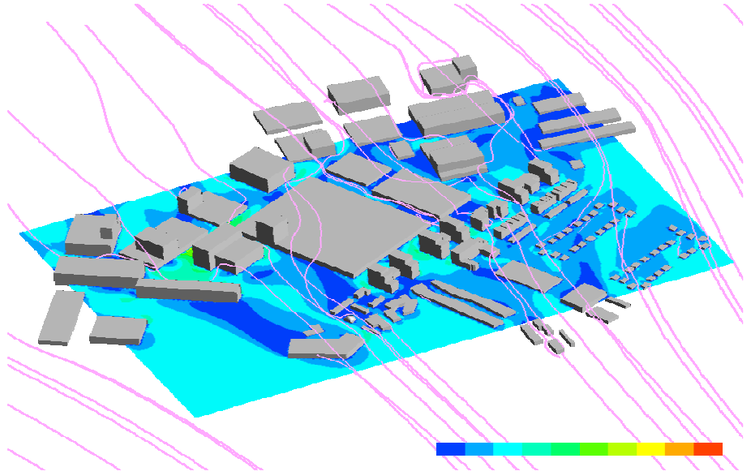


Figure A1.12: CFD analysis.
Prevailing wind direction output (NW).

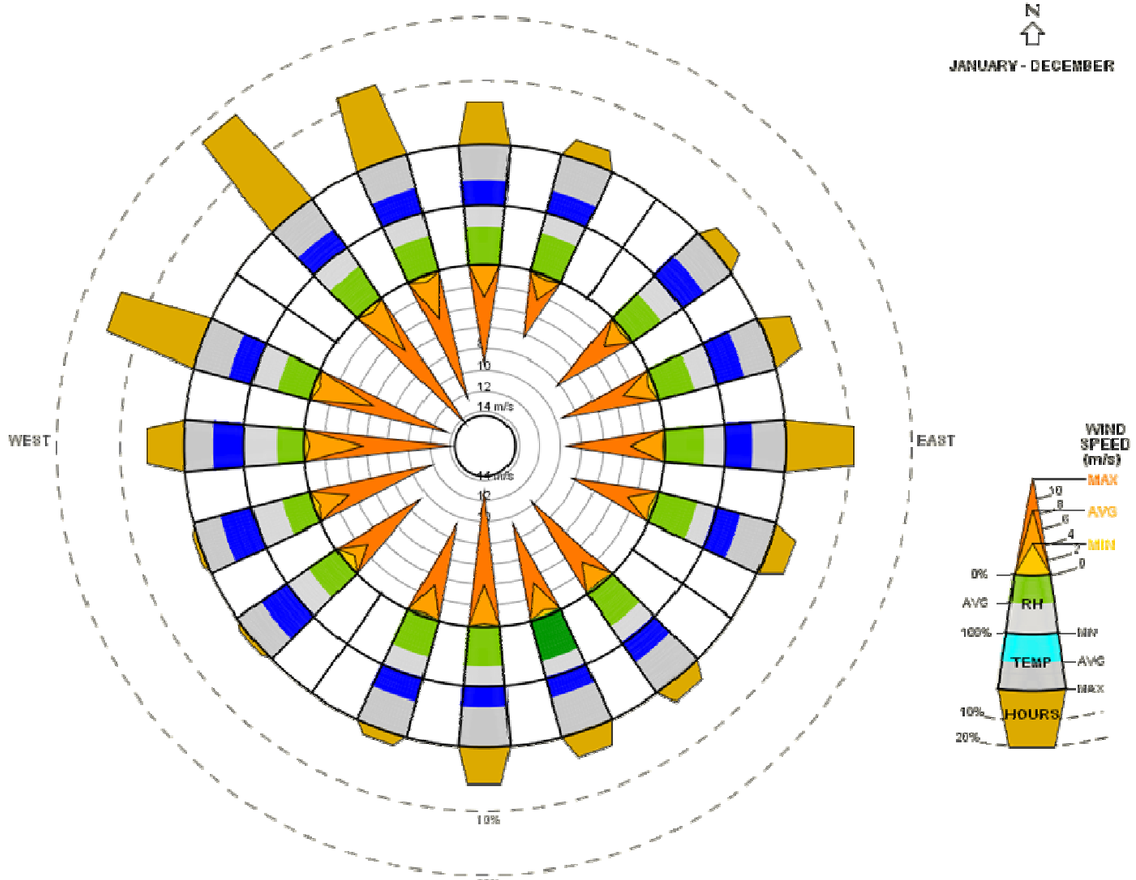


Figure A1.11: Wind Direction Rose.
The prevailing winds come from NW – NWW.

ARUP

A1.2.1 WIND EFFECT ANALYSIS

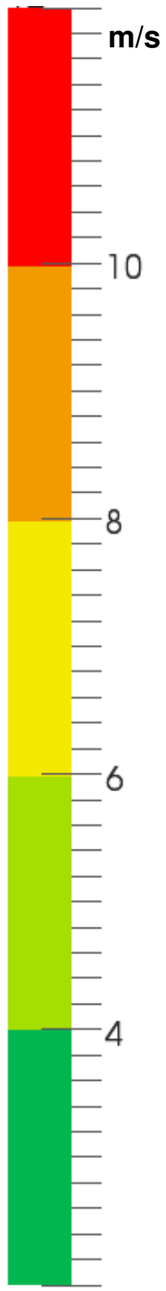


Fig. A1.13.1 Summer Morning

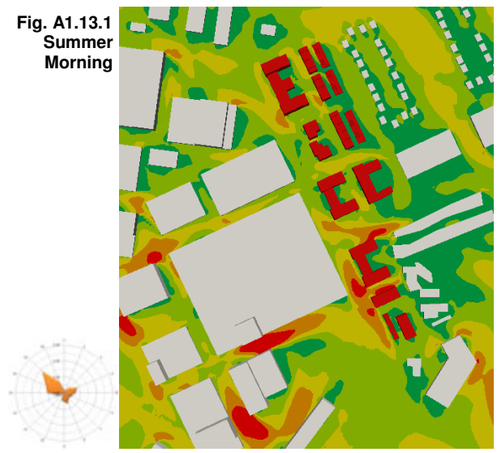


Fig. A1.14.1 Autumn Morning

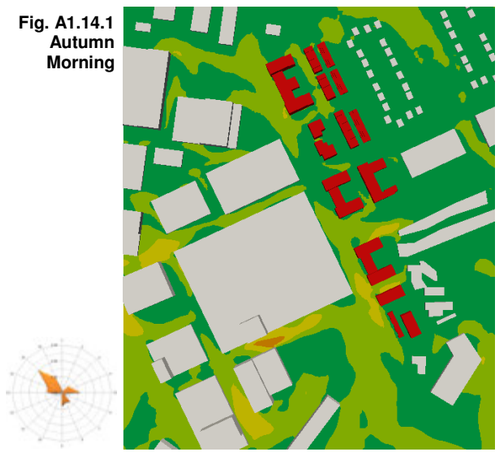


Fig. A1.15.1 Winter Morning

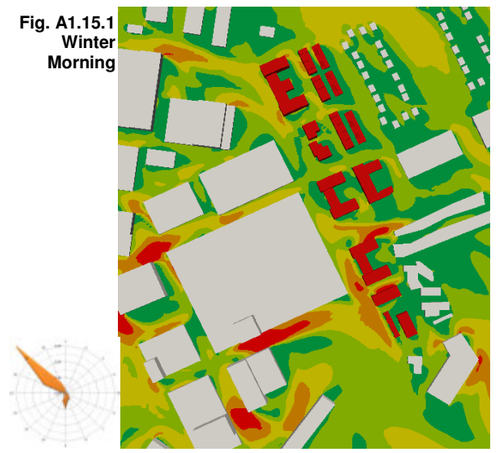


Fig. A1.16.1 Spring Morning

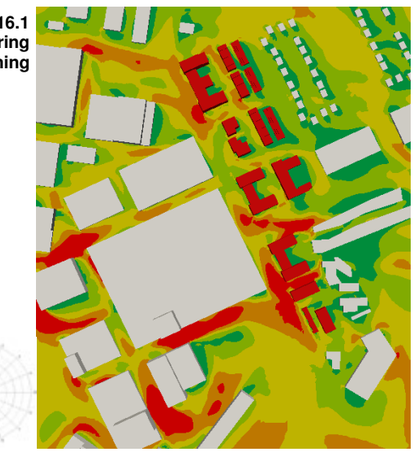


Fig. A1.13.2 Summer Midday

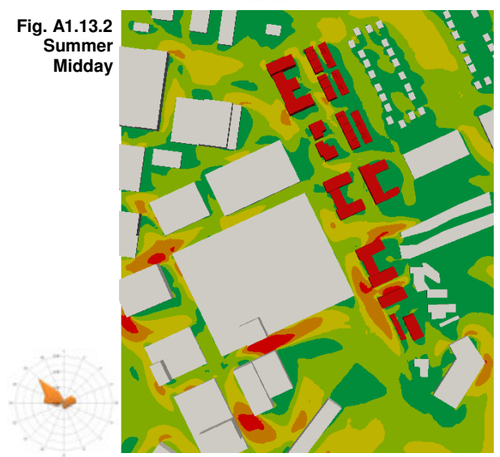


Fig. A1.14.2 Autumn Midday

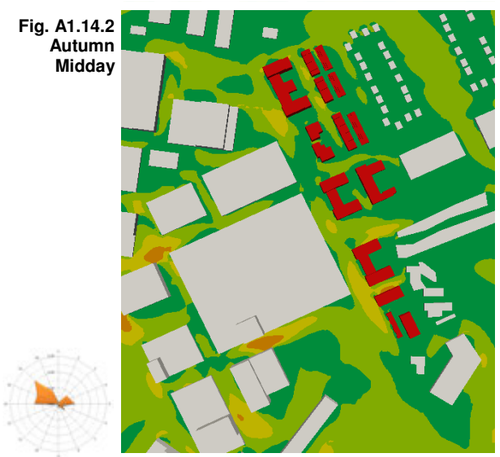


Fig. A1.15.2 Winter Midday

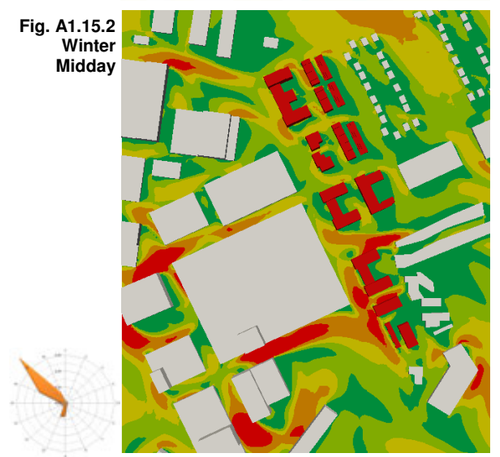


Fig. A1.16.2 Spring Midday

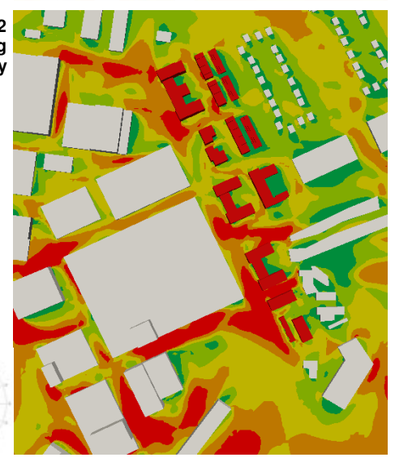


Fig. A1.13.3 Summer Afternoon

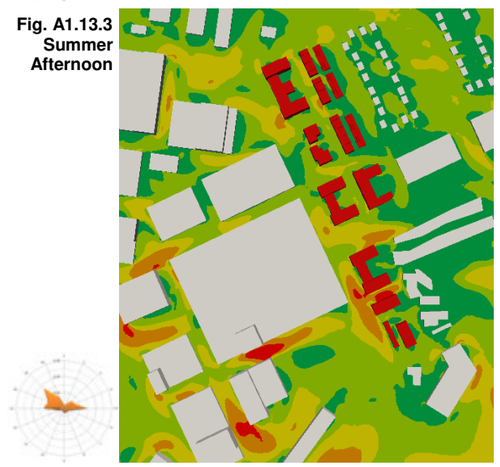


Fig. A1.14.3 Autumn Afternoon

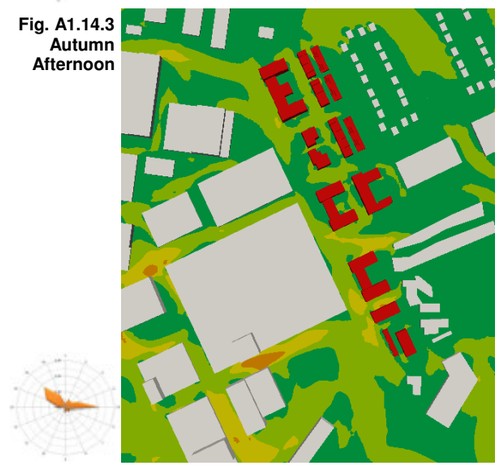


Fig. A1.15.3 Winter Afternoon

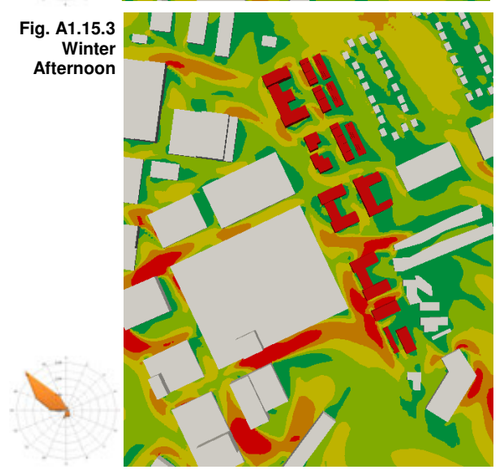
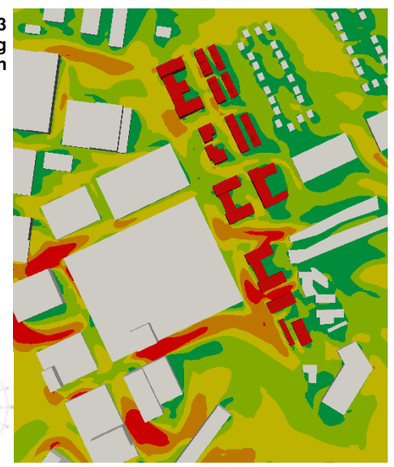


Fig. A1.16.3 Spring Afternoon



A1.2.1 WIND EFFECTS

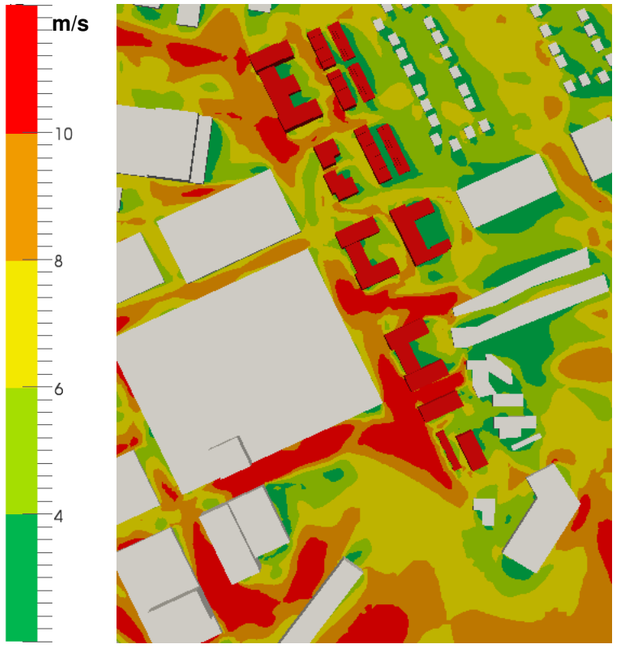


Figure A1.22: Multidirectional wind analysis at Spring Midday. Site-wide.

Lawson Criteria for Wind Acceptability	Threshold
Uncomfortable for all uses	
Fast or business walking	5% > 10m/s
Strolling or window shopping	5% > 8m/s
Short periods of standing or sitting	5% > 6m/s
Long periods of standing or sitting	5% > 4m/s

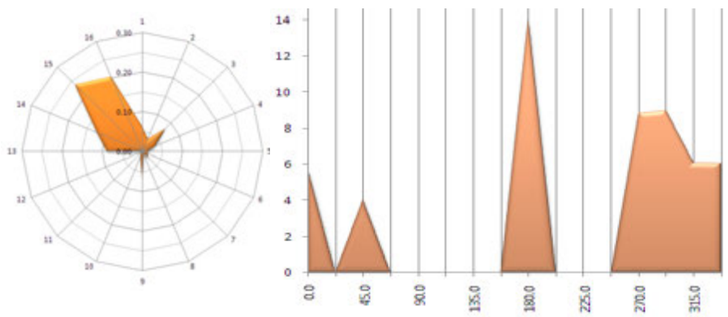


Figure A1.26 Probability of Wind Direction [m/s] for Spring

Figure A1.25: Probability of Wind Speed [m/s] for Spring

Figure A1.23: Multidirectional wind analysis at Summer Midday for Ainslie Ave.

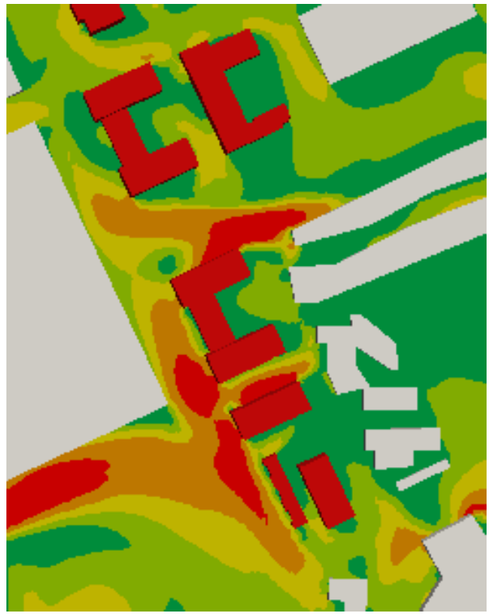


Figure A1.24: Multidirectional wind analysis at Winter Midday for Ainslie Ave.

Comments

- The figure A1.22 shows site-wide wind effects for a typical Spring midday. The area along Cooyong Street, Ainslie Avenue and adjacent to Blocks IV and V show higher than expected wind speed probability for this period, when compared to other areas in the proposed Master Plan.

North Cooyong Street

- The predominant North-West winds result in high wind conditions at the North end of Cooyong Street during some seasons of the year. Planting additional trees could mitigate this to some degree.

Ainslie Avenue

- There could be a tunnelling effect along Ainslie Avenue, particularly in Spring, which would likely be reduced by the existing trees. The trees are likely to reduce the wind to speeds which are more suitable for business walking.
- The eastern end of Ainslie Avenue will be more suitable for sitting or standing.
- Figure A1.23 and A1.24 show that during Summer and Winter months, a greater portion of Ainslie Avenue will comfortable for sitting or standing activities.

Southern site area

- The southern area of the site is fairly open. This results in high wind speeds at the South end of Cooyong Street and adjacent park, particularly during Spring and Winter.
- The effect is increased with the height of Blocks IV and V.
- The winds from the South are strong, but as shown in figure A1.26, they occur less than 10% during Spring.

ISSUE

A1.3 THERMAL COMFORT

Thermal comfort is a way of measuring how people may feel, given a combination of environmental effects in a space at a given time or over a given period.

Methodology

Thermal comfort has been assessed using a robust method for assessing the heat balance of the human body. The method used is called the Standard Effective Temperature (SET*), which was developed by Nakano and Tanabe in Japan for assessing comfort in outdoor and semi-outdoor spaces. This research work suggests the following thermal comfort limits for non-conditioned spaces.

- SET* between 15.8° and 33.7° (acceptable for 80% of people)
- SET* between 20.2° and 29.4° (acceptable for 90% of people)

The following is an example calculation using the SET* method, applied to a typical summer morning condition in Hobart.

- Average dry bulb temperature approximately 19℃
- Direct normal radiation approximately 450W/m^2
- Relative humidity approximately 55%
- Mean wind speed of 1.5m/s
- Clothing level assumed to be 0.65clo (varying)

Mean radiant temperature in the sun is estimated to be 42℃ based on level of radiation exposure. This assumes a person in a sitting position and receiving sun to approximately 30% of their body and that there is no thermal storage and release effects from the surrounding built environment.

Applying this information to the SET* method we obtain an SET* of 22.9℃, which would be considered acceptable to 90% of people using the space

A1.3.1 SET* APPLICATION

This method has been applied to the external environment by combining the wind analysis and solar analysis to obtain a spatial variation in SET*. Clothing levels are assumed to vary by season from 0.65 in summer to 1.3 in winter and 0.95 during spring and autumn. Dry bulb temperature and relative humidity are based on average weather conditions for the sample period.

A1.3.2 SET* RESULTS

The full results for the thermal comfort analysis are shown on the next page. These can be summarised as follows:

- Overall, the analysis concludes that comfortable or acceptable conditions will occur throughout the proposed Master Plan site for most of the year and will not significantly impact adjacent sites;
- Summer offers comfortable outdoor conditions (sun and wind) for the entire day around the new buildings;
- In Summer months, there is the potential for Blocks I and VIII to restrict cooling winds from the adjacent low-density residential area to the East;
- Mid-season afternoons will be quite sunny and windy, which will result in comfortable conditions throughout most of the year;
- For Spring mornings, as the wind is quite strong and the mean temperature still relatively cold, there is the potential for generally cold conditions throughout the site;
- Winter and Spring mornings were found to offer cool to cold conditions in the exterior public spaces mainly due to cooler temperatures and higher winds. The exterior spaces (balconies) of units with little morning solar access will experience similar conditions;
- The internal courtyards will likely not be attractive places for refuge during Winter and spring mornings, given the above conclusions.

A1.3.3 SET* ANALYSIS

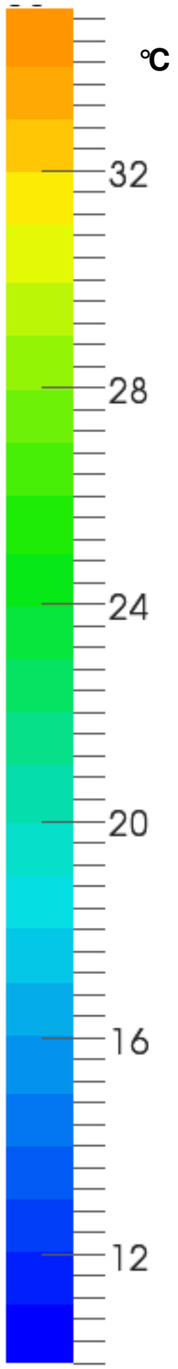


Fig. A1.27.1 Summer Morning

Cloth 0.6

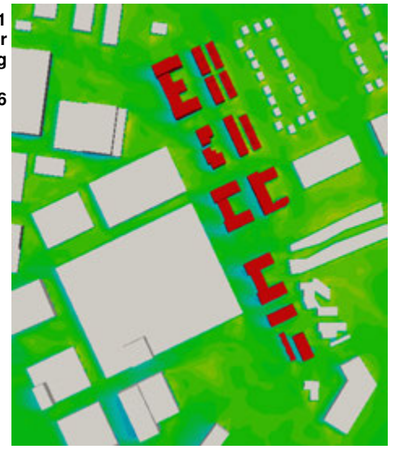


Fig. A1.28.1 Autumn Morning

Cloth 1.0

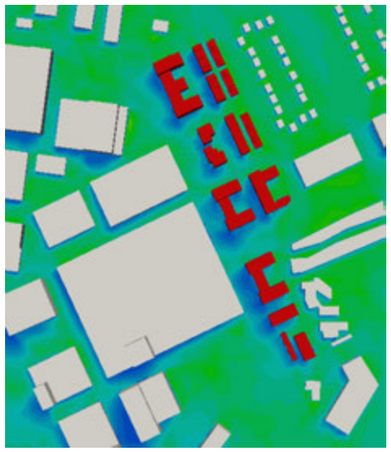


Fig. A1.29.1 Winter Morning

Cloth 1.3

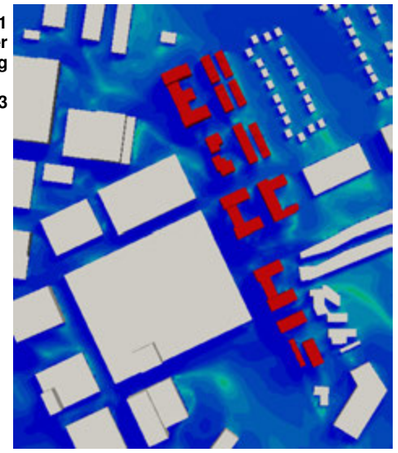


Fig. A1.30.1 Spring Morning

Cloth 1.0

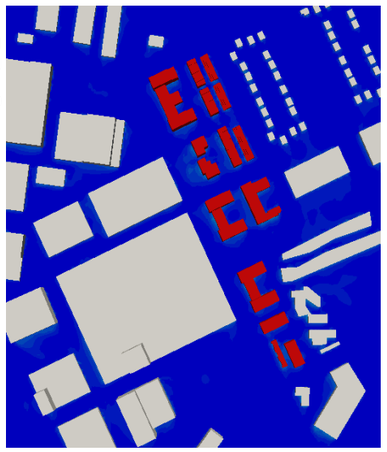


Fig. A1.27.2 Summer Midday

Cloth 0.6

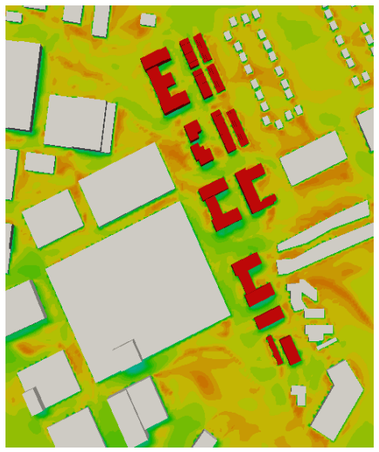


Fig. A1.28.2 Autumn Midday

Cloth 1.0

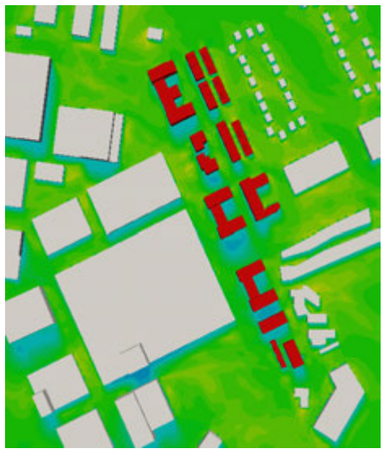


Fig. A1.29.2 Winter Midday

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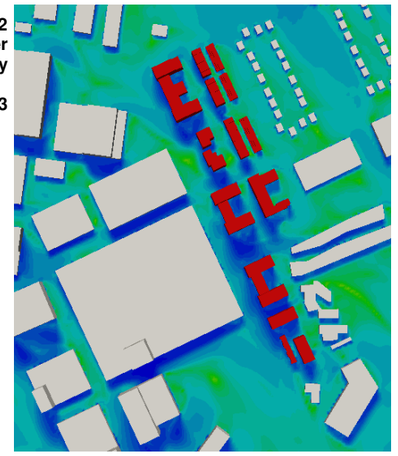

Fig. A1.30.2 Spring Midday

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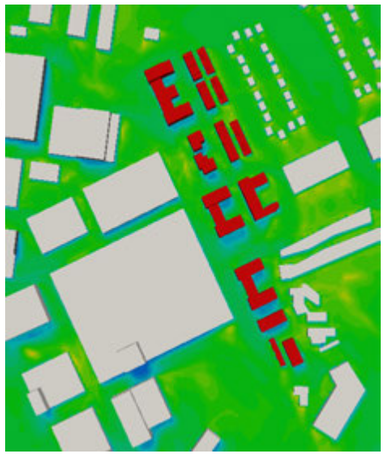


Fig. A1.27.3 Summer Afternoon

Cloth 0.6

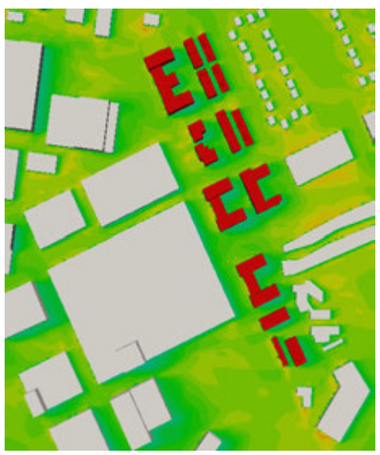


Fig. A1.28.3 Autumn Afternoon

Cloth 1.0

Fig. A1.29.3 Winter Afternoon

Cloth 1.3

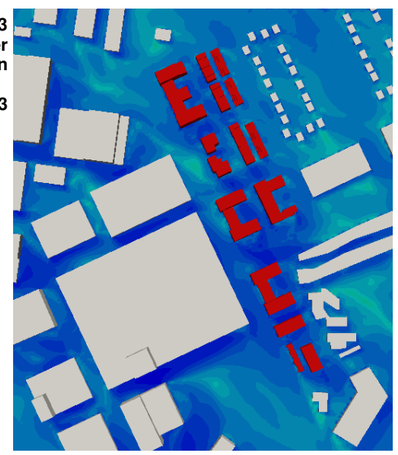
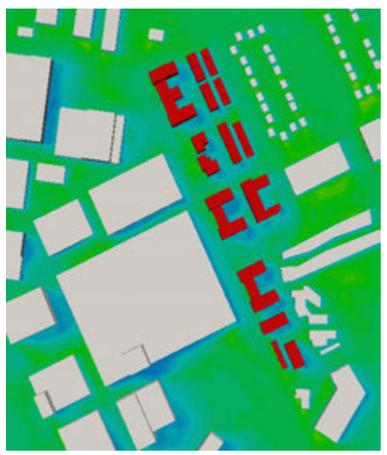


Fig. A1.30.3 Spring Afternoon

Cloth 1.0



A1.4 MICROCLIMATE CONCLUSIONS

Figure A1.34: Microclimate Analysis Summary: this is based on the model used for the microclimate and may not represent the final layout of the proposed Master Plan by Cox Humphries Moss and Purdon.

From a high level, the public spaces are expected to function suitably for a range of activities throughout the year, including sitting, resting or walking. The main impacts are the following, as keyed to the model shown at left:

1. The courtyards create a sheltered and pleasant space which will be protected from frequent winds coming from the North-west during most seasons. The building shape could be optimised to increase the solar radiation in winter, when the spaces will often be shaded, by increasing density along Cooyong Street and on the South side of each block. Block VI's low-rise elements function quite effectively in creating high levels of thermal comfort in the resulting courtyard.
2. In Summer months, there is the potential for Blocks I and VIII to restrict cooling winds from the adjacent low-density residential area to the East. This area will also experience a slight reduction in solar access during the other seasons due to shadows cast by Blocks VII and VIII.
3. Due to tunnelling effects, there will be some increase to wind speed along Cooyong Street, but it otherwise operates similar to other parts of Canberra's Civic precinct.
4. The landscaped island in Ainslie Avenue will experience some overshadowing and during Spring there will be some high wind speeds, but for the majority of the year, the eastern end of the avenue will be comfortable for sitting or standing activities.
5. The large buildings in Block IV and the northern building in Block V causes an increase in wind speeds as air drops after passing across the top of the buildings. This will impact the comfort conditions of public space in this area.

A1.4 MICROCLIMATE CONCLUSIONS

Figure A1.34: Microclimate Analysis Summary: this is based on the model used for the microclimate and may not represent the final layout of the proposed Master Plan by Cox Humphries Moss and Purdon.

MITIGATION MEASURES

At a building scale it is recommended that the following mitigation measures are implemented:

- Inclusion of trees across the site will reduce the general level of windiness locally. In particular, trees or porous wind baffles could be used at the south end of the site as well as along Cooyong Street and the western end of Ainslie Avenue. These measures will improve local wind conditions (a reduction in 1 Lawson category can be expected i.e. and area of business walking will be reduced to strolling).
- Avoid locating entrances and doorways at the corners of buildings, particularly of the taller buildings (where windier conditions can be seen).
- Inclusion of podium stepping or canopies on the tall buildings in Block V and the south end of Block IV to reduce the wind flow around this area.
- Rounding the corners of the tall buildings in Block V and the south end of Block IV will also reduce the wind issues.
- Stepping the eastern side of the tall buildings in Block V and the south end of Block IV will improve the solar access to the buildings to the east of the site.