197 Church Street Parramatta

Heliostat Solution for Overshadowing of Parramatta Square

DCP Solar Zone

September, 2017

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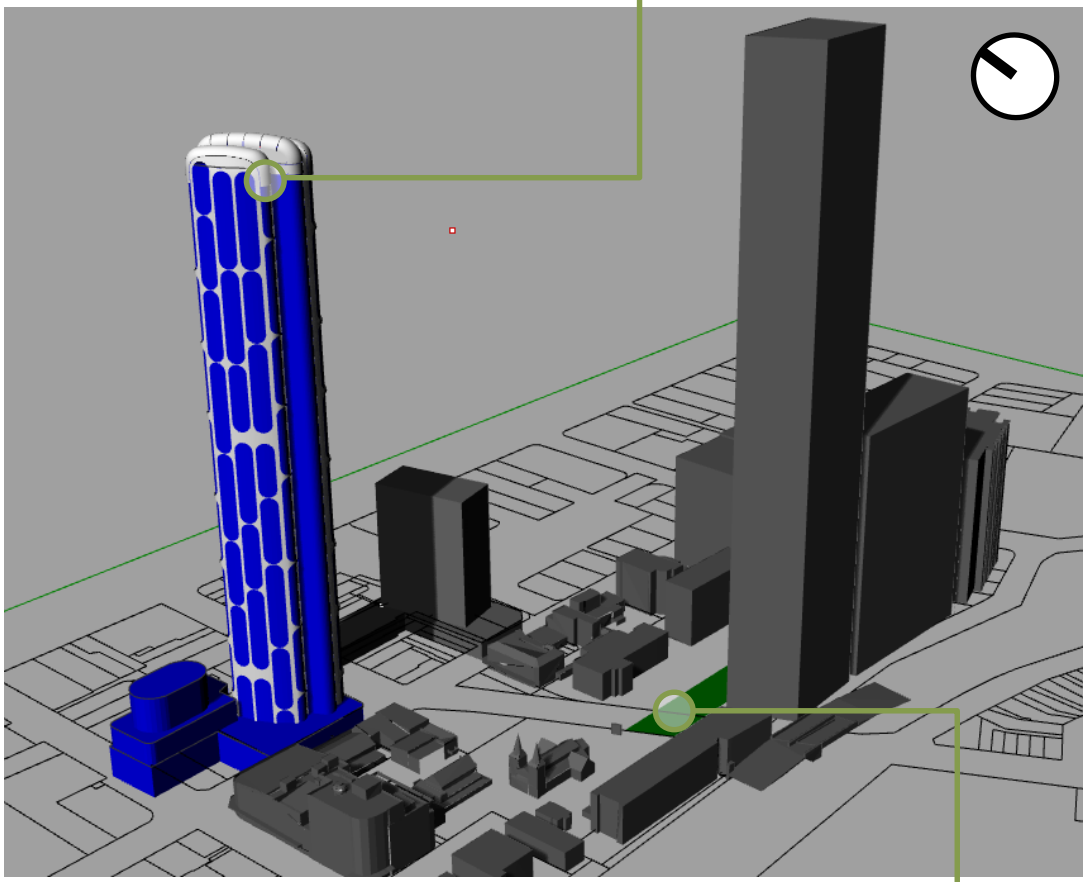
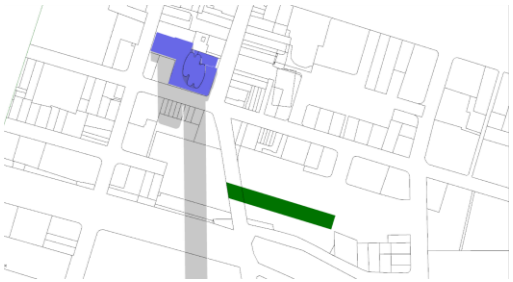
197 Church Street



Parramatta Square

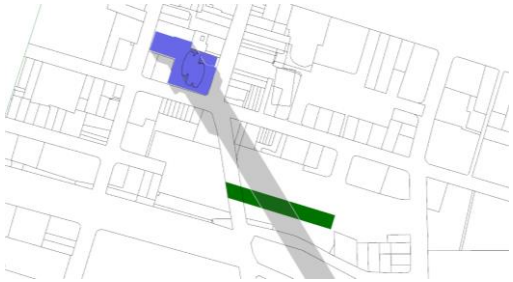
- Competition Winning Building
- Surrounding buildings
- Parramatta Square DCP Solar Zone

12:00, 21st June

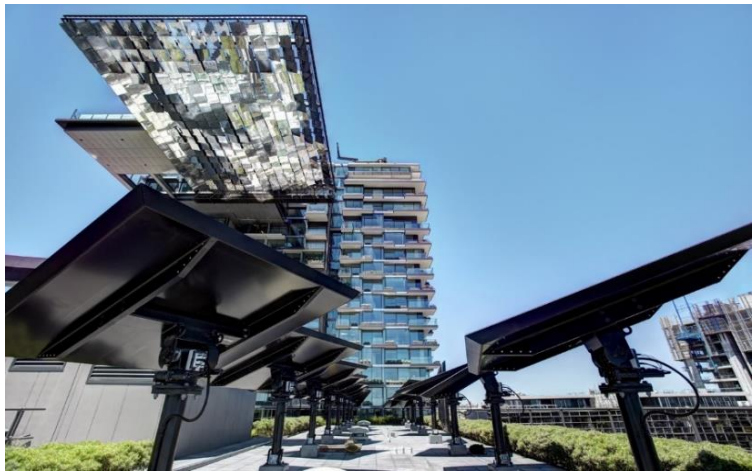


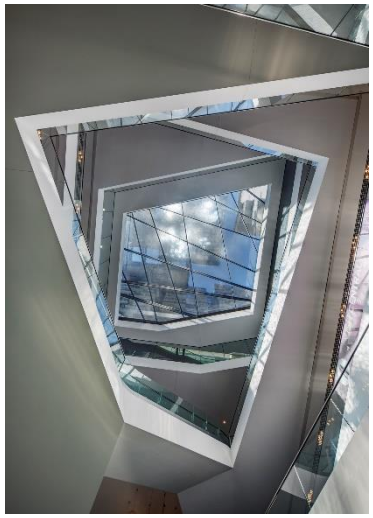
13:00, 21st June

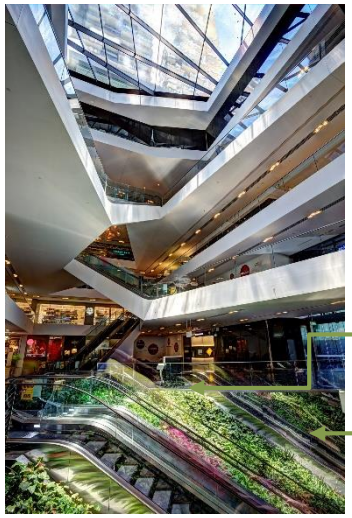
14:00, 21st June



Endorsed by the State Government appointed Design integrity Panel





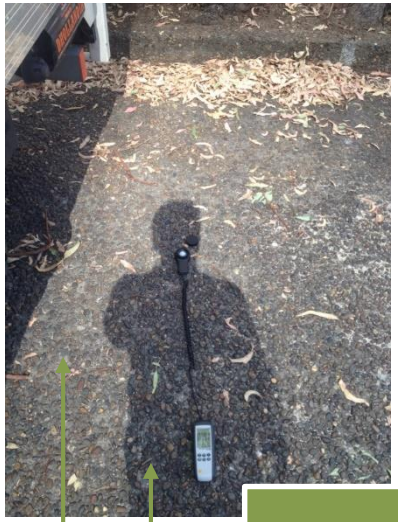


40-off heliostats reflect light onto a secondary reflector array which redirects light into a public plaza

16,700 lux in reflected light zone

6,800 lux in shade

Approved by Sydney Central Planning Panel



1-off heliostat reflects light onto a secondary reflector on the roof of a 26-storey tower which redirects sunlight onto a public park

13,500 lux in reflected light zone

5,800 lux in shade

3-off Ø2.4 metre heliostats reflect light into an urban canyon in Manhattan

3-off heliostats have been installed on a mountainside 450 meters above the town to redirect light into a public plaza.

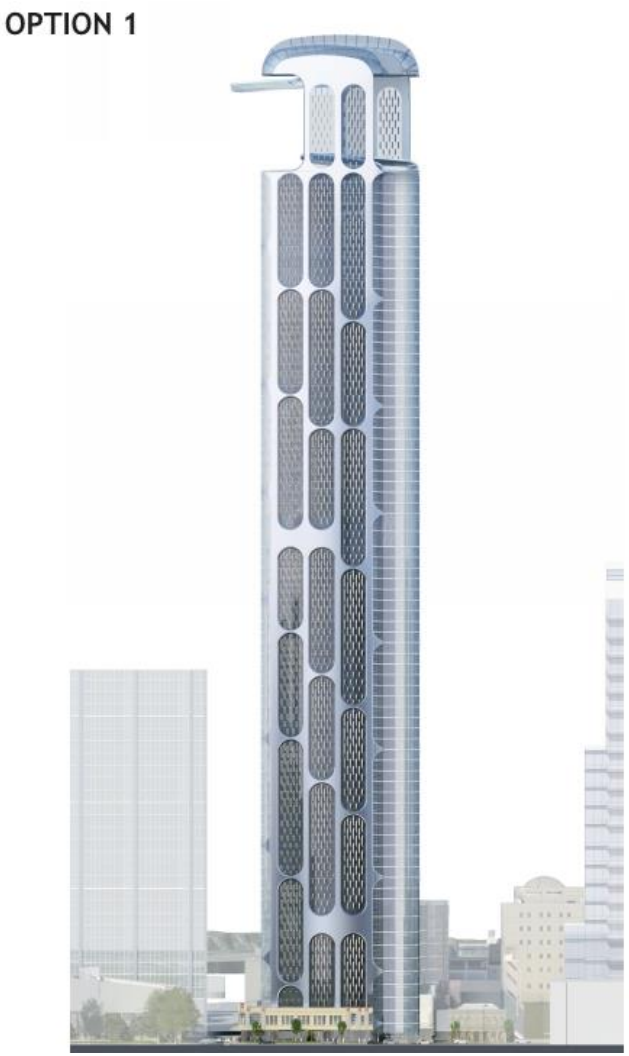
Heliostat Concept

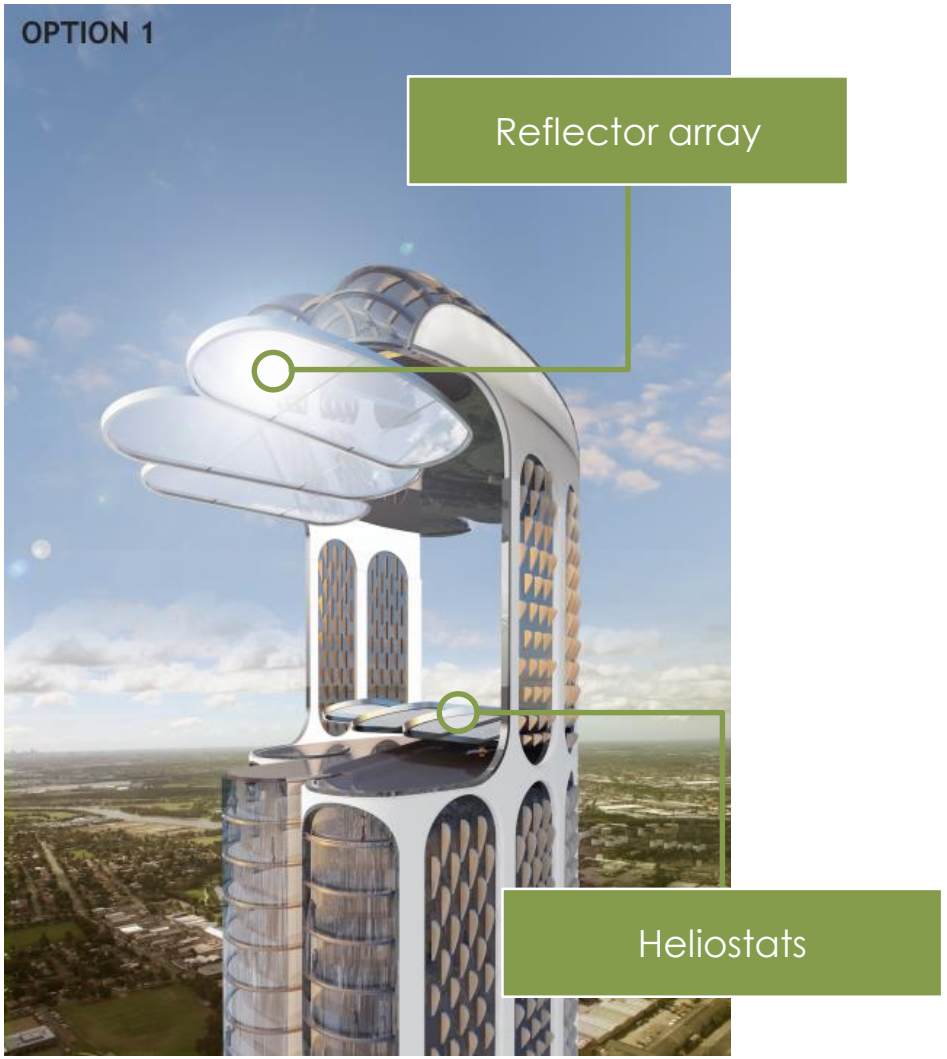
Heliostats are optimised motorised mirrors that can rotate with two-degrees of freedom. Their orientation is controlled by software so that they can redirect solar light and warmth at a known target at any given time of the year in equal measure.

The heliostats included in the simulation have been based on components that have been developed by the CSIRO. This heliostat system is an off-the-shelf product manufactured in Australia that was originally developed for the use in concentrating sunlight for solar thermal power stations.

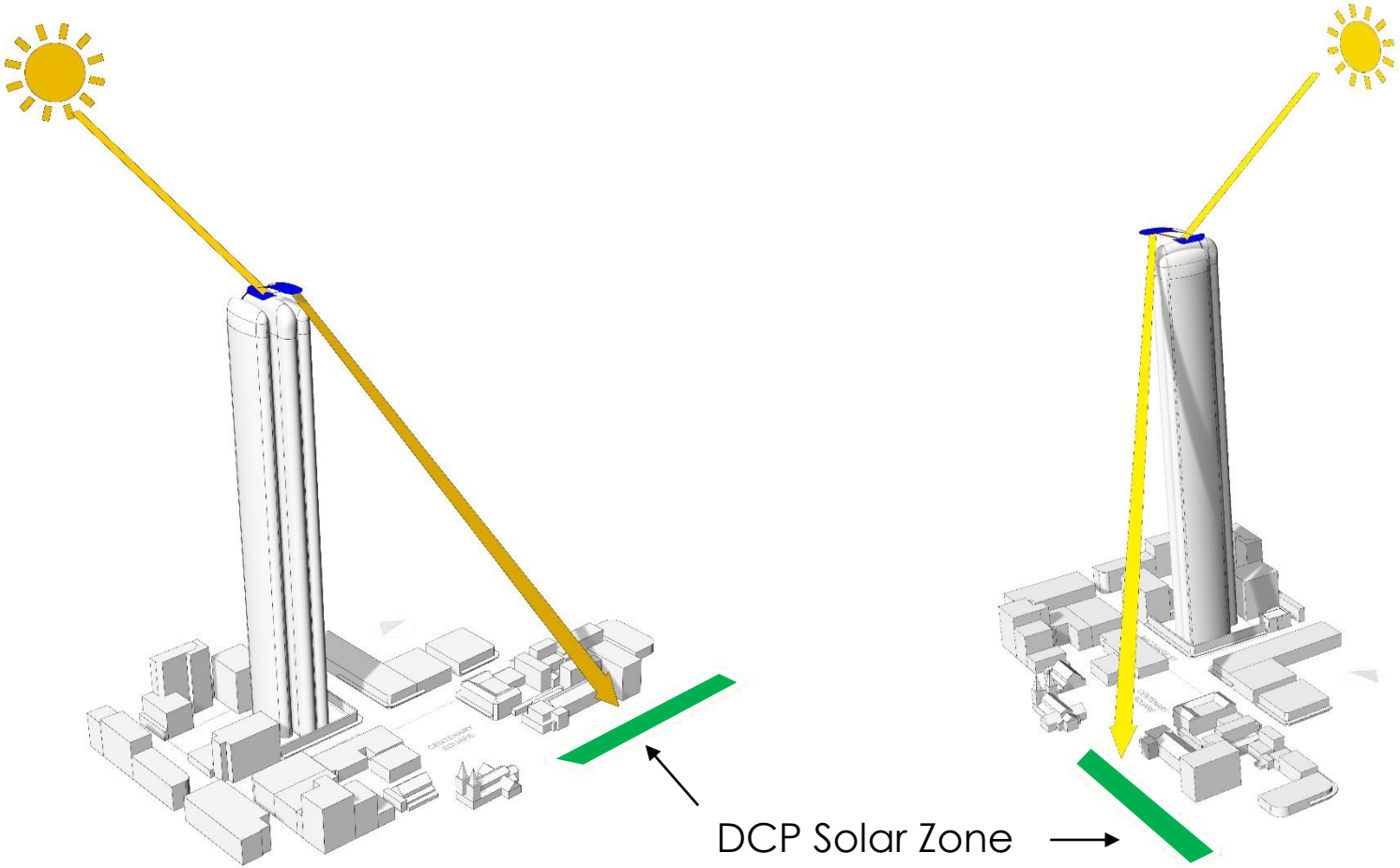
Over 600 of these heliostats are currently installed and operational at the CSIRO testing and research facility, where they are used to power a turbine for electricity generation. These heliostat systems have also been commercially installed for similar systems throughout Europe and Asia.

Each heliostat in an array requires a unique control system to take into account its position relative to the sun, and to the reflector that it redirects light onto. The control system is sufficiently accurate to ensure that all light is directed onto the reflectors and no stray light is directed skywards.





Heliostat Concept Design 197 Church Street, Parramatta



Heliostat Concept Design

197 Church Street, Parramatta

Buildings – AS1680.1	Recommended Illumination Level (Lux)
Corridors & walkways	40
Routine office work	320
Difficult Tasks	600
Supermarket	1000

Sport – AS2560.2	Minimum Illumination Level (Lux)
Tennis	1000
AFL / Rugby Union / NRL	500
Cricket	500 to 700
Netball	200

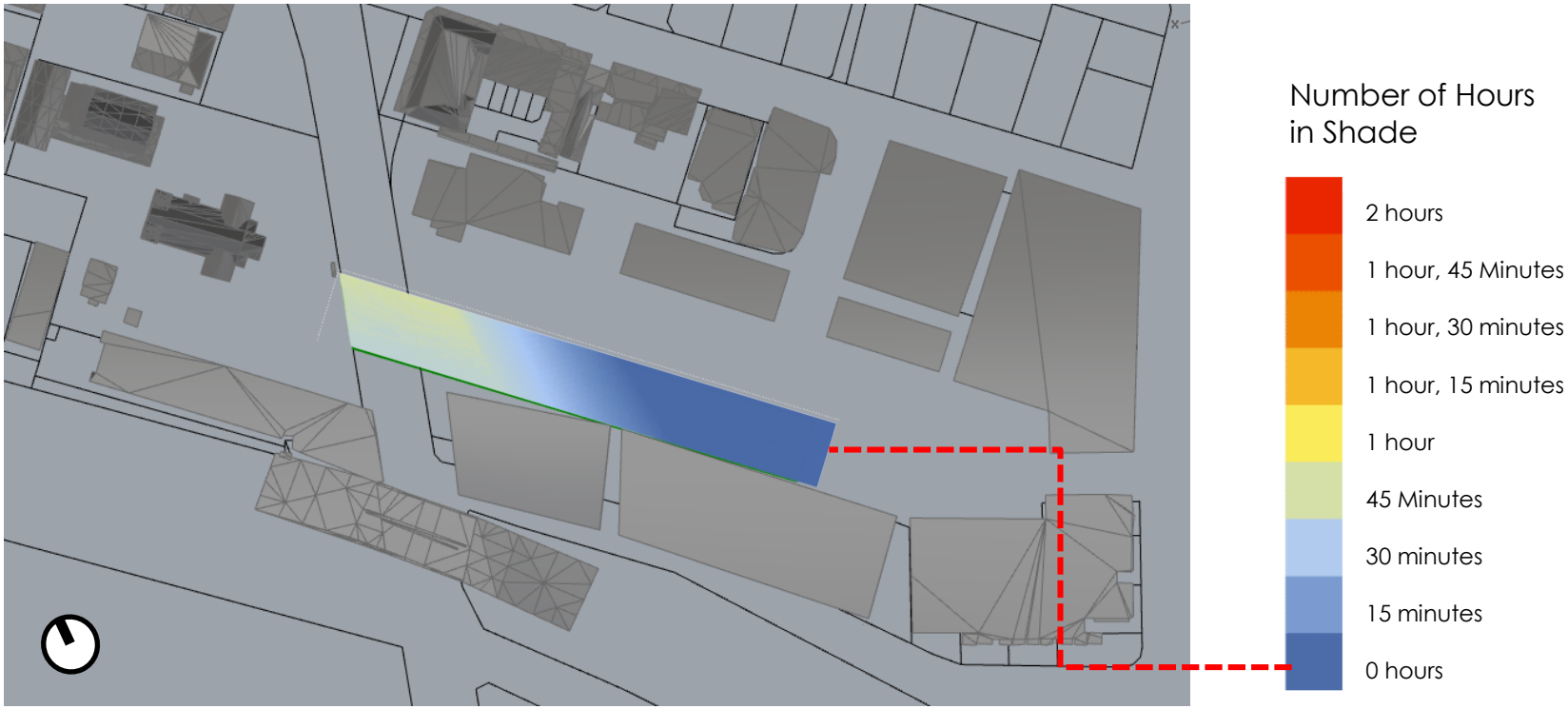
Natural Environment	Approximate Illumination Level (Lux)
Rain	10,000
Overcast	20,000
Bright	50,000

Light is often measured in lux, a unit used in lighting design to combine all direct and indirect sunlight during the daytime.

In comparison, the measured heliostat reflected light illumination levels in Sydney are:

- One Central Park: 16,700 lux
- Rhodes Prototype: 13,500 lux

- 0 m^2 of the DCP Solar Zone is overshadowed for a period >45 min
- Peak duration of overshadowing: 45 minutes
- Average duration of overshadowing of a single point across DCP Solar Zone: **18 min & 31 sec**



Tower Aligned with Church Street

(As per the winning design competition)

Date	Time	Proposed illumination level (lux)	Average ambient daylight (lux)	% Change
21st June	12:00	N/A	N/A	-
	12:30	**53,783**	**51,459**	**105%**
	13:00	43,614	49,481	88%
	13:30	40,228	46,780	86%
	14:00	31,351	40,883	77%

Proposed Illumination level = average illumination level of winning design with Option 1 of the heliostat concept.

Average ambient daylight = average illumination and warmth level across DCP Solar Zone

% Change = illumination % change as a result of the winning design with Option 1 of the heliostat concept.

E.g. On the 21st of June at 12.30 pm, the winning design with Option 1 of the heliostat concept has ambient daylight and warmth levels of 105%

Tower Rotated 26° to Church Street

Date	Time	Proposed illumination level (lux)	Average ambient daylight (lux)	% Change	% Improvement of rotation
21st June	12:00	N/A	N/A	-	
	12:30	66,806	51,459	130%,	+24%
	13:00	48,577	49,481	98%,	+11%
	13:30	44,235	46,780	95%	+ 10%
	14:00	39,818	40,883	97%,	+ 27%

By rotating the winning design with Option 1 of the heliostat concept by 26° counter clockwise, further improvements are available which provide a net increase in illumination at all time intervals during the 21st of June analysis period.

Comparison of Design Features

Tower Aligned with Church St		Tower Rotated to Church St	
Good lighting and warmth efficiency		Improved Lux lighting efficiency and warmth from +11.6% to +23.8 % *	
Building Parallel to Church St		Building aligned with Church St axis	
Greater movement required for heliostats and secondary reflectors		Reduced movement in heliostats and secondary reflector.	
Shadow complies with 45 minute rule with average duration of overshadowing of a single point across DCP Solar Zone: 18 min & 31 sec		Reduced shadow size with average duration of overshadowing of a single point across DCP Solar Zone: 13 min & 25 sec	
Armature supporting secondary mirrors will temporarily reduce some of the available sunlight		Heliostat easier access to sun after midday	
Secondary mirror close to boundary		Better fit of secondary mirror within site	
Compliant ADG setbacks		Reduced ADG set backs	
Compliant ADG solar access		Slightly improved ADG solar access	

Optimal operation of the proposed heliostat design is ensured through the CSIRO-developed software that controls the alignment of the heliostats in both normal and emergency operation.

This control system automatically re-calibrates the position of the heliostats according to the local conditions, using a closed-loop control logic that ensures they are continuously and systematically re-aligned in a precise manner.

The proposed heliostat configuration will be designed with all necessary hardware and software for maximum operational control, including but not limited to the following items:

- A centralised control system, complete with an operator interface and software capable of calibrating and tracking the heliostats
- An uninterrupted power supply (UPS) and/or battery backup (as required) to the various components of the heliostat array

Regular maintenance of the heliostat system will ensure that optimum performance of the system is maintained by maximising the amount of reflected light and warmth, and reducing any tracking error of the system.

The potential for tracking errors will be minimised through a rigorous design process; however regular maintenance will be required throughout the life of the system in order to ensure that any deviations from the optimal performance of the system are eliminated.

The maintenance requirements of heliostat and reflector system will be finalised throughout the design development process, and will be based on information provided by the heliostat manufacturer and the CSIRO, and will include the following:

- Safe access to heliostats and reflectors
- Cleaning reflectors and framing
- Servicing of key components

The shape of the heliostat array on the roof will be coordinated with any other services. In the case of the winning design for 197 Church Street, it's unique roof design will assist in minimising any material issues in this regard.

The heliostats must have adequate clearance between each other, in order to prevent them from overshading each other, or obstructing each other's movement. A nominal clearance of 3.5m from the perimeter edge of the building will be provided for BMU access.

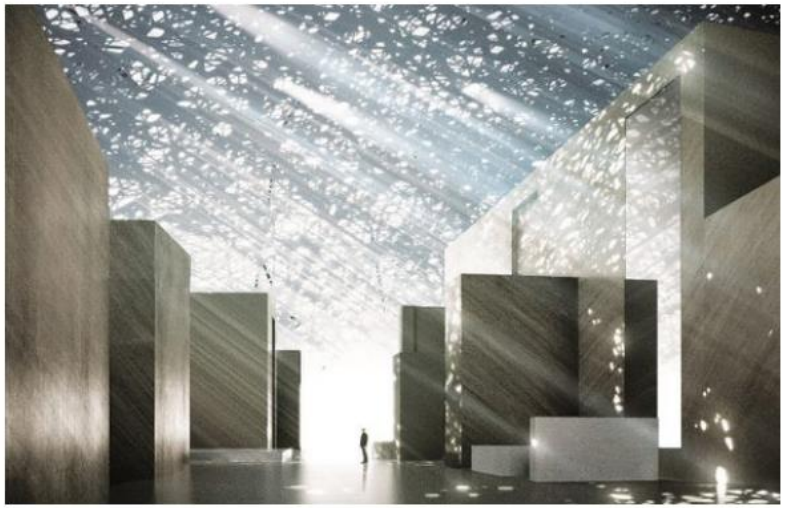
The heliostats require a clear line of sight between their mirrored surface and the secondary reflectors, therefore careful placement on the roof will be an important consideration in the design process.

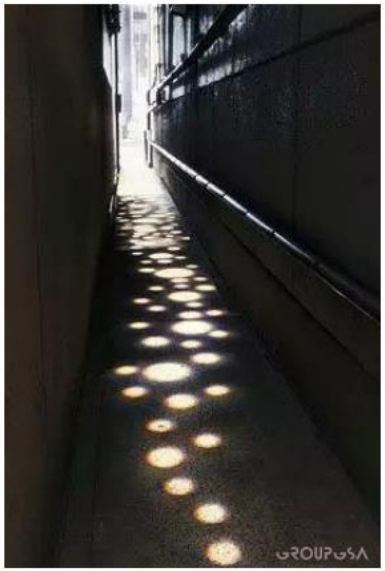
It is proposed to use a mirror system that is made of 3mm thick polished aluminium, manufactured by SatControl. The high-gloss aluminium surface ensures that up to 88% of the incident light and warmth is reflected and the diffusion rate is minimised. The accumulation of dirt or scratches of the mirror surface will reduce the performance of the system; therefore a special 'nano-transparent' coating protects the soft aluminium surface against weather, corrosion and any mechanical influences.

Utilising aluminium ensures that the mirror is lighter and safer than glass, reducing the loading requirements of the structural supporting systems. In addition, the ductile properties of aluminium under stress reduce the risk associated with the mirrors critically failing – a significant consideration when they are to be located on the roof of a building.

Any deviations in the mirror surface will cause inaccuracies in the system. In order to minimise this risk, all heliostats are to be precision cut with highly-accurate computer numerically controlled (CNC) machines. In addition, quality control of the manufacturing process includes a proprietary CSIRO-developed mirrored surface analysis system, which quantifies the deviation of a manufactured mirrored panel from the desired shape.

Through design optimisation, the proposed heliostat design offers numerous opportunities to present 'Light as Art' in the DCP Solar Zone.





When the heliostat is not actively redirecting light and warmth across DCP Solar Zone, there is an opportunity to capture this free heat source and convert it to useable energy.

Using a similar approach to Concentrated Solar Power (CSP) technology, where the sun's power is harnessed to generate electricity, the heliostat mirrors can be repurposed as lenses and reflectors to concentrate sunlight, heating a fluid such as water or oil and producing steam to drive a turbine.

This multi-functional approach also serves to meet the defined goals for the Smart City Policy - City of Sydney, particularly in reference to applying and utilising new approaches and technologies that deliver wider benefits for residents, businesses, local governments and tourism.

- Heliostat solution is a double win for Parramatta:
  - Effectively addresses overshadowing issue
  - Encourages development of a strategically significant site, with an iconic building and extensive socio-economic benefits
- Use of a heliostat is consistent with Parramatta's Smart City Masterplan Vision

"Parramatta will be a Smart City that leverages the foundations of good urban planning… and enabling technologies that will underpin our position as a vibrant, people centric, connected and economically prosperous city"

- Smart City Masterplan: Issue 1.0, August 2015

The Right Solution for Parramatta

Inhabit Experience – Light and Heat

Inhabit is a unique, multi-disciplinary team of professionals who are passionate about making a positive contribution to our built environment. We are a collective of experienced scientists, architects, designers, engineers and contractors who work both independently and in partnership to form a holistic approach to the services that we offer. Our respective areas of expertise can be integrated to allow seemless interdisciplinary synergy to create building solutions that are more relevant to our evolving society.

Established in 2010, with offices across Asia Pacific, the Middle East and UK, Inhabit has developed a diverse international body of work that includes partnerships with some of the most creative and celebrated architects around the world, resulting in a wealth of experience in different project types and scales.

We are focussed on design led engineering, providing technical and comprehensive solutions that thoughtfully and creatively consider building science, aesthetics, engineering, cost, procurement and sustainability driving towards a building that is sensitive and inspirational within its socio-cultural context.

40 WALKER STREET SYDNEY AUSTRALIA

Heliostat Design

THE RIBBON SYDNEY AUSTRALIA

SOLAR REFLECTIVITY, HEAT FLUX AND GLARE

Melbourne Park Melbourne Australia

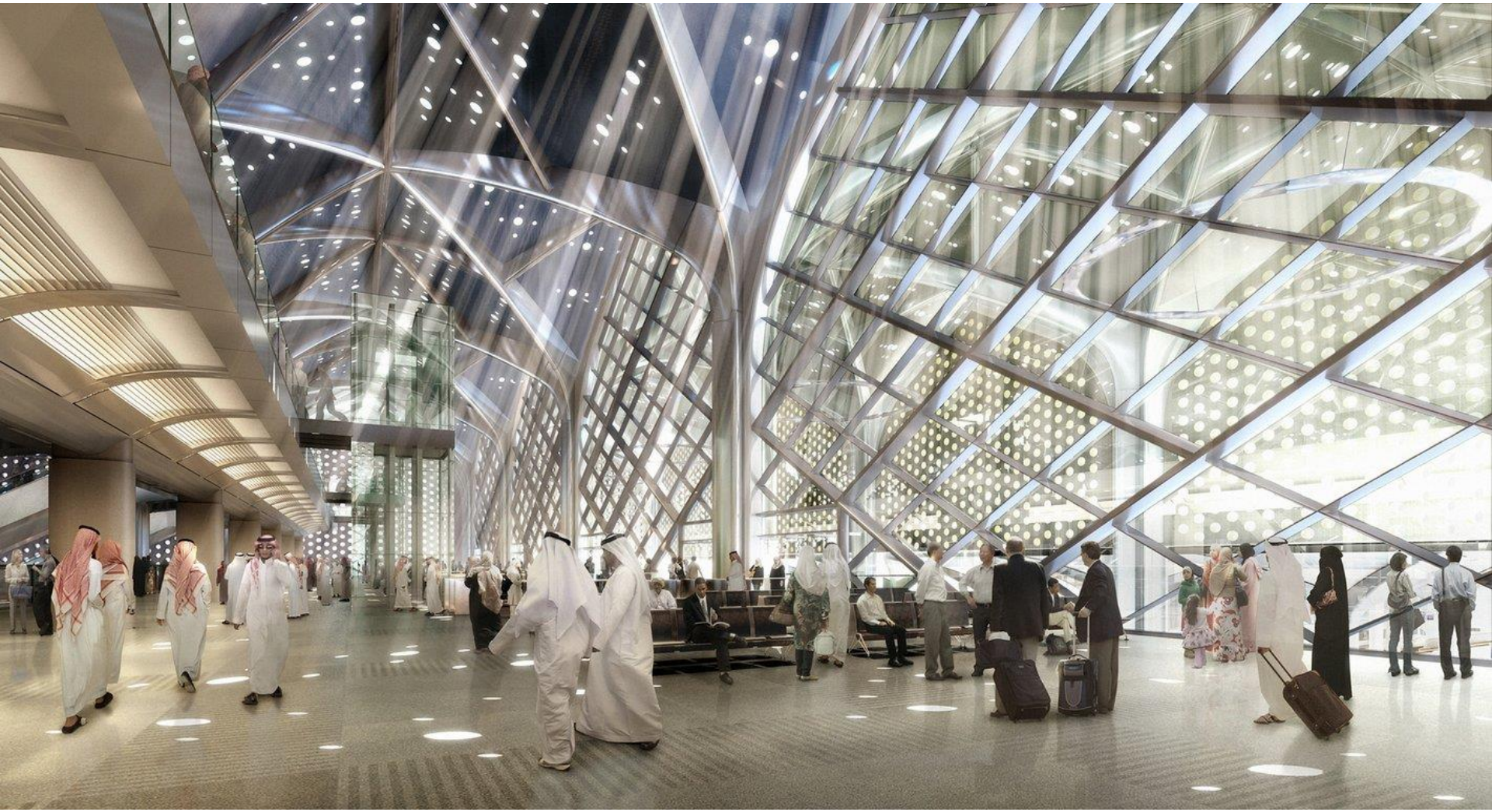
SOLAR REFLECTIVITY AND GLARE

QUEENSBRIDGE TOWER Melbourne, Australia

PEAK LOAD ANALYSIS AND SOLAR GLARE

CARLTON BREWERY WINTER GARDENS Melbourne, Australia

PHOTOSYNTHESIS ANALYSIS



Haramain High-speed Railway Jeddah Saudi Arabia

DAYLIGHT DESIGN

FAÇADE | ADVANCED STRUCTURES | BOUTIQUE FAÇADES + STRUCTURES | ESD + BUILDING PHYSICS | BUILDING ACOUSTICS | LIGHTING | ACCESS + MAINTENANCE | LOGISTICS