Optimising Photovoltaic Systems for deployment on residential apartment buildings

Contact Details

Wattblock
Michael Crouch Innovation Centre
Gate 2, High St, University of NSW 2052

Phone: +61 (2) 9977 1801

Email: support@wattblock.com.au

WATTBLOCK

Contents

Abstract

This paper documents the strengths and weaknesses of various Photovoltaic systems, as they are being applied to different residential apartments. The research will focus on the effects of wind, the viability of newer more flexible solar panels, as well as finding ways to calculate the optimal ways of installing solar systems on a rooftop whilst adhering to the structural design specifications. Multiple site visits across Sydney have been made, focusing on the conditions suitable for PV installation. The main site visit analysis was done at the Mosman Rowers Club, where a focus on the thermal efficacy was undertaken, with potential upgrades toward the exterior of the building and the kitchen/gas systems. Analysis of existing systems, their maintenance costs and interchangeability are a key component when considering various solar systems, as over time newer technologies may call for upgrades. Such is a situation where the ease of removal and replacement should be minimally invasive to the internal structural makeup of the building. Another important factor to consider is the thermal effects on a building that a solar system has. Many research papers have been reviewed and included below detailing the thermal effect comparison of buildings installed with a solar system vs those without.

Introduction

As we are living in the 21st Century, our reliance on electricity has skyrocketed. Industries, modes of transport, daily household appliances to the vehicles we drive all make use of this vital resource. As the demand for energy in the modern world is at record-high levels, considerations must be made for its sustainable generation for the future. Despite fossil fuels being the cornerstone of electricity generation in the last century, the future calls for a more environmentally friendly, less toxic alternative to the environment. Solar energy has stood out as a reliable alternative, despite initially being costly to implement compared to the benefits provided there have been significant breakthroughs in the technology, allowing for a cheaper cost vs the electricity generated, allowing for the expansion of PV into everyday people's lives.

Many comparisons have been made, illustrating how more and more the efficacy of PV installation becomes as time passes by. In the year 1975, solar panels were costing $100 per watt generated and only 2 Megawatts of electricity were generated globally. Compare this to 2015, where it costs roughly $0.61 per watt generated and there are 64,892 Megawatts of electricity generated globally.

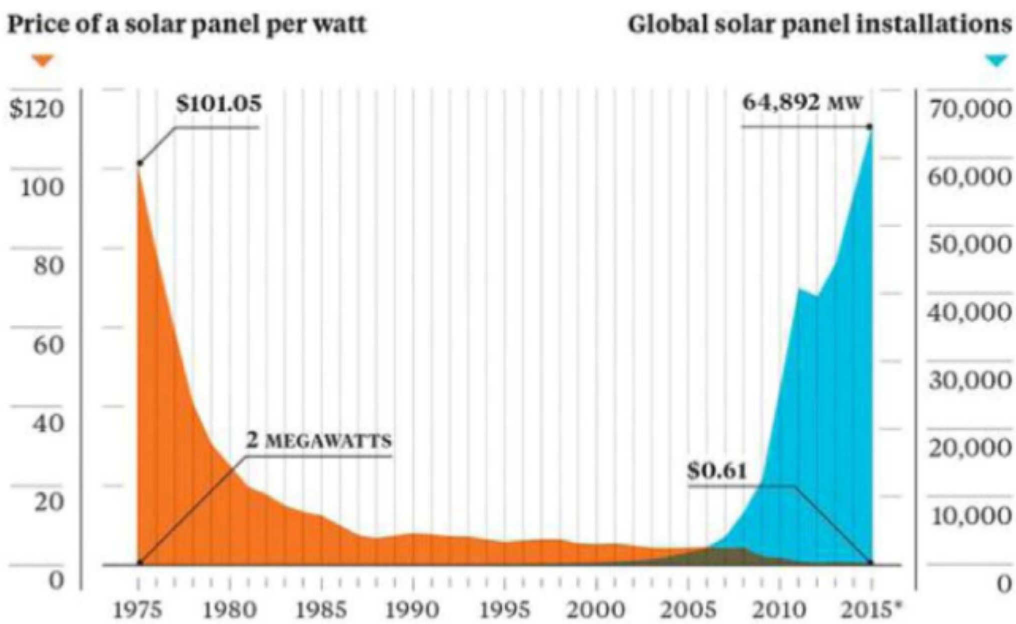


Figure 1: Comparison of Solar Panel pricing vs the Total Solar Panel Installations from 1975 to 2015.

Prominent brands of traditional Solar systems include Jinko, Trina and Qcell. They can provide a reliable source of solar panel installations for residential and commercial buildings. Recently however, a newer alternative has come into play: Energus. With its revolutionary light-weight flexible technology, this style of Solar system offers many alternative methods of installation, (including the option for an adhesive to stick it on a vertical wall), eliminating racking costs, and an improving bond-strength to the building's exterior.

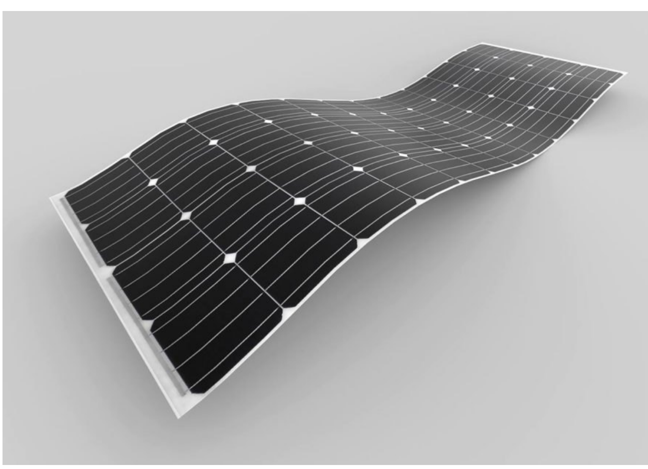


Figure 2: The Flexiglass by Energus

Literature review

Phase change materials in solar systems

Solar energy harnessed by photovoltaic panels has become one of the most promising renewable energy sources of electricity generation. PV installation increased by 42% annually from 2000 to 2015 in a report by the Fraunhofer Institute for Solar Energy System. Generally, only 5% to 20% of energy in solar radiation is converted to electricity by PV panel. – Ma et al (2017).

The thermal management of a PV panel is very important – as the Various thermal management systems have been proposed by scholars worldwide. Universally, we categorise them into 2 distinct categories: A **passive cooling** system and an **active cooling** system.

Passive cooling describes a constant naturally occurring process producing the desired cooling effect without interference or manual input, this method is inherent to the structure and saves energy long-term. Natural air convection systems are a good example of this: the constant flow of air in and out of the system allows for cooling to take place.

Active cooling describes an input of coolant, often consuming electricity to produce the desired cooling effect on the PV panels. The advantages of this option are rapid cooling, as well as allowing a system to be installed in places where naturally occurring airflow is not present. However, it can often increase costs for the upkeep of the system.

Below are the main shortcomings of each system:

- Low heat dissipation rate within **passive coolin**g systems
- Increased electricity consumption for **active cooling** systems

In this context, phase change material (PCM) was proposed as an optimal heat storage material to regulate the temperature of PV panel, i.e. PV-PCM system. The PCM can come in both active and passive cooling varieties.

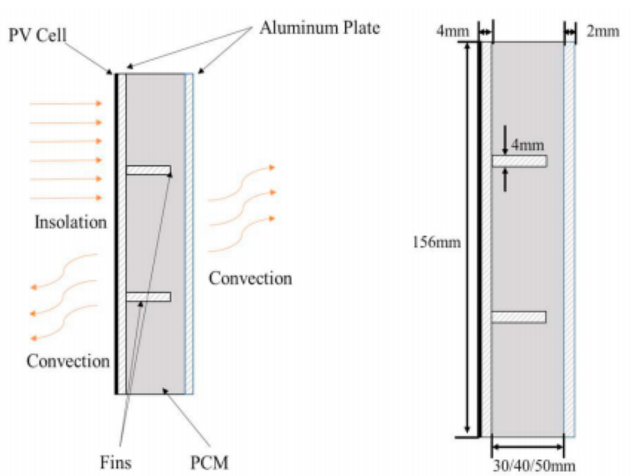


Figure 3: The system Configuration of a solar panel – Ma et al (2017).

Below is the comparison of different PV-PCM systems and how heat capacity, melting temperature and depth of PCM affect the performance of the system. The PV only system is compared to PV-PCM Ⅰ, Ⅱ and Ⅲ – each being filled with 30 mm depth of PCM RT35, RT35HC and RT42, respectively.

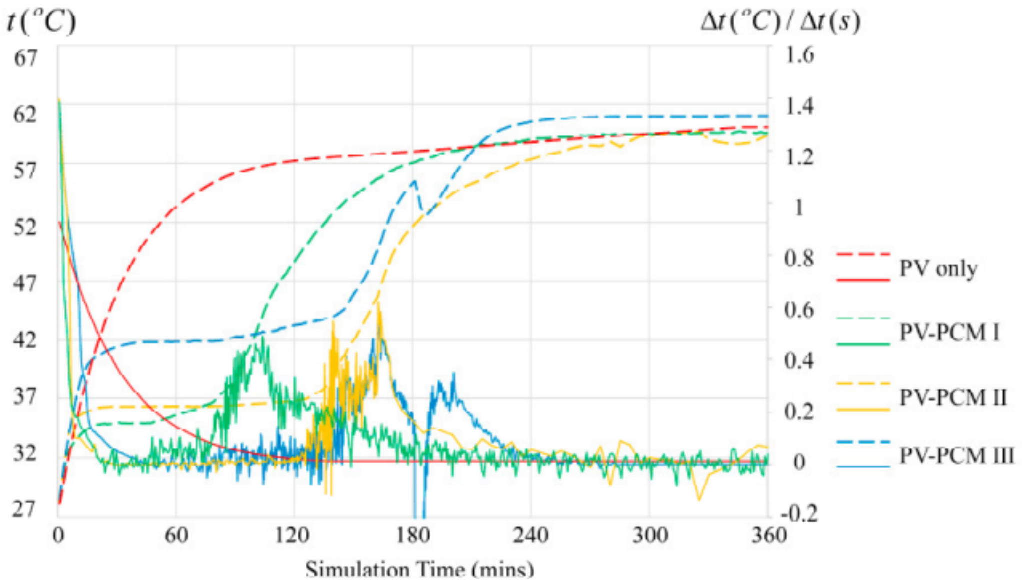


Figure 4: Comparing the Temperature effect vs Time for Solar Panels with varying Phase-change materials - Ma et al (2017).

The results of this study concluded that the ideal phase change material was the RT35HC (PV-PCM II) as it maintained a temperature below 57 degrees Celsius for 240 minutes, compared to the bare PV system reaching 57 degrees in a mere 100 minutes.

The evaluation of wind loads on solar panels

Solar power is the key to a sustainable future, with improvements in the quality of life and reduced dependency coming from the reduction of fossil-fuel based sources (that are a significant source of pollution and global warming). Solar panels are common devices used for harvesting solar rays – which is plentiful in Australia. Providing an accurate design for the resistance to wind loads is important, as these expensive structures may undergo constant loads from wild weather – causing much stress and potentially straining a few critical components overtime.

Computational fluid dynamics simulations were used – with the gathered results compared with available wind tunnel data, as a complementary tool with a potential to simulate wind loads at full-scale.

Research was conducted on ground-mounted solar panels, to understand the model scale effects on the pressure distribution.

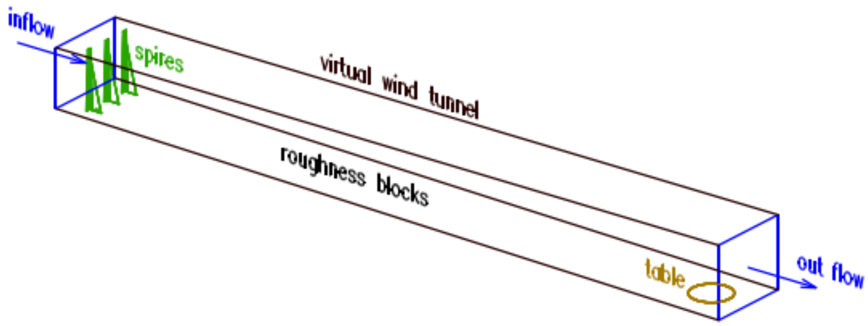


Figure 5: A geometrical representation of the virtual wind tunnel studied; 26m long, 2.4m wide, height increased linearly from a minimum of 1.55m at the spires to 2.15m at the table.

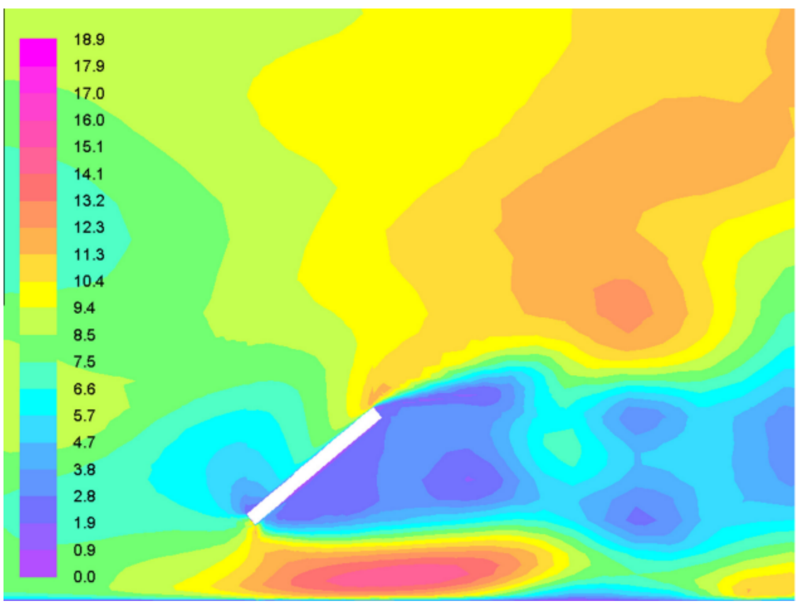


Figure 6: A CFD analysis (with LES) velocity magnitude around a PV panel.

Overall, research was made on ground mounted solar panels, aimed at understanding the model scale and the inflow effects on the pressure distribution Wind loads are an important component to take account of when installing structurally integrated solar panels. The placement of a panel reduced the amount of wind behind the panel.

Effects of solar photovoltaic panels on roof heat transfer

Heating, Ventilation and Air Conditioning (HVAC) is a major contributor to urban energy use. This is especially true in poorly insulated, single story buildings with large surface area as most of the heat enters through the roof. One of the most popular solutions involves application of a roofing albedo (or solar reflectance) as this tends to reduce the amount of cooling load required for such structures in sunny and hot climates. Akbari et al. found that through simply installing roof membranes on a home in California and a bungalow in Florida there resulted 57% and 49% cost savings respectively from reduced air-conditioning usage. A suitable proposal could potentially take account of the dual function of the Solar skin acting to provide the energy a normal PV panel would be tasked to do, whilst regulating the internal temperatures during hot summer days.

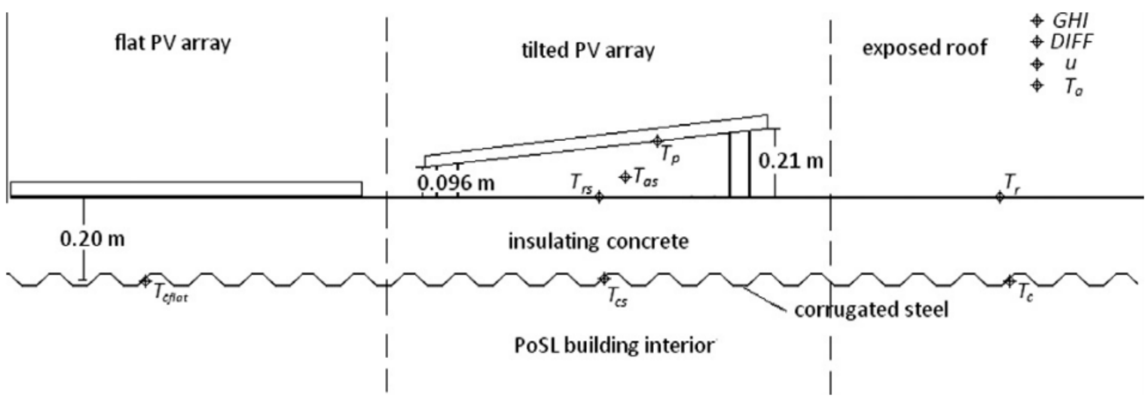


Figure 7: A roof fitted with a flat PV array, tilted PV array and an exposed roofing.

Comparisons were made between the 3 and shown in the figures below:

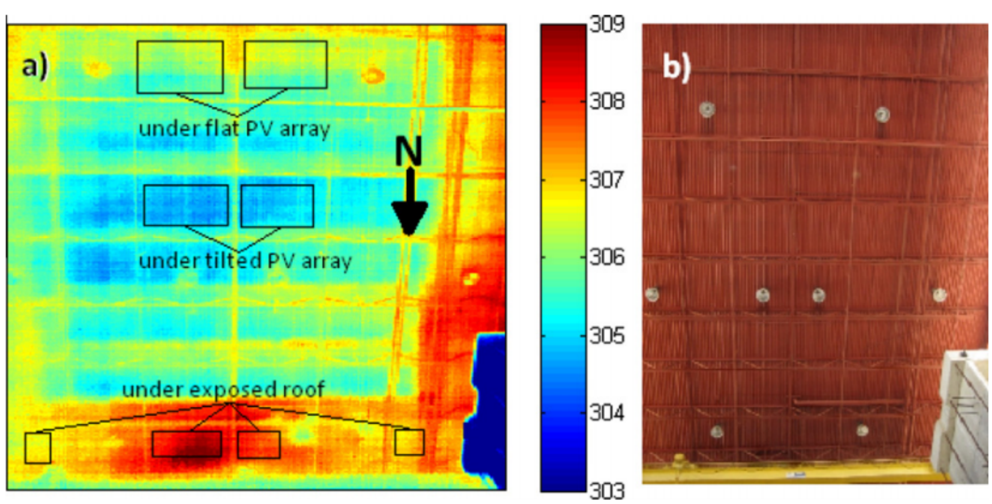
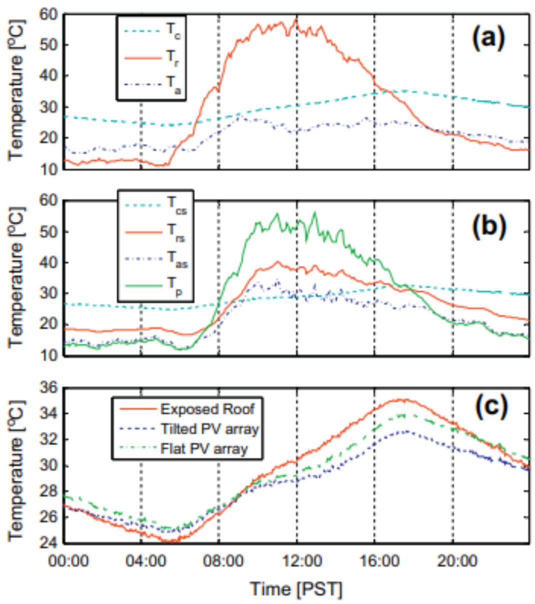


Figure 8: Exposed roofing was shown to have the highest temperature (measured in Kelvins). Tilted provided the most cooling effect.



The temperature of ceiling surface, roof surface and outside air temperature for exposed roof.

The temperature of ceiling surface, roof surface, outside air temperature and back panel measurements under tilted PV panels.

The interior ceiling surface temperatures under exposed roof, tilted PV array, and flat PV array average.

Figure 9: Comparison of different roofing types and temperature.

Modular solar racking system

Solar panels are becoming an increasingly useful means of generating renewable energy common household appliances as well as providing for commercial and residential properties. The mounting process for a PV panel is important component in the maximisation of energy production, as well as being an important stage to hold the solar panels from potential wind loads experienced on rooftops. The proper Solar panel mounting provides stability and the proper directional and latitudinal orientation for the solar array. The different mounting systems pose different challenges, as the location and direction of the panels, their ballast/racking support and direction of the wind have a large effect on their performance. These challenges include simplifying installation and maximizing use of space.

Modular solar racking systems should consist of ballast support systems as well as modular solar racking systems to aid wind resistance – especially important when installed at high locations.

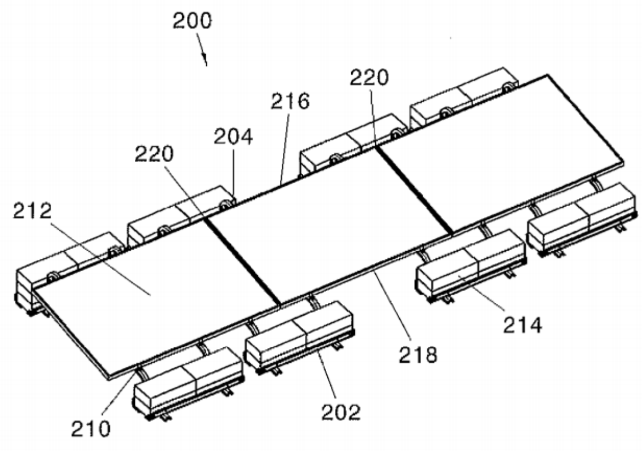


Figure 10: Diagram of Solar Panel setup containing a plurality of panel support members being weighed down by ballast - Harberts et al.

As shown in the figure above, at least one of the pluralities of discrete ballast holders of the array can be removably connected to at least one of the pluralities of panel Support members in a perpendicular manner.

At least one of the numerous ballast holders can be removably connected to a pair of the panel support members. This ensures that the given pair are spaced in parallel relationship to one another and substantially perpendicular to the ballast holder.

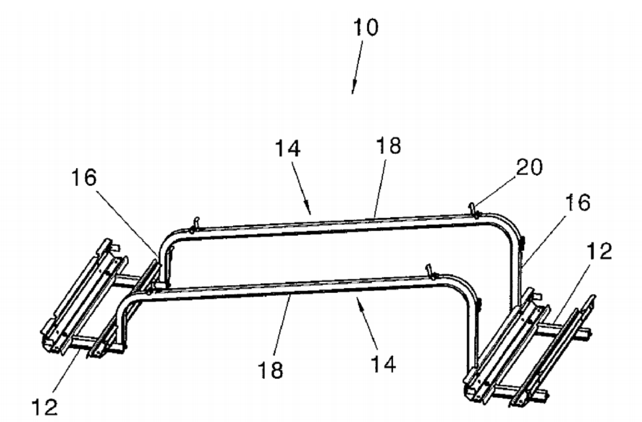


Figure 11: Representation of a solar panel rack - Harberts et al.

In the figure above, many different forms of ballast can be attached to the racking.

Wind load effects on low-rise house roofing

Wind loads on the top of low-rise buildings are determined by carrying out a wind tunnel model study – the region near the windward gable end is always subjected to the largest wind loads. AS1170.2 is the Australian Standard used for calculating the wind loads.

For most structures, many of them being low-rise buildings, the wind loading frequencies are much lower than the natural frequency of the structure. Another important design consideration is the lack of correlation of wind loads acting on large tributary areas of the structure – these are areas supported by a roof truss.

Design load effects were obtained from AS1170.2, by combining the peak pressures (both positive and negative) with the influence coefficients on the tributary area. Applying peak pressures in such manner provides conservatives load estimates.

The wind tunnel study was carried out on a typical low-rise house model to:

- Measure the pressure distribution on the roof
- Compare the results to the Standard AS1170.2
- Identify roof trusses which experience large loads
- Use the covariance integration method, compare values with Standard AS1170.2

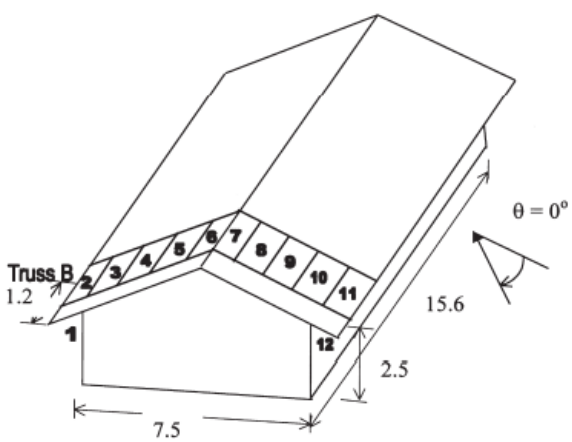


Figure 12: 15.6m x 7.5m x 2.5m house (low rise) with 20-degree pitch.

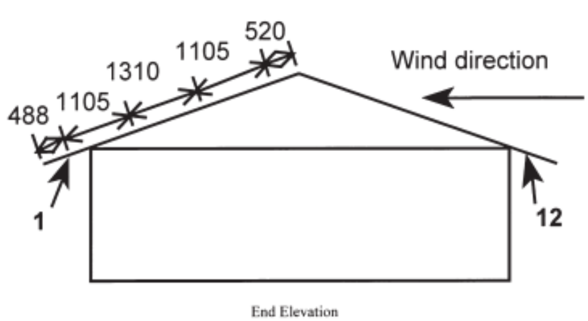


Figure 13: Diagram of Wind toward the windward side of the roofing of the low-rise building.

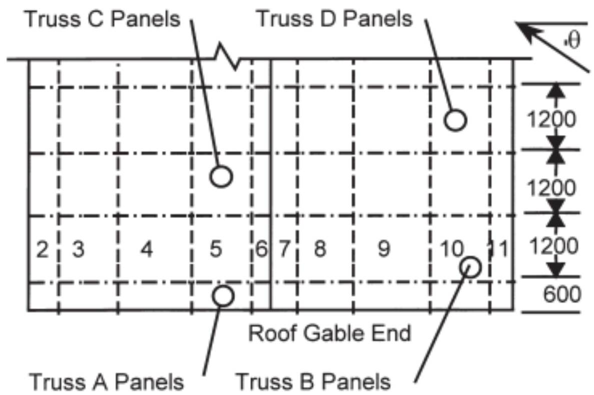


Figure 14: Diagram of roof trusses and panels 1 to 12.

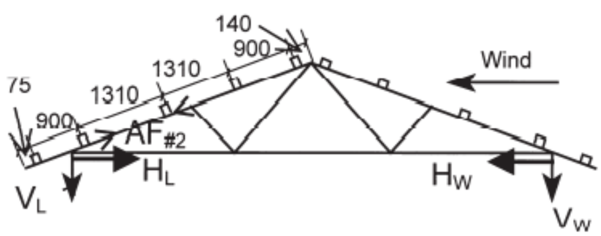


Figure 15: Roof design – containing truss components, batten positions and breakdown of loads in the x and y directions.

The extent of the areas of panels 1 to 12 and the influence coefficients for windward hold down force V_W, leeward hold down force V_L, windward horizontal reaction H_W, leeward horizontal reaction H_L and axial force on top chord member #2 $AF_{\#2}$ are given in the below table.

Panel areas and influence coefficients for selected load effects

Panel no.	Panel area (m^2)	V_W (N)	V_L (N)	H_W (N)	H_L (N)	$AF_{\#2}$ (N)
1	0.77	−0.08	1.02	0.37	0.71	−0.69
2	0.63	0.08	−1.02	−0.37	−0.71	0.69
3	1.33	−0.04	−0.90	0.22	−0.13	−0.39
4	1.57	−0.22	−0.72	1.01	0.67	−1.71
5	1.33	−0.39	−0.55	1.40	1.06	−1.75
6	0.71	−0.51	−0.43	1.45	1.10	−1.25
7	0.71	−0.43	−0.51	1.10	1.45	−1.46
8	1.33	−0.55	−0.39	1.06	1.40	−1.09
9	1.57	−0.72	−0.22	0.67	1.01	−0.64
10	1.33	−0.90	−0.04	−0.13	0.22	−0.13
11	0.63	−1.02	0.08	−0.71	−0.37	0.21
12	0.77	1.02	−0.08	0.71	0.37	−0.21

Figure 16: Values of all the horizontal, vertical forces and Axial force (AF).

To conclude, the research found that, based on the wind tunnel study and data analysis:

Large suction pressure coefficients were measured in the wind tunnel on panels of the gable (rooftop) end truss and second truss from the gable end for oblique approach winds and approach winds parallel to the ridge. Large suction pressure coefficients are given in AS1170.2 for specific areas located near the windward gable end for approach winds parallel to the ridge as they tend to generate conservative load effects on truss B.

Ballasted roof and ground mounted solar panel racking system

Conventional solar racking system often make use of penetrating the roof, alternatively they may use a concrete curb system that sits on the roof - potentially damaging the roof surface. These conventional mounting systems require careful maintenance, tong periods of dedication and investment (as bolted systems cannot be removed easily) and are often time consuming to build and install. There are many cases where leaks in the roof surface can appear over time. As can be seen, there is a need for an improved system, one which potentially uses ballast to weight the structure down.

A racking system for a Solar panel comprises a ballast pan having a base, first and second side extending from each side of the base; with a mounting strut extending along the first side of the ballast pan, running at an angle relative to the base of the ballast pan, and extending along the second side of the ballast pan; and one or more ballast blocks disposed on the ballast pan.

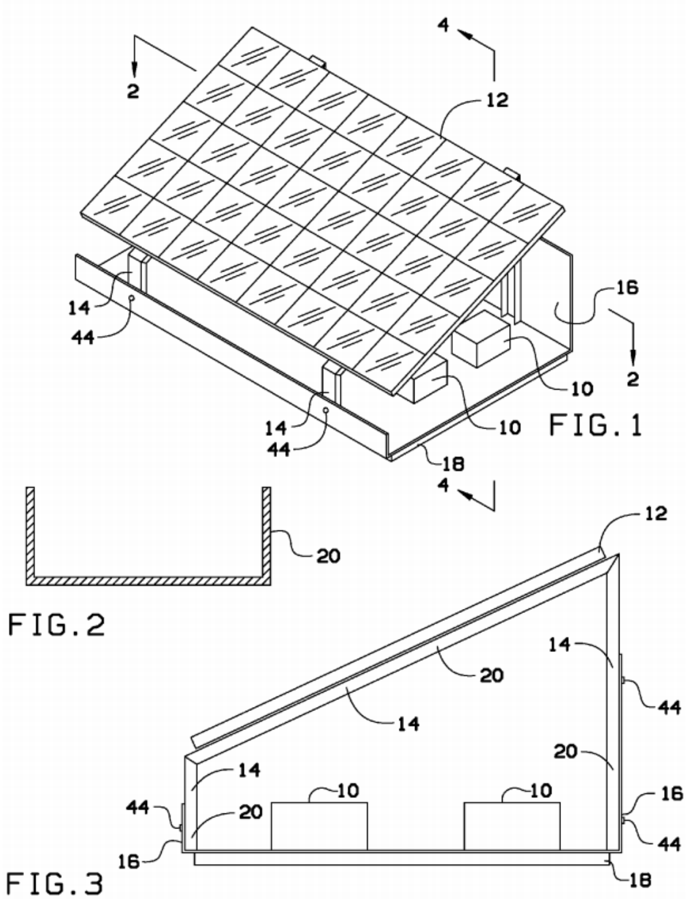


Figure 17 above:

1. Perspective view of solar panel racking system (present invention)
2. Cross-sectional view of the System viewed across line 2-2 (from above).
3. Side view of the system from line 4-4.

WATTBLOCK

How to calculate the wind pressure acting on a structure

(for structures which stand at 200m or less) – according to AS1170.2

P = (0.5Pair) x $[Vdes,_{\theta}]^2$ x C_{fig} x C_{dyn}

Sydney (Region A2) – Annual Exceedance Probability (AEP) = 1/500

Annual Exceedance probability is the likelihood that a Wind strong enough will be able to overcome the resistance of the structure – the lower the likelihood the better

Table 1

REGIONAL WIND SPEEDS

Regional wind speed (m/s)	Region				
	Non-cyclonic			Cyclonic	
	A (1 to 7)	W	B	C	D
V_1	30	34	26	$23\times F_C$	$23\times F_D$
V_5	32	39	28	$33\times F_C$	$35\times F_D$
V_{10}	34	41	33	$39\times F_C$	$43\times F_D$
V_{20}	37	43	38	$45\times F_C$	$51\times F_D$
V_{25}	37	43	39	$47\times F_C$	$53\times F_D$
V_{50}	39	45	44	$52\times F_C$	$60\times F_D$
V_{100}	41	47	48	$56\times F_C$	$66\times F_D$
V_{200}	43	49	52	$61\times F_C$	$72\times F_D$
V_{250}	43	49	53	$62\times F_C$	$74\times F_D$
V_{500}	45	51	57	$66\times F_C$	$80\times F_D$
V_{1000}	46	53	60	$70\times F_C$	$85\times F_D$
V_{2000}	48	54	63	$73\times F_C$	$90\times F_D$
V_{2500}	48	55	64	$74\times F_C$	$91\times F_D$
V_{5000}	50	56	67	$78\times F_C$	$95\times F_D$
V_{10000}	51	58	69	$81\times F_C$	$99\times F_D$
V_R ($R \geq 5$ years)	$67-41R^{-0.1}$	$104-70R^{-0.045}$	$106-92R^{-0.1}$	$F_C\,(122-104R^{-0.1})$	$F_D\,(156-142R^{-0.1})$

Therefore, V_R = 45m/s

$V_{sit} = V_r \times M_d \times (M_{z,cat}\ M_s\ M_t)$

Table 2

WIND DIRECTION MULTIPLIER (M_d)

Cardinal directions	Region A1	Region A2	Region A3	Region A4	Region A5	Region A6	Region A7	Region W
N	0.90	0.80	0.85	0.90	1.00	0.85	0.90	1.00
NE	0.80	0.80	0.80	0.85	0.85	0.95	0.90	0.95
E	0.80	0.80	0.80	0.90	0.80	1.00	0.80	0.80
SE	0.80	0.95	0.80	0.90	0.80	0.95	0.90	0.90
S	0.85	0.90	0.80	0.95	0.85	0.85	0.90	1.00
SW	0.95	0.95	0.85	0.95	0.90	0.95	0.90	1.00
W	1.00	1.00	0.90	0.95	1.00	1.00	1.00	0.90
NW	0.95	0.95	1.00	0.90	0.95	0.95	1.00	0.95
Any direction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

NW direction: $M_d^{NW} = 0.95$

SW direction: $M_d^{SW} = 0.95$

W direction = $M_d^W = 1.0$

$M_d = \max (M_d^{NW}; M_d^W; M_d^{SW}) = \max (0.95; 1; 0.95) = 1$

Determine the average height of the building.

- if the top is flat: That is the height.
- if there is a slanted roof, take the middle height.

In the case for a 15m (at highest) building, with 13m base height of the rooftop – we take the average height to be 14m.

Since 14m is not directly given in Table 3, we use Linear Interpolation…

Table 3

TERRAIN/HEIGHT MULTIPLIERS FOR GUST WIND SPEEDS IN FULLY DEVELOPED TERRAINS—ALL REGIONS

Height (z) m	Terrain/height multiplier ($M_{z,cat}$)			
	Terrain category 1	Terrain category 2	Terrain category 3	Terrain category 4
≤3	0.99	0.91	0.83	0.75
5	1.05	0.91	0.83	0.75
10	1.12	1.00	0.83	0.75
15	1.16	1.05	0.89	0.75
20	1.19	1.08	0.94	0.75
30	1.22	1.12	1.00	0.80
40	1.24	1.16	1.04	0.85
50	1.25	1.18	1.07	0.90
75	1.27	1.22	1.12	0.98
100	1.29	1.24	1.16	1.03
150	1.31	1.27	1.21	1.11
200	1.32	1.29	1.24	1.16

Using Terrain Category 2… We use Linear interpolation.

$M_{z,cat} = 1 + \frac{1.05-1}{15-10} \times (14-10) = 1.04$

Table 4

SHIELDING MULTIPLIER (M_s)

Shielding parameter (s)	Shielding multiplier (M_s)
≤1.5	0.7
3.0	0.8
6.0	0.9
≥12.0	1.0

NOTE: For intermediate values of s, use linear interpolation.

M_s = shielding multiplier = 1 (This is for the worst-case design)

M_t = max (M_h, M_{lee}) = max (1, 1) = 1

Therefore, V_{sit} = 45 x 1 x 1.04 x 1 x 1 = 46.8m/s

Therefore, the design wind speed is 46.8m/s

Solar panel manufacturers

Jinko

JinkoSolar is a global leader in the solar industry. JinkoSolar distributes its solar products and sells its solutions and services to diversified international utility, commercial and residential customers.

Trina

Trina Solar is a global leader in the field of solar PV modules, solutions, and services. The company, founded in 1997 as a pioneer in solar systems, today stimulates the development of the smart energy sector along with installers, distributors, utilities, and developers around the world. The company's leadership in the solar industry is based on innovation, superior product quality, vertical integration of production, and the desire to improve the environment.

Qcell

At its diverse R&D locations, Q CELLS employs a unique combination of R&D, pilot productions, and testing to develop and apply innovative manufacturing methods for high-tech products.

Energus

Launched in 2014 by Sunman Energy, eArc is the world's first glassless solar panel. This new generation of lightweight, thin, and flexible panels are an innovation combining proven crystalline silicon solar cells with Sunman's patented composite material. This composite material has the durability and robustness of glass, without any of the weight. eArc is the go-to solar solution for all roofs that cannot bear the load or uplift associated with glass panels, including but not limited to insulated panel roofs, lightweight metal roofs, awnings, carports and more.

Racking

Clenergy

Clenergy has different types of solar panel setups for residential, commercial, and utility areas. The PV panels are reliable and placed on mounting systems, solar systems last for around 25 years today, but the racking setup can last even longer.

Clenergy provides cost-effective solutions for different building designs. Newer, more flexible, and simple installation for tilt angles (pitch) of 5, 10 and 15 degrees.

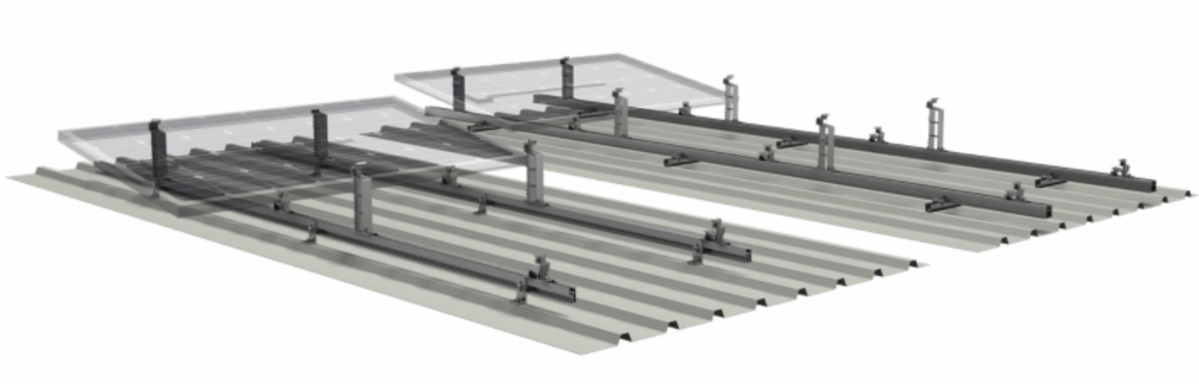


Figure 18: Solar panel racking system atop the Colourbond Steel.

Comparison of building materials

Timber

Although a concrete house design is generally better than the wooden alternative, in cold and windy climates the wooden house often performs better. This is due to wood carrying great heat isolation properties as well as a high heat capacity – this can be very useful where the risk of fires its very low. Moreover, a tree takes about 10 years to be grown and used as timber and during this 10 year it serve as CO2 absorbent and air conditioner and as timber concentrates a lot of CO2.

Colorbond Steel

A thermally efficient roofing material, reflecting the sun's rays off the roof. The steel sheets incorporate the Termatech technology, which aids in reflecting the sun rays off the roof. In the summer, a Colorbond roof could noticeably reduce the cooling costs. During the day, the heat from the reflected UV light cannot enter the inside of the house.

Concrete

Concrete has a high thermal mass like that of brick and stone. The insulation of the exterior walls is required for colder weather, and a high thermal mass to act as a heat sink in colder weather. It has a very low coefficient of thermal expansion, however large forces can be made if there is no room for this to occur, potentially devastating the structural integrity of the concrete.

The Mosman Rowers Club project

Thermal effect of installing photovoltaic (PV) panels

In this high-level analysis, the effect of external shades over windows on the sides of the building, impacting indoor temperatures and potentially adjusting indoor cooling savings such as air-conditioning, were analysed. Solar Panels installed on the Rooftop of a building have been known to reduce the indoor temperature by an average of 3 degrees Celsius. Considering that Solar Panels are expected to have a lifespan averaging 25 years, the saving from reduced air-conditioning costs would be significant. In fact, researchers through rigorous cross examinations on other buildings have determined that the savings from reduced cooling costs were equivalent to a 5 percent discount on the upfront price of a solar panel system.

Figure 19: The Aerial view of the Building with orientation facing north with potential Solar panel installation areas.

Most buildings are prone to losing energy through open exits such as open doors and windows. A study conducted by yourhome.gov.au revealed significant temperature fluctuations through uncovered windows resulted in **40 per cent temperature losses in the winter and 87 per cent temperature gains in the summer.** A good counter measure is through quality sunscreen fabrics as they deflect solar and heat radiation and reducing the intensity of the sunlight entering the building. This has the added benefit of protecting furniture and floor materials from premature ageing. Installing blinds, window furnishings and shutters with insulating properties are a sustainable and "passive" solution toward the enhancement of the indoor temperature-regulation system, as air-conditioning can be reduced.

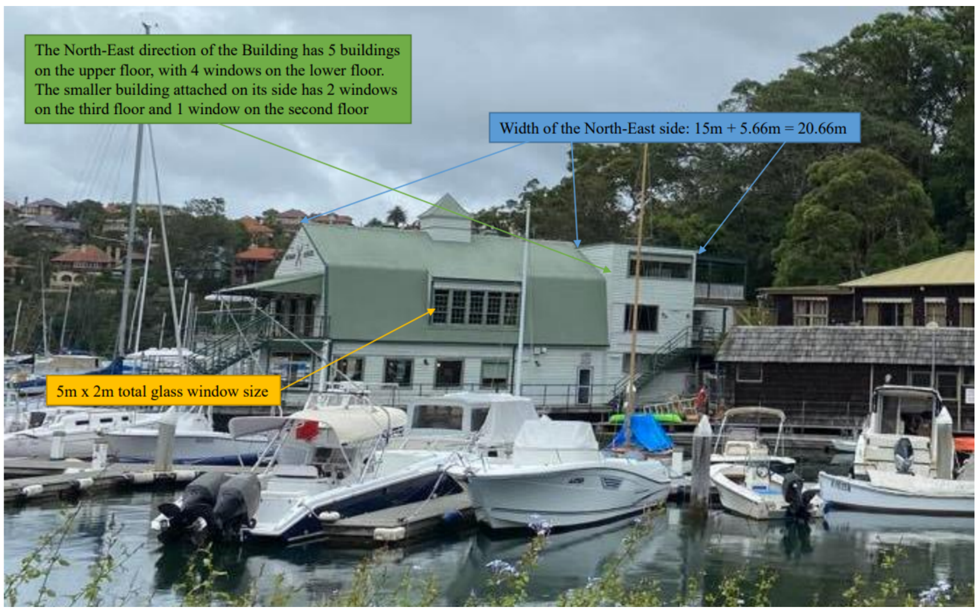


Figure 20: The North-east facing side of the Rowers Club prospective for solar panels

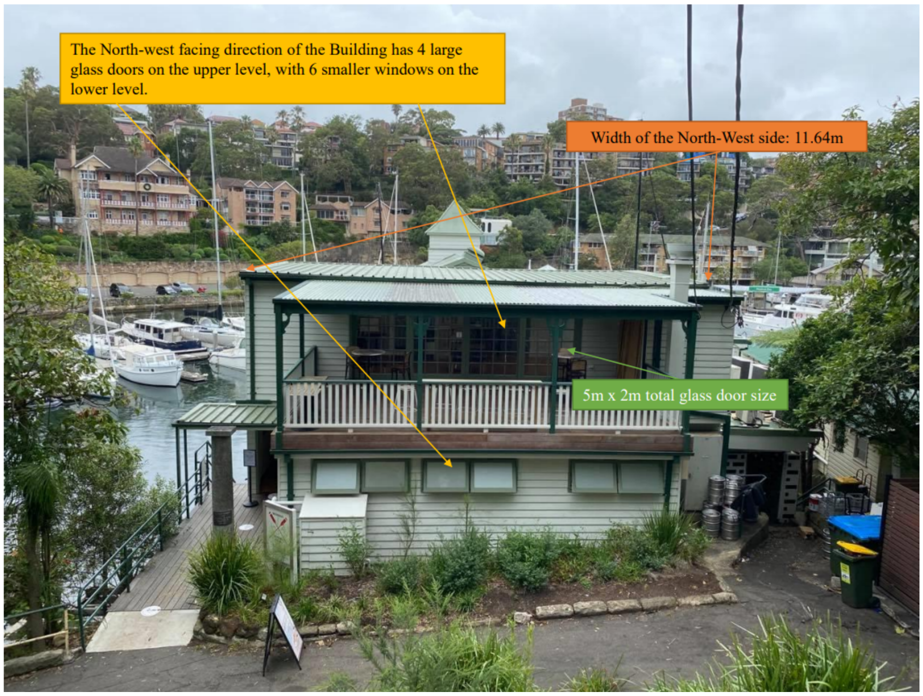


Figure 21: On the North-West side of the Building – the solar panels would experience some shading by trees.

eArc lightweight solar skin is a new flexible, lightweight aesthetic design of solar panel, which is conducive to application on sloped and curved surfaces. This is a functionally viable option for the North-East facing curved and vertical side of the building. This innovative material is increasingly being used in places once considered unusable for regular solar panels as these flex glass products can be "glued" to a surface, such techniques have allowed for interesting designs, such as the solar umbrella, providing shade for customers whilst generating electricity. This solar skin is already installed on the Maritime Museum in Darling Harbour, demonstrating its resilience in an environment exposed to salt water.

The effect of external (retractable) awnings on the indoor temperature of a building

For many buildings where excessive heat might be a common occurrence in the summer, the installation of awnings can decrease the impact of rapid temperature spikes and increase overall energy efficiency.

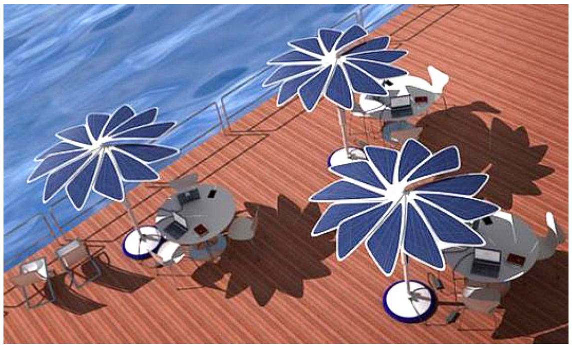
The range of materials to be used in the awnings can range from 100 percent acrylic fabrics, polyester fabrics coated with acrylic and cotton-polyester blends with an acrylic coating. Uncoated polyester tends to be unsuitable for awnings because it is more susceptible to sun damage.

Installing an awning over exposed windows can:

1. Decrease energy usage for cooling by 25%
2. Awnings can reduce solar heat by 50% in the East & West direction, and up to 75% in a North direction.
3. Reduced energy bills can also offset your carbon footprint by emitting fewer greenhouse gases into the air.

Similarly, installing blinds and shutters over exposed windows improves the insulation of the building:

1. Tightly installed cellular shades reduce heat loss through exposed windows by 40% or more, which equates to over 20% reduced heating costs in winter.
2. Cellular shades can reduce unwanted solar heat through windows by up to 80%, reducing the total solar gain to 15% or less when installed with a tight fit in summer.



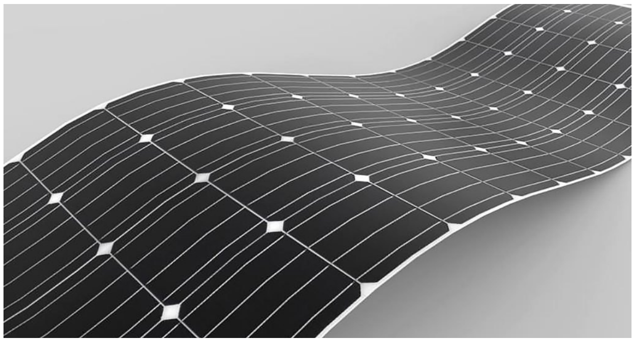


Figure 22: eArche lightweight flexipanel being used for electricity generation in the form of a utility (umbrella)
Figure 23: eArche lightweight flexipanel

An R-Value is a measure of a building's thermal capacity which is the ability to resist heat flow from one end of a material to another. All materials have different R-Values, and they are additive. For instance, combining a material with an R-value of 4 with another material with an R-value of 3, will result in a combined material R-value of 7.

The following chart details characteristics of different climate zones.

Note: Zone 1 and 2 regions require lower R values of 3 or 4, while zones 3-7 require an R value of 5. As we reach zone 8, R values of 6 are required.

Zone	Description
1	Hot humid summer, warm winter
2	Warm humid summer, mild winter
3	Hot dry summer, warm winter
4	Hot dry summer, cool winter
5	Warm temperate
6	Mild temperate
7	Cool temperate
8	Alpine

Figure 24: The recommended R-Value for a building's thermal value based on location.

As Sydney is in Zone 5, an average R-Value of 5 is required for each building surface to provide adequate insulation, this value is subject to change in the warmer months with added insulation being desirable for minimising cooling costs.

R-Values of Materials: Table of Insulation R-Values and Properties for Various Insulation Materials & Building Materials (brick, block, wood, soil, air gaps, etc) are available at sites such as inspectapedia.com.

Using this knowledge, different awnings, solar panels, and solar skins can be judged for the R-value for their thermal properties. It was observed that the building at Mosman Rowers Club has very thin walls which are not ideal for providing insulation during the hot summer days. Therefore, installation of awnings and solar panels should be considered, along with potential refitting's of internal walls with more R-valued materials for insulation. It is estimated that with the installation of multiple awnings over the North-West and North-East directions of the building, insulation levels would be increased until the optimal R-value of 5 minimum is reached and preferably a higher R-value can be achieved during the summer months. It is likely that given the current layout of Colorbond Steel and softwood surrounding the building, that insulation is below recommended levels (perhaps an R-value of 3 - 4).

Comparisons of blinds/shutters/awnings

A detailed investigation into the exact thermal resistance provided by the building can allow for accurate effects analysis of the awnings, blinders, and reflective solar panels to be calculated. This allows the active cooling costs to be significantly reduced. Another important observation is that since the premises is of commercial nature, energy usage would be prevalent during the day. Essentially this means that any generation of electricity via solar panels can be directly used by the appliances during the day rather than requiring batteries to store it for usage later in the day.

Product	Lifespan	Warm in winter	Cool in Summer
Mesh Blind	5-8 years	Low effect (rating = 1/4)	Low effect (rating = 1/4)
Roller Blind	2-5 years	Low effect (rating = 1/4)	Low effect (rating = 1/4)
Venetian Blinds (Cedar)	3-7 years	Low effect (rating = 2/4)	Low effect (rating = 2/4)
Venetian Blinds (Aluminium)	3-7 years	Slight effect (rating = 2/4)	Slight effect (rating = 2/4)
Curtains (Self-lined)	6-10 years	Moderate effect (rating = 3/4)	Moderate effect (rating = 3/4)
Vinyl Shutters	10-20 years	Moderate effect (rating = 3/4)	Moderate effect (rating = 3/4)
Curtains (Heavy Pelmet)	10-15 years	Strong effect (rating = 4/4)	Strong effect (rating = 4/4)
Cedar Shutters	10-20 years	Strong effect (rating = 4/4)	Strong effect (rating = 4/4)

External awnings are often made of acrylic, vinyl, metal, fibreglass, or other natural materials.

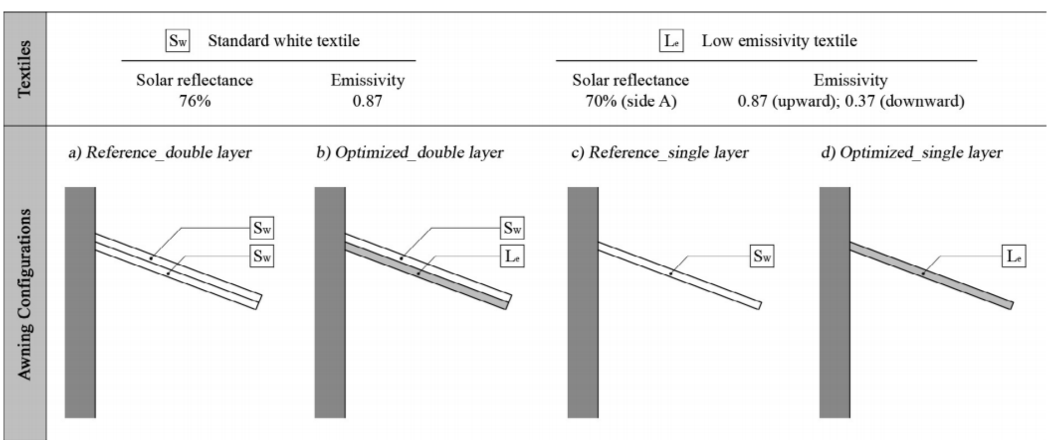
- Acrylic: Performs well in very humid environments as it resists fading, abrasion and stains, however, is usually opaque and very heavy.
- Vinyl-backed acrylic canvas: Waterproof and heavy-duty & can be exposed to rain and heavy weather.
- Vinyl laminates and denim-backed Vinyl is waterproof; however, it does not present many colour options.
- 

Figure 25: Comparisons of single layer awning vs double layer awning setups for solar reflectance

Figure 26: The 2 different types of textile being included in the comparison of figure 7 (Standard White, Side A of Low Emissivity textile and Side B of Low Emissivity textile)

Material	Solar reflectivity	Emissivity
Standard White Textile (Sw)	76%	0.87
Low emissivity textile (Le) side A	70%	0.87
Low emissivity textile (Le) side B	71%	0.37

Popular brands of shutters/awnings/curtains

Aspect Shade

- Awnings, Pergolas, Shutters store
- Good value for price, good customer satisfaction, excellent finishes.
- 5-year warranty for all products from date of purchase, with 12 months warranty for motorisation/batteries

Awning Worx

- Produces both commercial and residential products.
- Large range from Pergolas, Shutters, Awnings, Blinds, Louvre systems, retractable fabric roofing.
- Motorised awning options available
- Customisable options against horizontal protection for outdoor spaces and vertical protection for indoor building spaces.

Sunteca

- Shutters, Awnings, Blinds store
- Large variety of Indoor/Outdoor products for shading and insulation during summer
- Good thermal insulation for the space underneath

The Shade Professionals

- Excellent prices (willing to match competitors' prices)
- Compact, new technology for Awnings called Millennium.
- Excellent for commercial buildings which require larger awning sizes, as well as featuring compact family-friendly products.

"The Millennium is a low-profile full cassette awning which incorporates advanced German engineering. The fully enclosed cassette design provides optimal protection for the system while providing an aesthetic appearance to match into the surrounds of modern architecture. The low profile of this awning makes it stand out from other cassette awnings in a class of its own."

- The Shade Professionals about the Millennium

Roller Shutters

- Products designed to withstand bushfires and extreme environmental conditions.
- Roller Shutters will be able to resist security incursions.
- Shutters reduce noise and reflect sun's rays on hot summer days.
- Aesthetic design for display

DIY Blinds

- Many options for residential small-scale projects
- Cheap and affordable options
- Quotations available
- Easy to install by yourself

The Shutters Dept

- Good quality, very reasonable pricing
- Nice aesthetic design
- Many custom dimensions

B.A.C. Wholesale

- Excellent Customer Service
- Dutch Hoods, French canopies, Walkways, Wedge canopies, Wedge Awnings, Umbrella Bows available for sale and customisation.
- Better deals as it is a wholesale service.

Gas vs electric water system

Another technology to be considered for the Mosman Rowers Club requires an upgrade of the existing gas hot water system with an electric-powered heat pump system. Long-term cost savings can be achieved by using this alternative. Whilst on average, the installation of the electric pump system is more costly than its gas alternative, the annual maintenance rate is almost half the price.

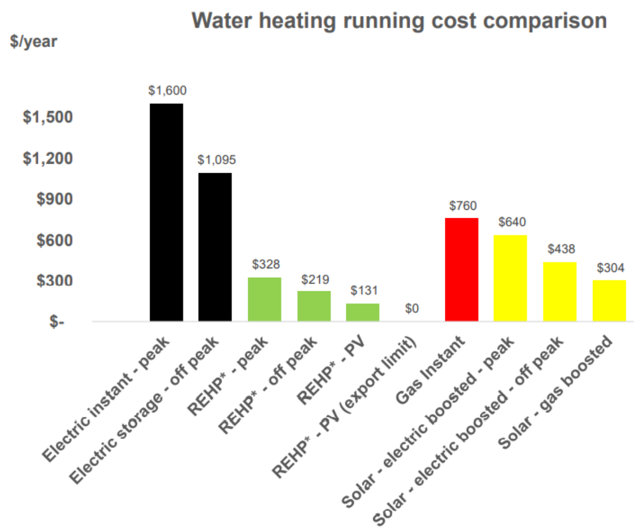


Figure 27: Electric Heating system is more efficient than the gas alternative.

It can be seen here that using REHP drastically reduced the cost from Instant gas, however using instant electricity is much more costly being around $1095/year for electrical storage in off-peak times and electrical instant during peak.

In Australian homes, household water heating is the 2nd biggest user of energy as well as being the 2nd largest contributor to emissions. Implementing an REHP system will benefit the environment with lower emissions as well as save significant costs. The reason for this is that REHP systems use a much lower amount of electricity and therefore costs materially less to run.

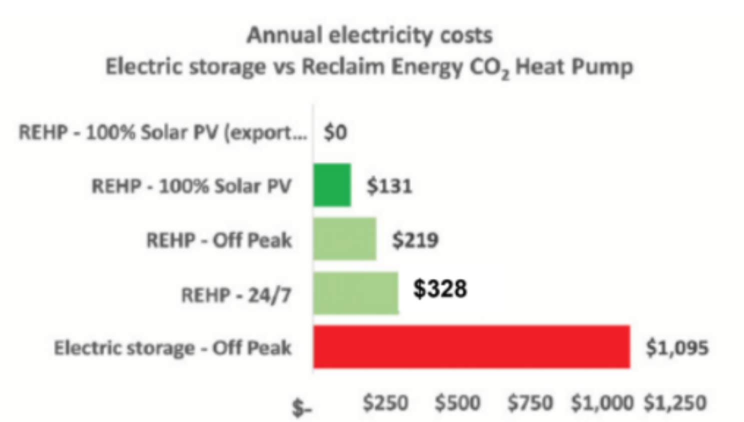


Figure 28: Electrical storage off-peak is shown to be the most expensive contributor to annual electricity costs.

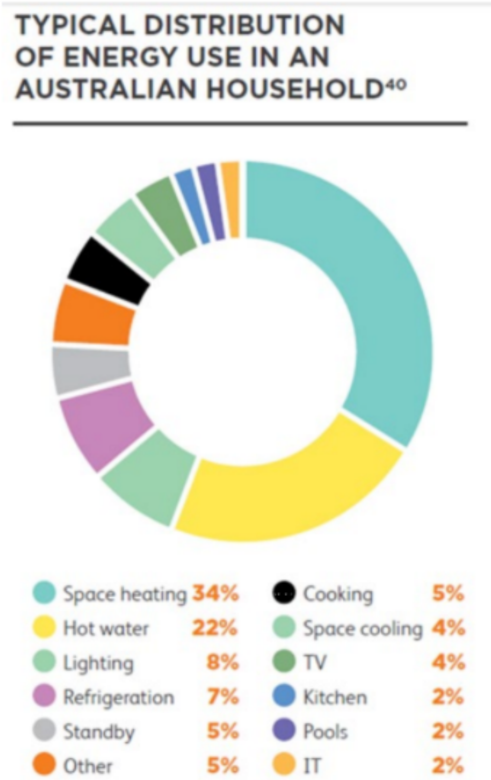


Figure 29: Distribution of Energy Use

34% of the energy use in Australian households come from heating, and 22% comes from the hot water usage.

Electrical kitchen upgrade

The electrical kitchen is a green solution for the Mosman Rowers Club, with up to 80% of the electricity generated potentially being dedicated to the cooking or baking during business hours.

Benefits from electric kitchens is that less excess heat is generated in the area, meaning air conditioning costs will be further reduced when cooking. This is also coupled with the benefit of lower energy requirements as the new technology produced much less excess unnecessary heat.

Below is a comparison of electrical vs gas kitchen cooktops as this is a step which the Mosman Rowers club could undertake for further electrical efficiency.

Electrical advantages	Gas advantages
• Able to set the temperature to the same every time, rather than having to play with the temperature dial. • Does not require a gas line to be connected to the building, which can be a problem in remote areas. • Low risk due to lack of open flames. • More Hands-off approach by putting your pot directly on the heat source, and choosing a setting (high, medium high, medium, medium low, simmer). • Easier to clean due to the smooth surface that will not enclose unwanted quantities of food. • Electric ovens produce an even level of heat due to the fan, making this option more versatile.	• Easier to see the level of heat with gas from the flames. • Quicker response times, more freedom of control, able to adjust heat level with a tiny turn of the knob. • Gas cooktops can do charring, toasting, and flambéing. • The heat produces a humid baking environment where vapour is produced, allowing for more moisture to be retained in the food, compared to electric which only targets the item directly on top of the electric stove and often dry out the food.

Figure 30: The Electrical cooktop in a modern kitchen

Mosman Rowers Club today compared with all the changes implemented

Implementing awnings & shutters will save an average of 25% for awnings and 20% for shutters.

Replacing gas cooktops with electrical cooktops powered by PV panels will result in an 83% decrease in cost of energy usage (when compared to instant gas).

The electrical water system saves over $700 every year compared to the current gas system installed.

It is advised to undertake these projects for the long-term sustainability and efficiency of the Mosman Rowers Club.

Conclusion

Evidently, installation of a solar system has many benefits to the building underneath ranging from increased thermal efficiency, reducing costs of air conditioning in the summer and heating in the winter. Additionally, energy efficiency is increased as solar panels have greatly increased in applicability, ranging from the solar flexi panels to improved efficiency PV panel technology. The addition of awnings, shutters and implementing phase change materials are a great compliment to buildings installing PV panels as this would only reduce the overheating experienced on the panels on a sunny day. No doubt, as time passes the feasibility of solar panel installation would greatly increase and we would be on our way to a renewable-energy fuelled environment.

Appendix

Case Study: 8-14 Fullerton St Woollahra - Piccadilly Gardens

One of the site visits, Wattblock was interested to install a solar panel (PV) system on the rootop of this residential building. One of the main issues that a structure this tall (21-storeys) often faces is the windspeed.

Figure 31: Street view photograph of the building

An interesting case study – the 21-level residential block was constructed in 1963. Many of the features present within the site were prevalent in the 20th century buildings, although features have been upgraded since.

Figure 32: The waterproofing on the rooftop of the building – not conducive to Solar Panel installation

Case Study: 30 - 40 George St Leichardt

Figure 33: A street view wide lens shot of the building.

Figure 34: The rooftop of the building complex, with walls separating a pool, resting area and pebbled area.

Case Study: 350 Liverpool Rd Ashfield

Figure 35: The image of the grey building

Figure 36: The image of the orange building

WATTBLOCK

Case Study: 1 Brown St Ashfield

Figure 37: Street view picture of the building

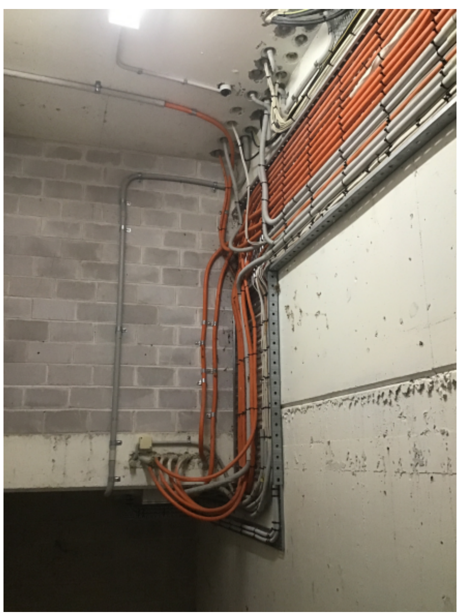


Figure 38: Sideways Cable trays in the basement garage

WATTBLOCK

Who is Wattblock?

Wattblock was started by Brent Clark in 2014. He is joined by Jacky Zhong (solar engineer/NABERS assessor), Kevin Hu (structural engineer) and a group of advisors. Wattblock is supported by UNSW Entrepreneurship.

What is Wattblock's mission?

The energy wasted in Australia's strata buildings has a bigger impact on carbon emissions than the cars driving on the roads. Wattblock aims to **crowdsource** the achievement of Australia's national carbon emission reduction target.

How many strata buildings has Wattblock assisted?

Wattblock has assisted approximately 1,000 strata buildings across Australia with energy reports. Wattblock has also directly project managed the upgrade of 100+ buildings with LED lighting, solar, ventilation and hot water. To date it has identified over $25m of annual energy waste across townhouses to high-rise residential skyscrapers. Over 250 strata buildings have participated in electric vehicle charging studies.

Who is partnering with Wattblock?

Jobs for NSW, Advance Queensland, North Sydney Council, Mosman Council, Lane Cove Council, Ryde Council, Inner West Council, Woollahra Council, Microsoft CityNext, Telstra's muru-D, UNSW Entrepreneurship, University of Western Sydney, Griffith University, University of Queensland, Queensland University of Technology.

Who is covering Wattblock in the media?

SBS, North Shore Times, Foxtel, BRW, The Australian, Business Insider, Computerworld, StartupSmart, StartupDaily, LookupStrata, Technode, Fifth Estate, One Step Off the Grid, Renew Economy, Inside Strata, Beyond Zero Emissions, Your Strata Property Online, Impakter and Telstra's Behind the Mic.

Wattblock Awards

Cities Power Partnership – Community Engagement, Innovation of the Year - Strata Community Association (NSW), Best Social Change Entrepreneur 2015 (Start-up Smart), Energy Winner at 1776 Challenge Cup Sydney, CeBIT Community Support Finalist (2015).

Who is backing Wattblock?

Wattblock has received investment from muru-D as part of Telstra's startup accelerator program, Eastern Hill Investments, an Asian-based environmental engineer, a UK-based energy company consultant, a U.S.-based hi-tech investor, a NZ sustainability funds manager, a Sydney-based environmental impact investor, a Sydney-based clean tech consultant, a Sydney-based clean technology finance consultant and an innovation laboratory research director.

Where is Wattblock located?

Wattblock is based at the Michael Crouch Innovation Centre at UNSW and acknowledges the support of UNSW Entrepreneurship.