WATTBLOCK

Sustainability Case Study

Jade Albion (SP259423)

35 Burdett St, Albion, QLD 4010

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Updated: 24th September 2018

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Sustainability Case Study
Strata Plan SP259423 Jade Albion
35 Burdett St, Albion QLD 4010

8/10/2018

This report has been prepared by Wattblock with support of Griffith University WILP:

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Document Control Log

Revision No.	Date	Prepared By	Checked By	Approved By
A	20/9/2018	Aaron Richardson	JZ	RM
B4	8/10/2018	Aaron Richardson		

Acknowledgements

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List of Acronyms

Acronym	Term	Meaning
A	Ampere (Amp)	Unit of electric current. Used to describe a rate of electrical flow.
V	Voltage (Volt)	Difference in electric potential between two points.
W	Watt	Unit of energy transfer and work. Equal to one Ampere multiplied by one Volt.
kW	Kilowatt	Output of 1,000 Watts. Used when referring to actual/working power of a device.
kWh	Kilowatt hour	1 kW of energy measured over one hour. Energy is charged for in this unit.
kVA	Kilovolt-ampere	Measure of apparent power. Includes any losses incurred in a system.
kL	Kilolitre	Measure of volume – 1,000 litres.
DHW	Domestic hot water	Central production of heated water (~60°C) using common property plant.
LED	Light Emitting Diode	Low-power light source using semiconductor materials.
PV	Photovoltaic	Conversion of light into electricity using semiconductor materials.
EV	Electric Vehicle	A vehicle powered by electric motors rather than an internal combustion engine.

Executive Summary

This case study investigates energy and water consumption in Jade Albion, primarily in regards to common property assets. Cost-saving initiatives are considered and detail provided on issues related to their implementation.

An investigation of water bills shows an excessive usage with unidentified cause. The most likely explanation given the available data is an issue with the main water meter responsible for measuring flow into the complex. After presenting the water utility (Queensland Urban Utilities) with data collection and analysis performed by Wattblock, they have agreed to perform a test on this meter to determine if it is at fault. The results of this test are forthcoming.

An analysis of existing water and energy assets is provided, with the findings generally showing a high standard of efficiency with some exclusions. The largest of these is the carpark lighting, which accounts for half of all common property energy usage. An upgrade to LED lighting is recommended, with options and costings provided. An upgrade to domestic hot water (DHW) heating is also considered with a shift from gas burners to electric heat pumps.

Electric vehicle (EV) charging is covered as a topic for investigation, with the expectation that action will need to be taken by 2021 to ensure the local electrical network is not overloaded by an increase in EV ownership.

Solar power generation is examined as a method to reduce electricity costs to the body corporate. Jade's large open rooftop spaces and embedded electrical network make it ideal for collecting and using solar energy. Three scenarios are considered for systems of various sizes, with the aim being to utilise this energy within Jade for fastest payback. Battery storage options are considered for the largest of these scenarios.

A summary of low-risk cost-saving initiatives is presented for consideration below, with estimated cashflow and payback periods listed. Wattblock are able to provide consulting and project management services for each of these opportunities.

Table 1: Project summary

Topic	Options	Investment cost	Annual cashflow	Payback period
Solar Power	100kW	$114,820	$20,720	5.2 years
	200kW	$348,980	$48,396 to $61,333	7.0 years
	500kW + Battery storage	$1,115,820	$105,435 to $146,833	12.7 years
Carpark Lighting	Replace with LED battens on individual sensors	$105,763	$32,738	2.4 years
	Refit existing fluoro battens with LED tubes	$48,063	$26,246	1.4 years
DHW	Heat pump upgrade	$278,300	$63,954	4.4 years

1.0 Introduction

Jade is a recently constructed apartment development located in Albion, Brisbane. The development was completed in early 2017. It contains 369 apartments spread across four 6-storey buildings, a two-storey underground carpark, multiple garden zones, a gym, a pool and a spa. 265 apartments are estimated to be occupied, with 235 of these tenanted.

Figure 1: View of Jade from Burdett St [1]

Building management and caretaking is provided by Arden Group, letting services by CBS Property Group, and body corporate by SSKB. Power is supplied via Jade Utilities Management Rights, water by Queensland Urban Utilities, and gas by Origin Energy.

Wattblock has been engaged by Arden to investigate current utility usage and identify opportunities for cost-saving investments. This report covers a broad range of topics relevant to water and energy consumption at Jade and their adjacent concerns. Where appropriate, project and product suggestions are provided along with fiscal analysis.

This report covers findings from a joint case study research project between Wattblock and Griffith University's Work Integrated Learning Program (WILP). The case study explores energy and water sustainability issues with Jade Albion being a typical example of recent high-density apartment developments. The work has been conducted by Sustainable Energy Engineer Aaron Richardson with review by Ross McIntyre, Wattblock, and Dr. Sascha Stegen, Griffith University. The project was conducted over a period of 12 weeks covering water efficiency, energy efficiency (electricity and gas), renewable energy technology (solar PV), impact of electric vehicle charging, and a pre-assessment of NABERS for Apartment Buildings energy and water efficiency ratings. Further information on project planning can be viewed in Appendix section 8.8.

1.1 Jade Albion Overview

Typical of high-density residential strata developments, Jade Albion provides common energy and water infrastructure for the residents. Apartment are connected with individual electricity supply via an embedded electrical network which allows for bulk energy supply discounts. There are also common area electricity meters for services such as lifts, ventilation fans, water pumps, and lighting in car parks, foyers, corridors and gardens. The building already makes use of energy savings technologies such as timers, sensors, variable speed drives, and LED lighting in some areas. Residents pay for their own water supply. The building has a central common hot water system with gas heated storage tanks. While hot water is heated centrally, residents pay for water heating directly to the gas company. However, there is also common area water supply for the swimming pool, gardens and car wash area.

Common area energy and water usage is covered by the Owners Corporation along with other common property expenses such as building maintenance, cleaning, and insurance. These costs are covered by strata levy contributions from the apartment owners between owner occupiers, owner investors, and tenants. This common arrangement in residential strata can sometimes lead to split incentive issues. In the case of LED lighting upgrades in common areas the owners can realise direct payback on the investment via reduced common area power bills translating to lower strata levies. However, in the case of the common hot water system, energy efficiency improvements are more likely to translate to lower energy bills for residents.

Payback to owners may therefore be indirectly achieved through higher rental over time or increased property valuation where higher demand for energy and water efficient 'green' buildings can be realised.

There is increasing evidence that green buildings are attracting premium property valuations. One of the most visible ways of displaying green credentials has been rooftop solar PV. Jade Albion is blessed with a large expanse of flat roof area representing the greatest opportunity for sustainability investment. Furthermore, due to the presence of an embedded electrical network a solar PV investment can take advantage of the total aggregate electricity demands of all apartments and common areas. Depending on the commercial arrangements with the embedded network operator, financial benefits could be passed on to residents or used to offset common energy bills to allow for more direct payback of the investment.

In this report we take a holistic approach to considering sustainability investments. In the case of solar PV, it is important to first consider expected future energy demands. Therefore, we cover energy efficiency initiatives that could reduce common area power demands as well as the impact of electric vehicle charging which may increase common area energy demands. We start our analysis with a NABERS energy and water efficiency pre-assessment before looking at sustainability initiatives and the potential impact of electric vehicle charging. This is followed by an assessment of the solar PV opportunity.

2.0 NABERS for Apartment Buildings Pre-assessment

The NABERS energy and water efficiency rating scheme was introduced to the residential strata market in July 2018 [2]. Managed by the Office of Environment and Heritage, the rating system provides a star rating between zero and six stars for common area energy and water efficiency. Six stars is considered best in class, zero stars is poor, and three stars is average. To obtain an official NABERS for Apartment Buildings star rating requires formal engagement of a certified NABERS for Apartment Buildings assessor and payment of lodgement fees to the Office of Environment and Heritage. As part of this research project we have estimated what we believe would be the outcome of a formal NABERS for Apartment Buildings assessment. However, it is noted that a complete formal assessment considers a wider range of details that may affect the result.

According to pre-assessment data collection we estimate that Jade Albion would currently achieve a 5.5 Star energy rating and a 4.5 Star water rating [3]. This is broadly based on overall common area energy consumption of 384,153kWh and annual common area water consumption of 21,455kL. It is noted in particular that due to building not having full occupancy for the review period, and the presence of abnormal consumption (such as during construction works), these results may not be representative of normal building load. General assumptions include 369 apartments, fully lift serviced, central hot and cold water with individual meters, no central air conditioning (with small exceptions), an unheated swimming pool, a gym, and no open-air car spaces (all underground and mechanically ventilated). With estimations for full occupancy, the rating drops by 0.5 stars for both water and energy efficiency.

Our assessment of energy efficiency aligns with the NABERS for Apartment Buildings pre-assessment conclusions in that the building generally has good energy efficiency. However, our analysis of the water consumption at Jade Albion indicates a much higher level of water consumption than would be expected. The NABERS pre-assessment result indicates good water efficiency at current occupancy, but makes no distinction between fully occupied and partially occupied apartment complexes. The high rating is attributable to this as well as the building's use of water-saving fittings and the water rating including end usage inside the apartments.

3.0 Water usage investigation

There has been an ongoing dispute between Jade building management (Arden) and the water supplier, Queensland Urban Utilities (QUU), in regards to excessive water billing. These bills show a usage that is much higher than expected with no obvious cause. Wattblock have previously been engaged by Arden to assist in data collection and analysis to reach a resolution with QUU.

This section broadly covers the investigation, analysis, and findings. At the time of writing, the dispute is ongoing, with QUU having agreed to perform a flow test on the main meter, which is most likely to be the cause of the issue according to the research performed so far.

3.1 Metering setup

There are seven water meters in the Jade Albion apartment complex which appear on the water bills. They are as follows:

Table 2: Water meters in Jade Albion

Meter name	Purpose
F1861	Main water meter
CBP1507636	Hot water meter for Sage
DBA 1504017	Hot water meter for Fern
DBA 1504023	Hot water meter for Jasmine
DBA 1600029	Hot water meter for Lotus
ABG 1552884	Common property cold water sub-meter
ABG 1552884	Common property cold water sub-meter

Each apartment has its own hot and cold-water meters and are billed individually by Queensland Urban Utilities. Their portion of water usage is subtracted from the main meter reading and is not charged to the body corporate.

Common property cold water use includes the car wash bay, pool and spa, taps around gardens, site office, gym and bathroom, and fire hoses. There is no common property hot water usage.

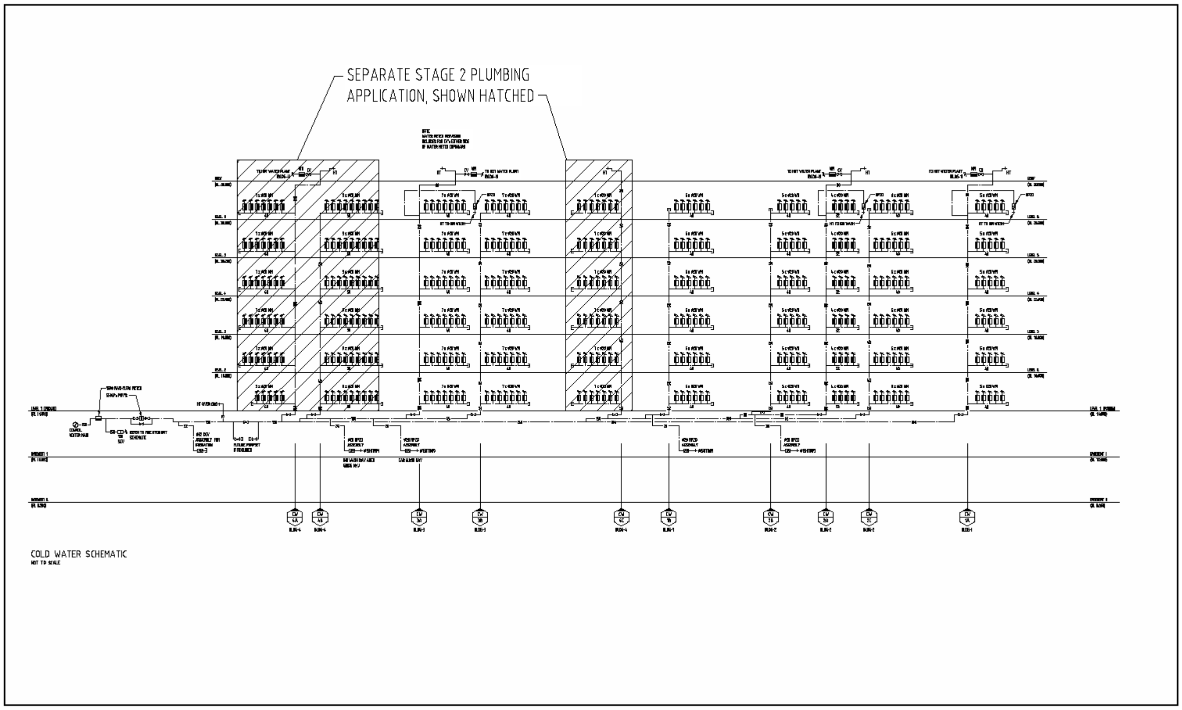


Figure 2: Cold water hydraulic schematic

3.2 Excessive reported water use

Of the 369 apartments at Jade, approximately 265 are presently occupied. For the period of April 2017 to April 2018, common property water intensity was 230L/day, and residential water intensity was 163L/day. Assuming the average apartment has between one and three residents, this residential use is below the average Brisbane average of 150L per person per day [4]. Proportionally, common property water use is greater than expected.

Charges for common property usage have been significantly higher than expected since April of 2017. A previous investigation of water use by Wattblock, conducted between February and April of 2018, estimates that 83% of usage (112.4kL/day) is unaccounted for in the month of March 2018 [5].

Possible causes for this excessive use are:

- The main water meter is measuring flow incorrectly,
- The DHW meters are under-reporting usage,

- The residential hot and cold-water meters are under-reporting usage,
- Pool water is being refilled too rapidly,
- A leak is flowing directly into stormwater drains, or
- Water theft.

3.3 Flow testing

Two methods of flow testing were performed:

- Watergroup flow monitor: March-April 2018
- Ozganga ultrasonic flow test: 19 April 2018

The results of the Watergroup tests were deemed to be unreliable, as there were noted inaccuracies in the monitor's flow reporting. The monitor also relies on the accuracy of the main water meter, which has been called into question, in order to report flow.

The ultrasonic test revealed useful information regarding the minimum flow rate through the main water meter. Between 12pm and 1pm the lowest measured flow rate was the equivalent of 1.08kL/hour. Between 3pm and 4pm, the lowest flow rate was calculated to be 0.72kL/hr.

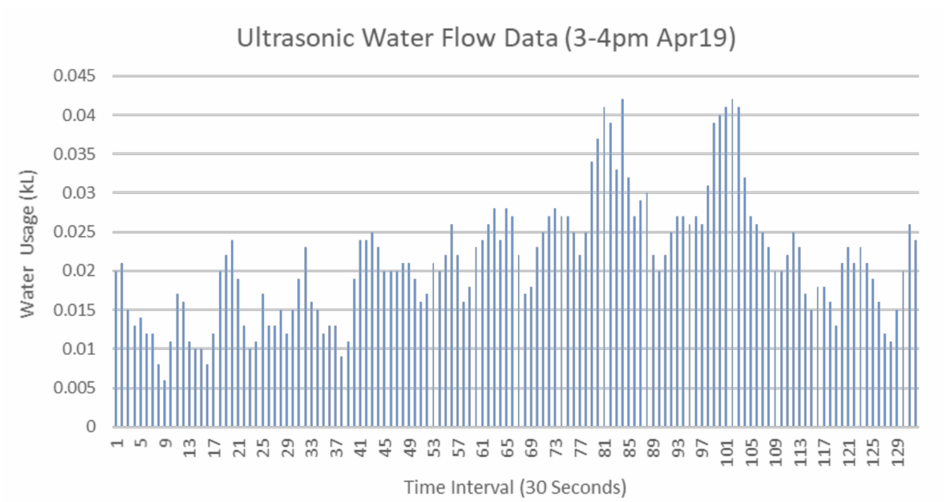


Figure 3: Ultrasonic flow metering data from Ozganga

3.4 Meter reading analysis

Utility bills

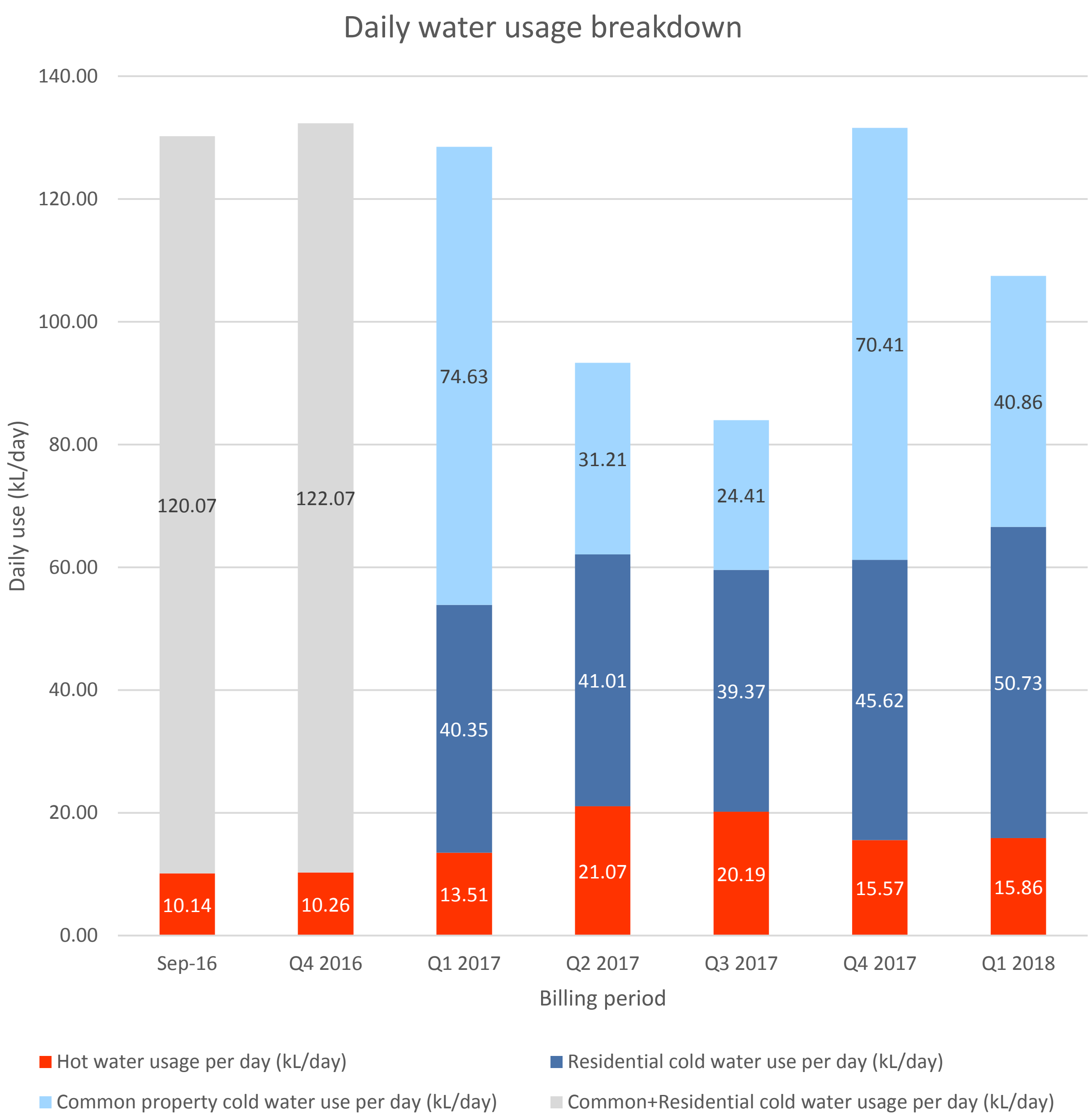


Figure 4: Daily water usage as reported by QUU bills

Table 3: Bills received from QUU

Bill period	Billed usage (kL)	Charge
5/9/16 to 19/10/16	446	$1849
Q4 2016	941	$3902
Q1 2017	8197	$34388
Q2 2017	4653	$19564
Q3 2017	4014	$17089
Q4 2017	7910	$33723
Q1 2018	4878	$33723

Differentiation between residential and common property cold water use before Q1 2017 is not available, as Queensland Urban Utilities charged for a reduced quantity of water in the first two bills.

Common property cold water use can be seen to vary greatly between Q3 2016 and Q1 2018. This pattern does not follow the expected usage profile for water assets at Jade.

A gradual crest in hot water use was observed during the winter months of 2017. Following this, slight rises in residential water use were observed in Q4 2017 and Q1 2018.

The seemingly random peaks and valleys of common property cold water use would suggest that there is not a steady leak contributing to the majority of unaccounted usage. In contrast, the steady rise in residential hot and cold water use over the period where occupancy increased suggests that these meters are accurately measuring residential water use. The possibility that the unaccounted use is a result of under-reporting by these meters can be discounted.

Manual readings

Table 4: F8161 Manual readings since last utility bill (including residential use)

Date	Meter read (kL)	Difference (kL)	Daily use (kL)
13/04/2018	66929	-	-
18/04/2018	67655	726	145.20
30/04/2018	69460	1805	150.42
1/05/2018	69649	189	189.00
9/06/2018	75252	5603	143.67
10/06/2018	75417	165	165.00

Manual meter readings exhibit the same erratic usage pattern characterised in the previous billing periods. As of 30/07/2018, the main meter has been removed by Skilltech (on behalf of QUU) and further measurements cannot be taken until it is reconnected.

Table 5: F1861 Overnight main meter readings for 10/06/18

Date	Time	Meter read (kL)	Difference (kL)	Hourly rate (kL)
9/06/2018	6:30	75252	-	-
9/06/2018	9:30	75274	22	7.33
9/06/2018	12:30	75299	25	8.33
9/06/2018	15:30	75320	21	7.00
9/06/2018	18:30	75343	23	7.67
9/06/2018	21:30	75364	21	7.00
10/06/2018	0:30	75384	20	6.67
10/06/2018	3:30	75400	16	5.33
10/06/2018	6:30	75417	17	5.67

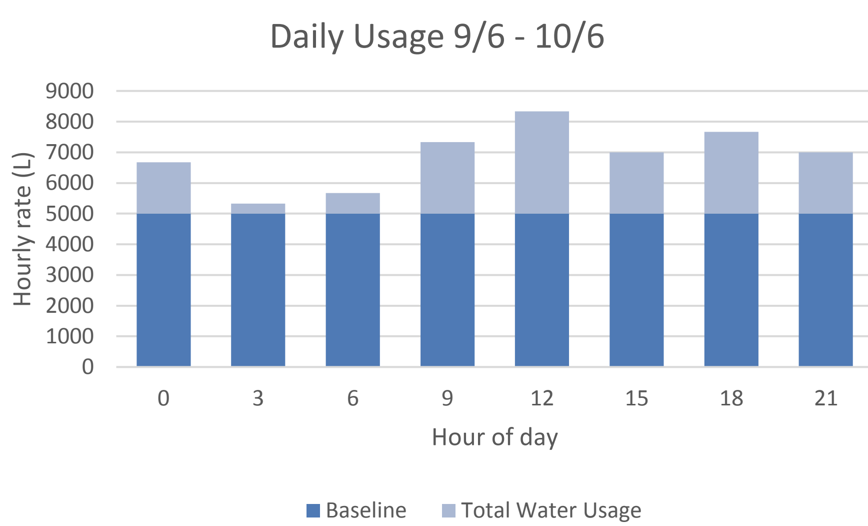


Figure 5: Daily usage profile (main meter readings)

An overnight meter reading on 10 June 2018 showed a high degree of flow being metered during hours when the flow is expected to be at its minimum, with a baseline of approximately 5kL/hour. Over a 24-hour period, this minimum flow rate amounts to 127.9kL/day, which is in the same order of magnitude as the unaccounted-for common property usage of 112.4kL/day in March 2018.

This minimum flow rate does not correlate with that of the ultrasonic flow tests, which gave the minimum flow rate at 0.72 to 1.08kL/hour during daytime hours.

Daytime use above this minimum flow is between 1.77 and 3kL per hour, or 42.48 to 72kL per day. This usage is similar to expectations for average residential water use (hot and cold) of 40 to 66kL per hour from Figure 4.

3.5 Leakage assessment

Except for a few small pipes leading to the garden taps, there are no buried cold-water pipes. These pipes are visible throughout the two basement car park levels. In the above-ground sections the pipes are accessible through hydraulic cabinets.

No leaks from these pipes have been detected after site visits by Hutchinson Builders and a leak detection plumber engaged by Scott Pike, the previous building manager. An earlier leak was detected and rectified in Q1 of 2017.

3.6 Water meter test

Queensland Urban Utilities agreed to perform a test on the main water meter to judge if it is measuring flow to an acceptable degree of accuracy. The test is to be conducted by Skilltech, who collected the meter on 30 July 2018. At the time of writing, Skilltech and QUU have yet to report on the results of this test.

3.7 Efficiency assessment

Where appropriate, water-saving tap fittings and toilets are in use. Pool water loss is only via evaporation, and the spa is drained and re-filed weekly. Water use in the street park is not charged to Jade Albion. Gardens are hand-watered, and no sprinkler system is in use.

Rainwater collection would help reduce water use for gardening. An appropriate location for rainwater collection and storage would be on the south edge of Sage, near the Jade Common garden. Rainwater piping on the exterior of the building could be routed into this tank, with overflow running into the nearby stormwater pipes.

Small leaks were observed during site visits. On 13 July 2018, water was observed on the floor underneath the basement staircase and beneath the ground level carpark ramp. The source of this water is being investigated by Shaun Beck of Hutchinson Builders.

On the same date, a fire hose in the second level basement was observed to be leaking as a result of damage and/or tampering. These hoses will need to be checked periodically to see if any further damage occurs and ensure that they meet fire safety standards.

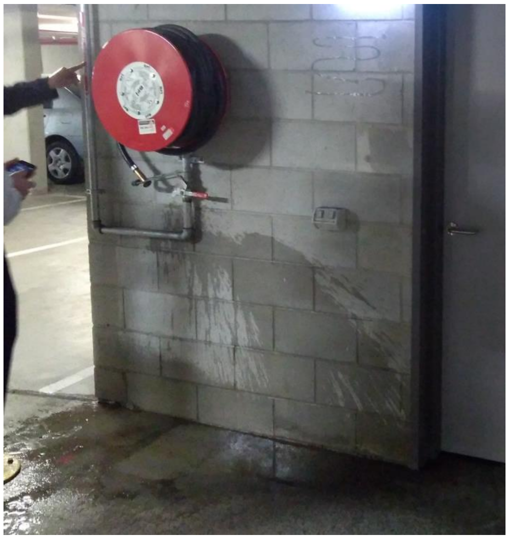


Figure 6: Leaking fire hose

3.8 Water investigation conclusions

The analysis of billing data and meter readings, along with site visits and information from Hutchinson Builders, suggest that the most likely cause of the excessive billing is a fault with the main water meter. Follow-up from Skilltech with meter test results will provide further insight into the problem, and suggest next steps for dispute resolution.

Existing water-saving fittings and procedures meet a high standard of efficiency, and no major changes are necessary to further reduce water usage.

4.0 Energy Efficiency

This section considers existing common property energy assets in Jade, and identifies opportunities for cost-saving investments. Where opportunities exist, project proposals are offered for consideration.

At present, approximately 265 of the available 369 apartments are occupied. It is expected that residency will gradually rise over time, increasing energy usage for both individual apartments and common property.

A number of assumptions and best estimates are made when calculating asset energy usage. Where possible, wattage data has been gathered from plant plates and datasheets. Duty cycles are estimated from expected usage patterns and information collected from building maintenance and management staff.

Where billing figures are provided, these include GST unless otherwise stated.

4.1 Energy bill summary

Energy bills show an average common property usage of 887 kWh per day, with some spikes observed during construction and upgrade works at Jade. Increased occupancy in the future can be expected to positively impact common property energy bills. It is recommended that consumption be analysed again after 12 months to observe how occupancy affects common property energy use.

Jade uses an embedded electrical network, where power is purchased in bulk from the utility and on-sold by the network manager. Each apartment is billed individually based off readings from electronic, networked power meters, significantly reducing meter reading costs compared to analogue electricity meters.

Electricity supply is managed by Jade Utility Management Rights (Jade UMR – the embedded network manager), who on-sell energy for both common property and residential use at a price of 28.6 cents per kilowatt hour. The average rate in this area is between 26.7 and 30.6c/kWh [6]. Common property energy use for the last year of available bills amounted to $146,917. This figure can be expected to rise with greater occupancy and increasing energy costs over time. With full occupancy, common property energy bills can be expected to cost $190,443.

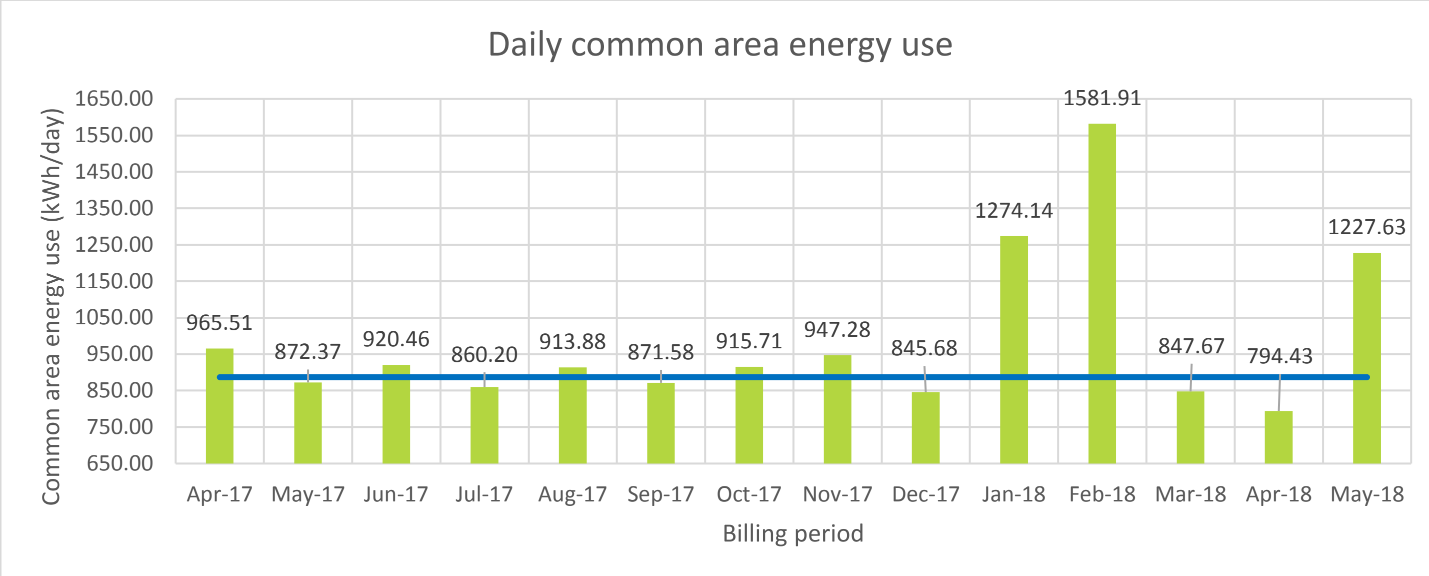


Figure 7: Daily common property energy use as shown on Jade UMR bills with baseline

4.2 Load profile

Common property energy assets account for 39% of the total power supplied to Jade, with the remainder accounted for in residential use. Residential power use is estimated using data from comparable buildings. The majority of common property energy use is consumed in lighting (65.7%), with basement carpark lighting using 49.1% of the total.

Figure 8: Overall load profile

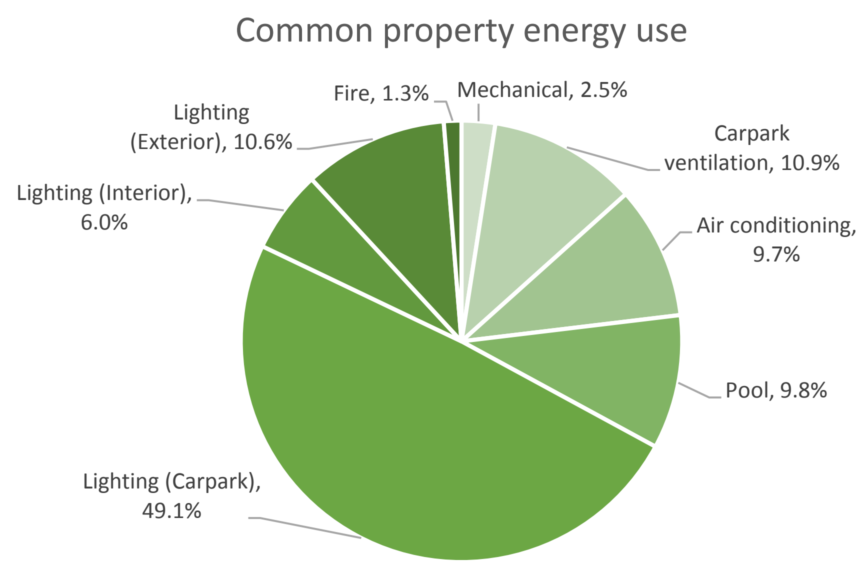


Figure 9: Estimated common property energy usage

4.3 Existing energy assets

Mechanical systems

Seven Schindler 3300AP elevators are used for apartment access, with two in each building except Sage, which has one. One of the lifts in Fern was observed to be inactive during site visits. These residential elevators have a high degree of energy efficiency, receiving an 'A' class rating, the highest possible, using the VDI 4707 standard for energy efficiency in passenger lifts [7].

A Safetech freight hoist connects basement level 1 to ground level for refuse transfer.

Depending on the type of elevator system in use, energy usage can vary widely. Energy-saving characteristics of elevator systems include:

- **Regenerative drives:** These capture energy that would otherwise be lost when the elevator descends and brakes, and feed it back into the local network [8].
- **Gearless, variable-frequency traction drives:** These adjust motor speed and torque to better match elevator load [9].

- **Machine room-less:** Modern elevator systems for low and medium-rise buildings can integrate the motor and traction systems within the same space as the elevator, eliminating the need for plant rooms and reducing hoist length and weight.
- **LED lighting inside lift:** The longer lifespan and lower energy consumption of LED lighting helps to reduce maintenance and energy costs.
- **Standby mode:** Controls, lighting, and inverters can enter a low-power state while the elevator is not in use.
- **Lightweight construction:** Lower weight means less work for the motor, and greater energy savings.

The Schindler 3300AP elevators installed at Jade include all these characteristics, and no additional controls or upgrades are recommended.

For high-volume lifts, destination control technology can improve efficiency for both transit time and energy use by optimizing passenger routing [10]. These systems make the best use out of elevators by determining which destination each passenger needs to reach before they enter the lift. This technology is best suited for large commercial buildings with significant foot traffic, and would not offer a great deal of savings for Jade.

Two sliding security gates are located in the first level basement carpark around the perimeter of the visitor parking area. These operate frequently to allow entry and exit to residential parking bays. Centurion D5 and D10 motors regulate their operation. These do not provide a significant impact on overall energy use at Jade, and are not considered for efficiency upgrades.

Table 6: Mechanical system energy usage

Mechanical system	Yearly energy use	Portion of total	Yearly cost (inc. GST)
Residential lifts	6,859 kWh	2.1%	$1,962
Freight hoist	750 kWh	0.2%	$215
Security gates	438 kWh	0.1%	$125

Carpark ventilation

The carpark ventilation system consists of several separate ducts located along the perimeter of the basement levels. 17 Fantech Axial Flow fans are installed throughout these ducts, each with power ratings to suit the volume of air they need to move. ABB variable speed drives (VSDs) control their operation, which are triggered by carbon monoxide (CO) and smoke sensors. Some degree of natural ventilation is also present through the vehicle entrance and north stairwell.

HVAC systems are designed for peak load, and typically oversized to allow for future or unexpected loads [11]. VSDs help to improve energy efficiency by adjusting fan output to match demand, providing only the volume of airflow required for ventilation. With the addition of CO sensors, demand can be accurately determined as a function of CO present in the ventilation ducts. This allows the HVAC system to automatically assign operating hours, rather than relying on timers, which reduces overall duty cycle.

The ventilation system in place is very energy efficient thanks to its bespoke design and inclusion of sensors and VSDs, and requires no additional investigation for upgrade or replacement at this time.

Figure 10: Duct smoke sensor

Figure 11: Variable speed drive control systems

Table 7: Carpark ventilation energy usage

Ventilation system	Yearly energy use	Portion of total	Yearly cost (inc. GST)
Fantech Axial Flow (x17), 1.5kW – 5.5kW	35,624 kWh	10.9%	$10,188

Air conditioning

A small number of split system conditioning units are installed for common property use.

Each of the four refuse rooms in basement level 1 are serviced by a LG Inverter V split-system unit, which were observed to be powered down when the rooms were not being accessed. Two LG multi-type air conditioners are installed for common property use – one for the site office, and one for the gym room.

The inverter-type air conditioning systems presently installed offer superior energy savings compared to fixed speed systems, and can vary their power usage to match output settings [12].

No upgrades are recommended at this time, but if replacement is needed in the future, Panasonic brand split-system inverters are noted to be the most energy efficient air conditioners of those on the market [13].

A degree of seasonal variance is expected for air conditioner use, so the energy use values below are averaged for all seasons over a 12-month period.

Table 8: Air conditioning energy use

Air conditioning unit	Yearly energy use	Portion of total	Yearly cost (inc GST)
Office: LG multi-type Inverter V, 11200W	12,264 kWh	3.8%	$3,508
Gym: LG multi-type Inverter V, 15500W	16,973 kWh	5.2%	$4,854
Refuse rooms (x4): LG Inverter V, 3500W	2,517 kWh	0.8%	$720

Car wash

A MONO 180W water pump services the car wash faucet. Under the expected use conditions at Jade, this is estimated to account for 0.04% of building energy use, costing $38 annually.

Pool

Two AstralPool BX water pumps are active for 15 hours per day to service the pavilion pool and spa. No heating is provided to the pool, and the spa heater runs for 21 hours a day. Water levelling and sanitization are managed electronically.

Pool energy usage can be expected to vary between seasons. The figures below are averaged over a 12-month period.

Table 9: Pool energy use

Pool asset	Yearly energy use	Portion of total	Yearly cost (inc. GST)
AstralPool BX 1.5 pool pump	9,006 kWh	2.8%	$2,576
AstralPool BX 2.0 pool pump	11,114 kWh	3.4%	$3,179
Spa heating	11,498 kWh	3.5%	$3,288
Automated levelling and sanitization	456 kWh	0.1%	$130

BBQ

Two 3600W Christie Parksafe electric barbeques are accessible to residents. These have been observed to have a low utilisation, and a negligible impact on overall energy use.

Fire

AMPAC fire brigade panels are located near the entrances of each building except Lotus, where the main fire brigade panel is located. These are low-power devices and do not contribute significantly to energy bills at Jade, accounting for 1.3% of total power usage.

Lighting

Lighting at Jade is the largest common property energy asset, accounting for 65.7% of common property energy bills. Exterior lighting is provided primarily by LED bulbs, which are switched on by the detection of low ambient light by photoelectric (PE) cells, and switched off by timers. Exterior lighting timers are noted to have been recently adjusted by an electrician in late August.

Six 400W low bay fittings are installed at the carpark entrance to ease the brightness transition between the road and basement for driver safety and comfort, which use 21,024 kWh per year for an annual cost of $6,013.

Figure 12: Car park entrance 400W low bay fittings

Lighting for apartment corridors is supplied by 12W LED bulbs arrayed to motion sensor banks.

The majority of lighting costs come from the fluorescent battens installed throughout the carpark area, which are frequently switched on and off by motion sensor banks. In addition to the power costs associated with the high duty cycle, the frequent switching is a cause for early failure, increasing maintenance costs [14].

Table 10: Lighting energy use

Lighting area	Yearly energy use	Portion of total	Yearly energy cost (inc. GST)	Yearly maintenance cost (inc. GST)
Car park	160,597 kWh	49.1%	$45,931	$11,540
Interior	19,710 kWh	6.0%	$5,637	-
Exterior	34,571 kWh	10.6%	$9,887	-

An upgrade to the carpark lighting system has been investigated, with the recommendation to replace the existing fluorescent tubes with LED battens on individual sensors. Section 4.4 covers this topic in greater detail.

Domestic hot water (DHW)

Hot water is supplied to Jade residents by Rheem 6-star continuous flow gas water heaters [15]. These activate according to demand, firing the burners when stored hot water drops below a given level. Gas supply is provided by Origin Energy, with residents billed directly based on hot water meter readings.

Figure 13: DHW heaters and storage

Using hot water meter data provided by Queensland Urban Utilities, DHW is estimated to cost residents of Jade $116,470 annually at present occupancy, and $162,179 with all apartments utilised. Improvements to water heating costs are possible with the inclusion of more efficient electric heat pump water heaters. Discussion on this upgrade is presented in section 4.4 below.

4.4 Opportunities for cost-saving investments

Most energy assets at Jade operate at a high degree of energy efficiency. There are two main areas where opportunity exists for improvement, being the carpark lighting and domestic hot water systems.

Carpark lighting upgrade

The currently installed carpark lighting uses fluorescent bulbs connected to sensor banks which regulate their operation. The sensor system switches on several fluoro battens at a time, including some that are not required to illuminate the area being travelled through. This increases the overall duty cycle of the system, which in turn increases energy costs. The additional switching also impacts the lifespan of each bulb, necessitating frequent replacement and producing significant maintenance costs.

Two upgrade options are available to reduce these costs:

1. Replace existing fittings and sensor system with EnLighten Vico battens [16]
2. Refit existing battens with LED tubes

Option 1 offers the greatest energy savings, with an annual reduction of 114,470 kWh. This reduction is thanks to the reduced wattage of these fittings, and the individual motion sensors which ensure that only the areas in immediate need of lighting are illuminated.

Option 2 also offers significant energy savings of 91,770 kWh per year. These LED tubes use less energy than both the fluoro tubes and the Vico battens, but operate at a higher duty cycle due to the reliance on motion sensor banks.

Both options will reduce maintenance costs as LED lighting is less susceptible to early failure from frequent switching. Maintenance costs will be higher for option 2 than option 1, as the sensor banks will switch more of these lights on at times when they are not directly needed.

Table 11: Carpark lighting upgrade comparison

Upgrade option	Investment cost (inc. GST)	Total yearly savings	Payback period
Option 1: Vico battens, individual sensors	$105,763	$32,738	2.4 years
Option 2: LED tubes, sensor banks	$48,063	$26,246	1.4 years

Option 2 provides the fastest payback period at 1.4 years thanks to the lower investment cost and significant energy savings over the existing fluorescent lighting. Option 1 requires greater initial investment but is offset by the superior energy savings offered by the individual sensor system.

There is variation in the product lifespan between both options. LED tubes can be expected to last between 30,000 and 50,000 hours, whereas the Vico battens are rated to last over 60,000 hours. Consideration to future replacement needs should be factored in when comparing the available upgrade options.

Heat pump hot water system

Heat pump DHW systems are more energy efficient than the best gas or electric heaters, as they draw heat from the surrounding air to feed into the tank [17]. A replacement hot water system using only heat pumps is considered here.

Table 12: Domestic hot water system comparison

Heating system	Yearly energy use	Energy rate	Annual heating cost (inc. GST)
Gas	2,421,414 MJ	$0.048/MJ	$116,470
Heat pump	141,249 kWh	$0.286/kWh	$52,516

A heat pump upgrade project could be expected to cost $278,300 (including rebates), and save around $63,954 annually for a payback period of approximately 4.4 years. Jade residents will be the beneficiary of this upgrade project rather than the body corporate, as there are no common property hot water assets in use; DHW is supplied only to apartments.

The upgrade from gas to heat pump DHW setup will have flow-on effects to other aspects of building management. Gas for hot water is currently charged to residents directly, using apartment hot water meter readings to calculate billing. These same meters could be used to bill residents individually for hot water supplied by the heat pump, but alternate arrangements will be needed to read the meters and charge for electricity instead of gas. If these arrangements are not made, hot water will change from being a residential expense to a common property expense.

The drop in overall gas supply will not trigger an increase in cooking gas prices to residents, as gas is not purchased in bulk at Jade as for electricity.

Heat pump DHW systems heat water at a slower rate than continuous flow gas systems. When the ambient air temperature is low, at night or during winter months, electric boosting elements are activated to make up the difference. This energy use is accounted for in payback calculations.

Replacing the gas hot water system with electric heat pumps will also have implications for electric vehicle charging, which are covered later in this report.

4.5 Energy efficiency conclusions

Most energy assets in Jade utilise energy-efficient components and controls, and will not require attention when considering cost-saving investments. The key exception to this is the carpark lighting system, where a significant opportunity exists for reductions to common property energy usage.

The two upgrade options presented each allow for large savings in the near and long term. Refitting the existing battens with LED tubes gives the fastest payback, but retains the issue of frequent switching by sensor banks. Replacing the fittings with LED battens and individual sensors saves the greatest amount of energy and limits their duty cycle to only what is required.

A switch from gas to electric heat pump DHW will save a great deal in water heating costs, but with some caveats. The body corporate will not receive the benefits of this lower heating cost directly, and changes to billing arrangements will need to be made to properly allocate DHW costs.

The quantity of energy saved for either carpark lighting upgrade has the possibility of improving a NABERS rating from the pre-assessment value of 5.5 to the maximum of 6. Replacing the gas DHW system with a heat pump alternative will save energy and money for the building overall, but as the electric heating costs will become a body corporate expense, the NABERS rating may drop by half a star.

5.0 Electric Vehicle Charging

This section provides background information on Electric Vehicle (EV) charging for residents and the benefits of preparing Jade Albion for future infrastructure needs. It allows the Owners Corporation to reach a conclusion on questions such as how to bill owners for charging their Electric Vehicles, which location is the best to put the charger, how to set it up, what type of charging equipment should be used and what to do once the building gets near to the maximum number of Electric Vehicles before overloading the common area power supply.

Using resident survey results to estimate current and future electric vehicle ownership rates, it is expected that EV charging may cause issues for common property power supply by 2021. It is likely that, in the absence of formal arrangements or by-laws, current EV owners at Jade are able to use spare carpark power sockets to charge their vehicles using common property power. This report makes recommendations on how to plan ahead for EV needs and arrange suitable billing for charging.

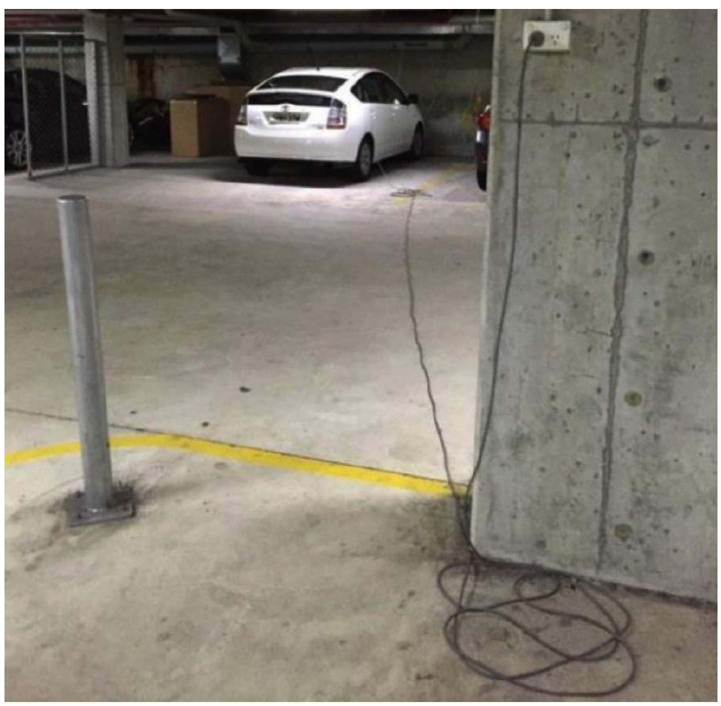


Figure 14: Example of EV charging using standard 10 Amp power socket

General information on EVs and their characteristics is provided in the Appendix.

5.1 EV survey results

Tenants of Jade Albion were surveyed on their interest and preferences for electric vehicle charging in July of 2018, with survey open for two months [18]. Of the 235 tenants contacted there were 37 who completed the survey, a response rate of 15.7%.

The results of note are:

- 76% of respondents are in favour of installing EV charging facilities.
- 5% of respondents already have an electric vehicle (11 total), with 41% more planning to own one in the next ten years.
- Individual charging facilities are preferred, accessible only to Jade residents.
- 42% of respondents are interested in a user-pays system, and 48% prefer a service paid for by strata (Note: The majority of residents at Jade are tenants, who would not be liable for increased strata levies).

These survey results are the best place to start when planning for EV charging, and are offered as a free service by Wattblock if participants are happy to share the results with local councils to assist in city planning.

Additional survey responses may be forthcoming from apartment owners and owner-occupiers should the owner's corporation agree to forward the survey link to these parties.

5.2 Electric vehicle charging options

Most electric vehicle vendors sell a variety of chargers that can be purchased along with the vehicle. Different electric vehicle brands tend to have their own proprietary connection nozzles. There are also third parties who offer charging equipment with adaptors for different vehicles.

Electric vehicle chargers are rated based on the amount of electrical current, measured in the Amperes (Amps) they deliver to the vehicle. The larger the current, the faster the vehicles battery will charge up. The energy stored in the batteries is measured in kilowatt hours (kWh), and 1 kWh of stored power will deliver approximately 5-6kms of driving range for a typical electric vehicle in normal driving conditions. Car chargers generally convert alternating current (AC) from the source into direct current (DC) to charge the cars battery.

Table 13: EV Charger levels [19]

Type	Amperage	Charge Rate	Range / Hour
Level 1	10 Amps	1.5 kW	7-10km
Level 2	16 Amps	3.3 kW	15km
Level 2	32 Amps	7.6 kW	30km
Level 3 (Super Charger)	100 Amps	23.8 kW	94km

Level one: standard 10 amp charging adaptors

The most basic chargers on the market are designed to be safely plugged into standard 10 Amp power outlets. 10 Amp power outlets are commonly provided in basement carparks for using vacuum cleaners. Standard electrical extension cords will also work with these basic EV charging adaptors. Charging vehicles at 10 Amps can be a very slow process. A 10 Amp charger will deliver 1.5kW of charge per hour, which is equivalent to about 7-10 kms of driving range.

Level two: wall mount solutions (16-50 Amps)

Common faster charging solutions on the market are in the 16-50 Amp range, single phase. They are usually fitted on a wall and require installation by a qualified electrician. These are usually sufficient to meet the needs of private overnight charging. Wall mounted chargers are sometimes referred to as "Electric Vehicle Service Equipment" (EVSE). There are higher capacity 'super charger' solutions (eg 100 Amp) also available on the market. However, it should also be noted that charging rates can also be limited by vehicle model as well as the charger.

DC fast charging (3 phase)

More suitable for public charging stations or shared charging facilities these systems can deliver 80% vehicle charge in 20-30 minutes by converting high voltage AC power to DC power for direct storage in EV batteries. Installing DC Fast Charging is a capital-intensive project costing $20,000 to $100,000 depending on power availability at the site. These systems can also have a huge impact on peak energy demands when in use which can drive up energy supply charges. In most residential strata schemes DC Fast Chargers will not be viable.

Besides basic charging equipment, further technology exists to assist with power management. Usually a combination of hardware and software technology, these solutions can smooth energy loads from larger numbers of electric vehicles to avoid overloading power boards. Furthermore, these types of solutions can also include integrated metering and billing services. These are important considerations for high density strata schemes.

5.3 EV charging incentives

Not all residents are interested in driving an EV in the future, but there are benefits to both residents and the body corporate in preparing for EV charging needs:

- Increase in property valuation of all apartments in a block which is EV charging ready.
- Increase in rental income and more attractive for green minded residents
- Reduce emissions from combustion engines in enclosed basement carparking for all residents

Barriers to introducing EV charging in residential strata include:

- Capacity and physical space limitations of power distribution boards
- Cabling distances and access
- User pays considerations

5.4 Location of charging equipment

EV charging stations could be installed in parking spaces around lift entrances for shared use or at residents individual car parking bays for private use. By-laws and formal processes should be set up for the Owners Corporation to govern usage, payments, charger capacities, installation and de-installation depending on the decisions made about where to locate the charging stations. Installing a publicly-accessible charger in the visitor parking area will also impact availability of existing visitor car spaces and will require local council approval for a change of use. In addition, the use of shared charging is less convenient for residents. According to the survey results there is an overwhelming preference for individual charging facilities.

Connection to tenant meters versus common area

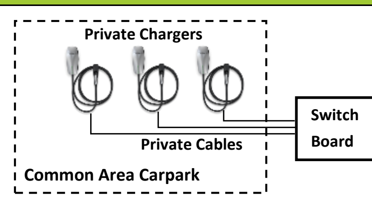
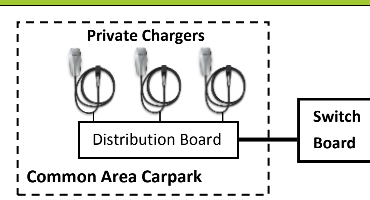
Connection of an electric vehicle charger to a tenant’s own apartment meter generally has the benefit of being able to directly pay for and monitor the electricity usage. Depending on the set-up proposed and location of meter rooms the set-up can be expensive. It may be necessary to apply for a revenue grade meter installation from the network operator, which will all require Body Corporate involvement to review and approve each installation.

Connection to the common meter board is usually more economical in terms of both installation costs and on-going electricity usage costs. In the longer term with increasing EV adoption this offers the best value to owners and tenants and may be easier for the Owners Corporation to effectively manage. Apartment blocks with more than 20 units typically will need an EV recharge solution connected on common power.

Electric vehicle charging solutions and setup arrangements

EV owners can charge their vehicle using common power sockets or set up a private charger on their carspace. There are different types of set up arrangements and the benefits and drawbacks of each are summarised below.

Table 14: EV Charging Solutions and Set Up Arrangements

	Common Area Power Socket	Private Charger With Private Cable Connection	Private Charger With Shared Cable Connection
Conceptual Diagram			
What is it?	Use existing power socket with extension cables or install new power socket and connect to either residential or common area electricity boards based	Install EV charger in private carspaces and connect to existing electricity boards via private cables Use either the residential or common area electricity boards	Owners Corporation set up new common electricity boards and shared cabling throughout all carpark levels, making the building EV ready

	on the lowest set up cost option	based on the lowest set up cost option	Residents can connect the 'last mile' of cabling into their individual car space
How to bill for charging Electric Vehicles?	Install a new electricity sub-meter behind power sockets. Requires administration (reading & billing) or, Flat-rate annual fee based on driving distances (see appendix 8.5). Billing not required if the charger is connected to residential metering	Install a new electricity sub-meter behind the private cable. Requires administration (reading & billing) or, Flat-rate annual fee based on driving distances (see appendix 8.5). Billing not required if the charger is connected to residential metering	Install EV charger with smart meters and engage a third party billing service ($30/month) to reimburse electricity costs to the Owners Corporation. No additional administration for strata management. DIY billing off individual meters by building manager
Who pays for set up costs?	EV Owners Est. Set Up Cost Per Socket: $0 - $1,000	EV Owners Est. Set Up Cost Per Charger: $1,500 - $8000	EV Owners & Owners Corporation Est. Set Up Cost Per Charger: $500 - $1,000
Who should use this solution?	Small apartments and inter-mediate solution for larger buildings Proven to be successful in Canada	Small apartments and inter-mediate solution for larger buildings Provides faster charging speeds in comparison to using power sockets	Long term solution for large apartment buildings Owners benefit from increased rental return and property valuation uplift Increased adoption rate for EV as its easy for residents to set up a charger at home
Drawback	Additional administration cost for billing to Owners Corporation Difficult to manage a large number of meter readings Slow charging speed	Capacity in existing electricity boards can only accommodate a limited number of EV chargers Difficult to manage a large number of meter readings	Capital spending for Owners Corporation

5.5 Carpark layout

Basement level 1 has 147 car parking spaces for residents and 54 visitor spaces, and basement level 2 has 244 spaces. Both include some double length spaces for apartments with multiple vehicles. Residential parking is securely separated from visitor parking by key-fob activated sliding gates.

Several 10A power sockets are located throughout the carpark and are accessible to all residents. These are connected to common property meters and charged to strata. Figure 16 shows the location of these sockets in basement level 2.

5.6 Energy supply and distribution

Power supply into Jade is serviced by two 1000kVA transformers, each connected to an 11kV supply from Energex. The main switchboard is located in the south-west corner of the basement carpark, with several distribution boards situated near building lifts. The below diagrams show the layout of the main switchboard connections with spare capacity highlighted, and position of distribution boards in basement level 1. An electrician is required to identify whether all slots can be used for slow or fast charging without overloading the board, and to determine the suitability of lift-adjacent distribution boards for inclusion of EV charging connections.

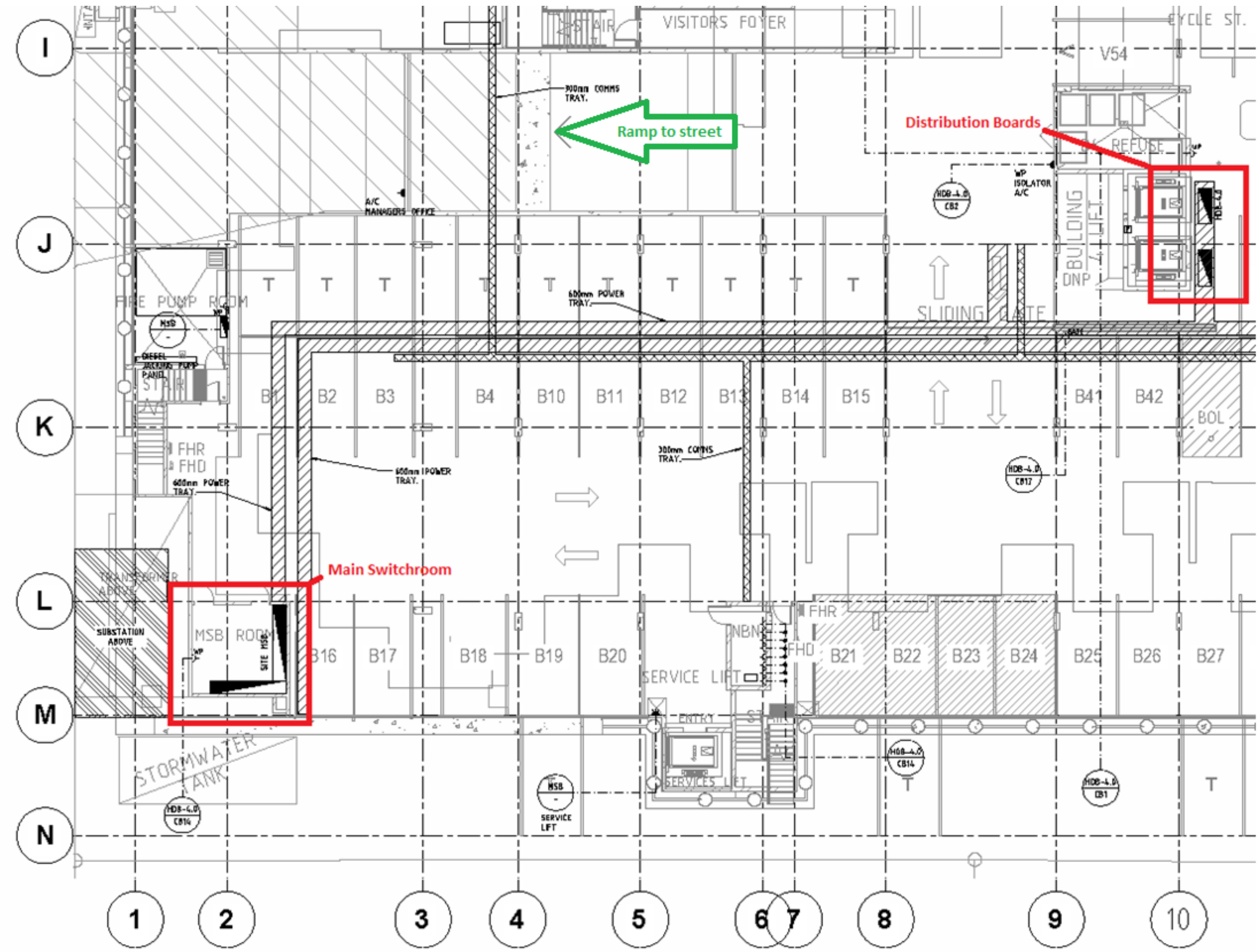


Figure 15: Basement level 1 MSB and distribution boards (Bld 4 lifts)

Figure 16: Basement level 2 carpark layout, common area 10A sockets marked by green squares

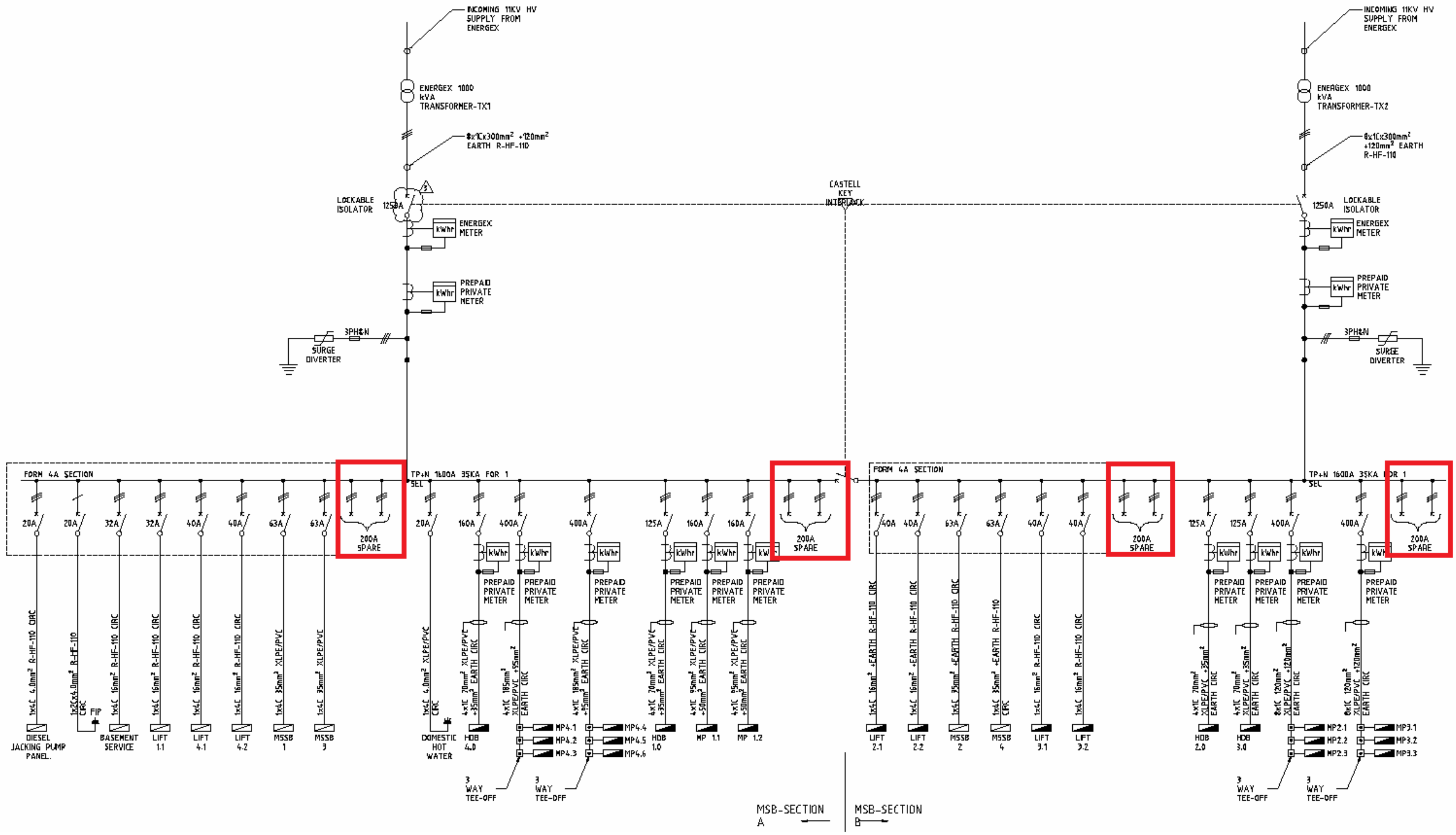


Figure 17: Supply and main switchboard, spare capacity highlighted

5.7 Risks of overloading common power

Unchecked and unmanaged, the installation of EV charging equipment in the building may be limited and the maximum threshold depends on two factors:

- Capacity of main switchboards and sub-boards in the carparking levels
- The speed used for charging the EV, which is related to the amperage used for charging. Common power sockets have the slowest charging speed of 10 Amps, while private EV chargers range from 16 Amps to 100 Amps. EV owners often prefer the use of 32 Amp charging as it is practical and convenient.

Based on our on-site assessment for the common area switchboards and the EV survey results:

- Your building has **11 Electric Vehicles** today and the number will grow to **108 by 2028.**
- Your building could **currently support charging for 25* Electric Vehicles at 32 Amps** before disrupting common area power supply. Overloading of common power supply could become a problem by 2021.

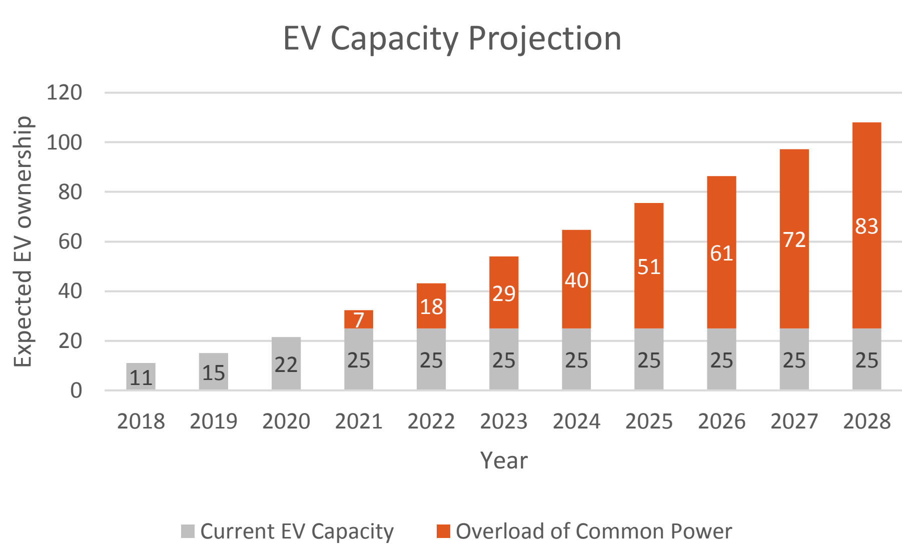


Figure 18: EV Capacity Projections for Jade Albion

*Prior to installation of EV charging for a large number of residents, an onsite capacity analysis conducted by a qualified electrician is recommended. Please contact Wattblock for further information.

5.8 Increasing Capacity for Electric Vehicle Charging

There are several ways to increase the capacity for EV charging in your building. Careful consideration for the options below can help to identify the most cost-effective way to implement EV charging solutions for residents.

1. Limit charging speed to 16 Amps or lower.
2. Run energy efficiency projects within the building (e.g. LED lighting) to reduce the baseload in the building and free up more capacity for EV Charging.
3. Install a solar system for charging Electric Vehicles.
4. Expand capacity of basement distribution boards.

Restricting Electric Vehicle Charging Amperage

For individual car spaces, electric vehicles can be left to charge overnight. For this reason, a high-powered supercharger is not an appropriate solution. The Owners Corporation may consider drafting a by-law to restrict the charging speed to 16 Amps or lower.

Driver preference is most commonly for 'Level 2' 32 Amp fast charging as this will typically take only 1.5 hours to charge an average driving distance of 50km per day. Restricting this to 16 Amps would effectively double the projected EV charging capacity before costly upgrades are needed. Such a restriction would also double the time required to charge for a typical daily driving distance to 3 hours. However, this should still be more than enough for the majority of drivers given vehicles can be left to charge overnight.

If restricting EV chargers to 'Level 1' 10 Amp chargers, note that this can be facilitated by existing 10 Amp power outlets. However, it can take 7 hours to charge up an electric vehicle for the typical driving distance. These power sockets can be used with an adaptor plug for slow charging if the by-laws permit. If this is not covered in existing by-laws and process, then EV owners may already be using these power sockets. The main limitation with using standard 10 Amp power sockets is that there are usually only a few of these available in the car park. Consideration could be given to providing more power outlets over time. If the existing power outlets are too far away from the desired carparking location, new connection points could be set up at a low cost if the plan allows for nearby circuit access. Installing more 10 Amp sockets is the cheapest way to set-up a carparking area for EV chargers. Furthermore, a simple user pays schedule can be put in place, although this would require some administration by the Owners Corporation.

Improving energy efficiency of other services

A reduction in common area energy use can free up capacity for EV charging without additional spending for infrastructure upgrades. LED lighting upgrades for the basement carpark levels provide the largest opportunity for reducing overall network load.

Implementation of a heat pump DHW system will **reduce** the common area capacity for EV charging, as it will change the energy source from gas to electricity, increasing load on the network. A heat pump DHW system would use an estimated 141,249 kWh annually on top of the current 384,153 kWh/year used by common property energy assets. This represents a 37% rise in electricity consumption, which would necessitate an earlier adoption of EV charging capacity management methods.

Installation of a solar system

The Owners Corporation may want to investigate the use of a solar system for charging EVs, which removes the power demand from common area power supply. However, this solution is only recommended for EV owners who often leave their cars at home during the day. EV owners who drive to work will not be able to utilise the solar power, unless a battery storage system is integrated. A dedicated circuit could be fitted to supply EV chargers directly with solar energy during the day if demand exists.

Power management solutions

Power management helps avoid the risks of larger numbers of EVs charging at the same time so that the main switchboard will not be overloaded. As mentioned in earlier sections, the typical daily driving distance in a city environment is about 50km and 32 Amps standard charging takes about 1.5 hours to complete charging your

EV. With power management this can be facilitated without restricting chargers to 16 Amps. Such solutions allow EV owners to connect their vehicle whenever they want.

Staggered Charging

One simplistic approach is to separate EV chargers into two or more circuits set up to charge on different time intervals. In-line timers can be used to stagger the charging cycles. For example, one group of EVs might charge for 30 minutes at a time overnight with 30-minute breaks, while a second group of chargers power on. This effectively doubles the maximum number of EV chargers with relatively minimal infrastructure cost. This can be achieved without a costly billing system if the Owners Corporation or Building Management is happy to administer a simple access charge fee.

Power Management Systems

A more advanced solution is to set up a third-party managed service with built-in power management functions. A smart power management system is capable of identifying the vehicles which have the highest priority of charging and supply power to those vehicles first. The use of power management charging stations can support up to **10 times** more vehicles charging simultaneously than a traditional solution by intelligently allocating power. The upfront cost of a charger with built-in power management functions is typically around $1,800 per charger. An on-going monthly service fee of approximately $30 will also be charged to EV owners to reimburse electricity costs to the Owners Corporation with no additional administration for strata management.

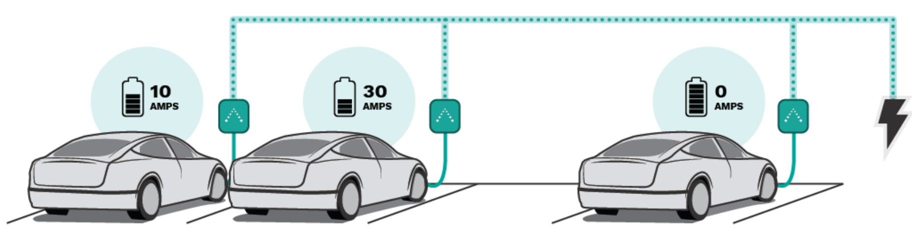


Figure 19: Power management of EV Charging [20]

5.9 Public EV charging stations

Private chargers are convenient for residents. However, public charging stations are also important for the increase of EV uptake in the future. Public charging stations have the following benefits for residents:

- Top up the vehicle, but not necessarily fully charging it
- Emergency back up and relieving range concerns of EV drivers

The public charging stations available near Jade are summarized in the map below. Additional information on the charging stations such as how many are available, detailed location inside the building, and whether it is a free charging service or user pays can be found on **https://www.plugshare.com/**.

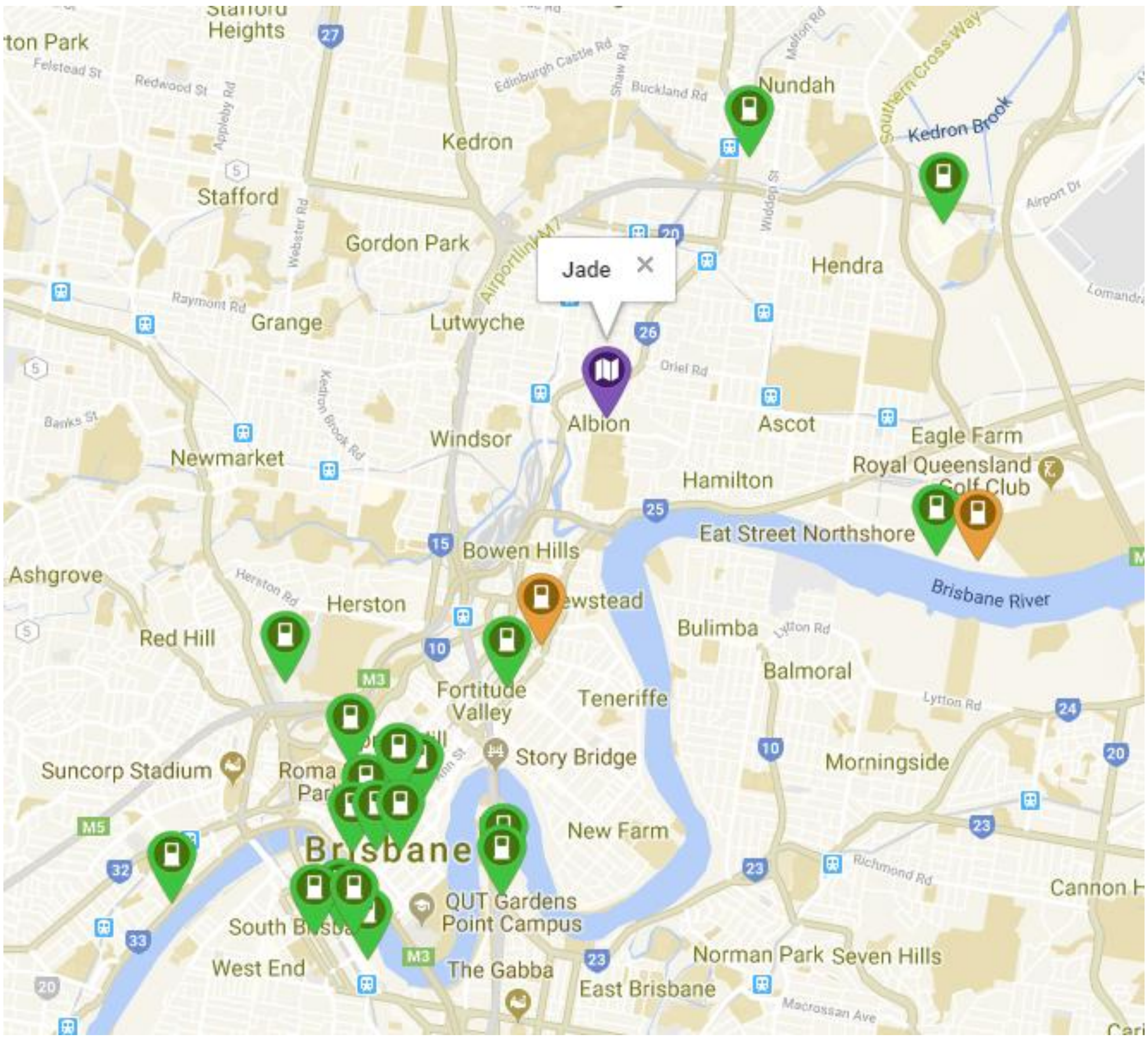


Figure 20: EV charging locations around Jade [21]

5.10 EV Charging Conclusions

EV adoption is set to increase rapidly in the coming years, which will place strain on Jade's existing electrical services. Unchecked, most EV recharging will tend to occur in the 'after work' hours when energy usage in the building is already at its peak. It is sometimes the case that people with EVs will utilise existing common area power sockets without a user pays agreement. In this case the power would be paid for by the Owners Corporation, which is not an ideal long-term solution.

Managed EV charging is the best long-term solution for apartment buildings. This can dramatically increase the number of vehicles that can charge and usually provides for a means of user pays based implementation.

Mitigating actions can lessen the need for an immediate EV charging solution. In particular, putting a by-law in force can limit the impact of individual charger installations. It is even possible to set up a simple interim user pays solution with or without individual sub-metering of EV chargers.

Should a lighting upgrade project be undertaken for the basement carpark, the overall electrical requirements at Jade will reduce significantly, allowing for more EV chargers to be installed before managed solutions are required.

Investment in switchboard improvements will likely not be needed until more than 25 EVs are owned by Jade residents. With power management, by-law restriction and energy efficiency initiatives this can be extended beyond 2028.

6.0 Solar Feasibility Study

Jade possesses a large unused area of rooftop space with very low shading, and is well positioned to make full use of the potential of photovoltaic (PV) solar power generation. This section considers options for solar systems with three scenarios presented and compared.

6.1 Rooftop area considerations

Brisbane has an average of 5.4 hours peak sunlight per day [22]. To achieve maximum power output, solar panels should be oriented and tilted to the north to best follow the path of the sun throughout all seasons.

Jade is oriented with an 8° azimuth to the east and possesses large north-facing roof sections. On each building, the rooftop is tilted towards central walkways. Buildings at Jade have two or more of these roof sections tilted at angles between 3 and 5 degrees from horizontal. The available roof space for each building and direction is given below.

Table 15: Rooftop area and orientation.

Direction of tilt	Lotus	Jasmine	Fern	Sage
North	503 m^2	203 m^2	347 m^2	-
East	100 m^2	238 m^2	-	240 m^2
South	625 m^2	241 m^2	354 m^2	-
West	-	-	-	354 m^2

6.2 Structural considerations

The rooftop is constructed of corrugated steel cladding in the Lysaght Trimdek style [23], resting on trusses above concrete slabs.

General structural considerations for this rooftop include:

- Ensuring that the roof, its trusses, purlins, connections, and other structural support members can support the array under building live load conditions.
- Ensuring that lag screws have adequate pull-out strength and shear capacities as installed
- Maintaining the waterproof integrity of the roof, including selection of appropriate flashing; and
- Ensuring safe installation of all electrical aspects of the PV array.

Additional structural considerations are covered in the following sections.

Wastewater stack vents

Sewage and wastewater plumbing at Jade uses a drain-waste-vent system, with several stack vents protruding above the roof. These vents are clustered towards the centre walkways and reach 30-60cm above the rooftop. Several dozen of these exist on each rooftop and restrict the area available for solar panel installation.

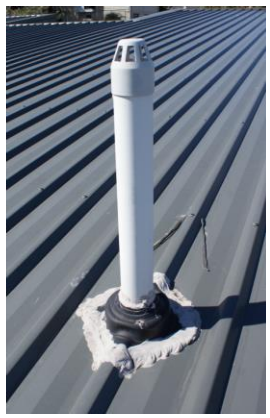


Figure 21: Stack vent

Reducing the height of these vents to fit under tilted panels would unlock additional rooftop space, and is considered in scenario 3. Adjustments to sewage and wastewater piping, including stack vents, requires the engagement of a licensed plumber [24].

Racking system and tilt frames

For a solar panel installation at Jade, a racking system would be used to support the panels above the steel cladding. The frame would be connected to the trusses underneath the cladding by means of a tin interface. Rubber pads may be needed to prevent galvanic corrosion between the interface and truss material. Non-penetrative frames are available but will not be suitable for this style of rooftop.

Much of the rooftop space is tilted away from north, for which tilt frames will be necessary to improve insolation for these sections.

Shading

Jade reaches the maximum height that its zoning permits (Zone MDR, medium density residential), and all surrounding buildings in this zone are of a lower or equal height. Housing on the rise to the east of Jade is distant enough not to cast shade on Jade rooftops in the morning.

Shading from rooftop air conditioning and hot water plant will impact panel location planning. Adequate space is needed to prevent power loss from this shading. During winter, the lowest angle of the sun in the sky at noon will be 39.12° from horizontal [25]. Rooftop air conditioning plant frames are approximately 1.8m high, casting a shadow 2.18m along the plant axis at this time of year. Any solar panels south of these frames should therefore be spaced out by at least 2.18m.

For shade-creating rooftop assets arrayed in a north-to-south direction, shading is a lesser concern as it would only reduce generation outside of peak sun hours where solar power generation will be minimal.

Wastewater stack vents will also provide shading and impact power generation. A spacing of 0.5m would be appropriate for panels southward of these vents.

Wind

Brisbane falls within wind region B (57m/s) [26]. Wind speed will be greater near to the edges of the roof, so additional space must be allocated around the edges to reduce strain on the racking fixtures. Wind speed will be a consideration for racking and tilt frames, contributing to the determination of spacing of rack-truss interfaces. A larger array situated closer to the edges of the rooftop will require stronger connections to the truss than a smaller array with greater spacing.

Cabling

The placement of the solar panels should also take into account the distance of the panels from the connection points into the distribution boards. There is a loss factor where power is transmitted over long cable runs. Each building has its own distribution board and electrical service rooms to house inverters at a minimal distance from the rooftop solar arrays.

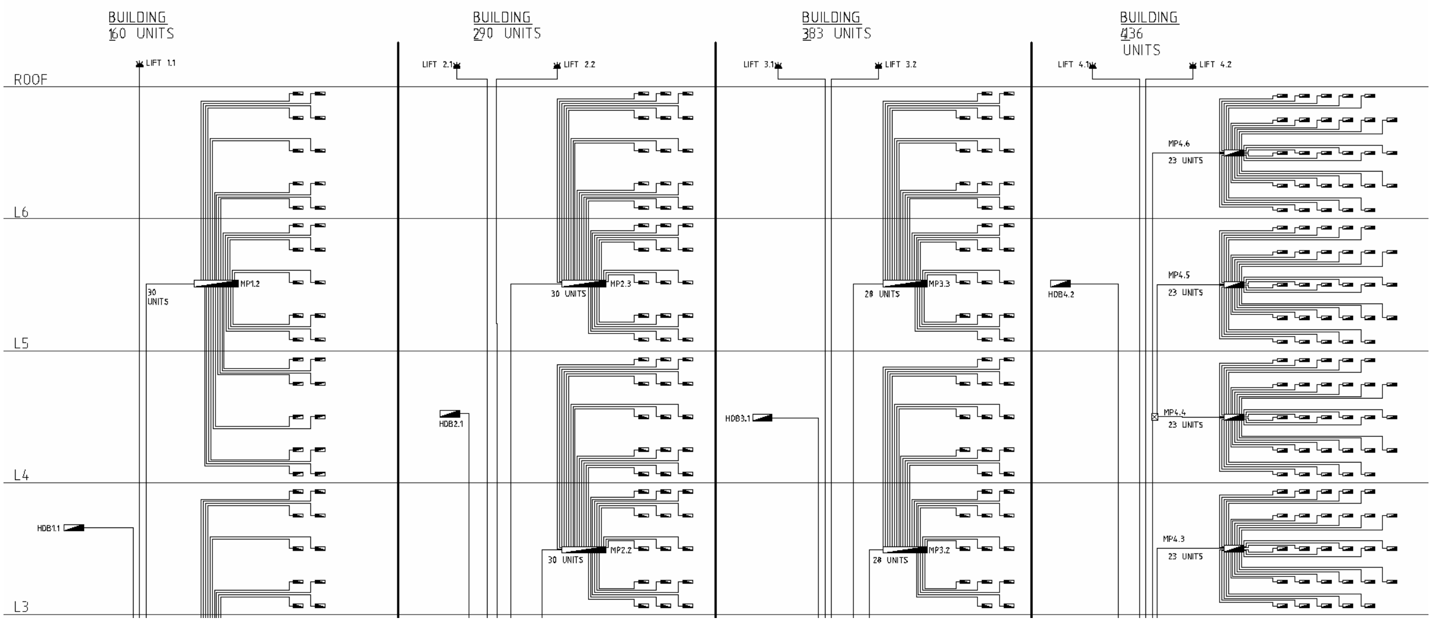


Figure 22: Positioning of distribution boards

Based on the optimal positioning of solar panels, the following are estimated cable run distances from the nearest solar panel (the last panel in the array) to the building distribution board.

Building 1: 15m

Building 2: 12m

Building 3: 12m

Building 4: 9m

The size of the cables to be used depends upon:

1. The generating capacity of the solar panels (larger the current generated, bigger the size)

2. The distance of the solar panel system to the loads (greater the distance, bigger the size)

6.3 Types of solar panels and inverters

The rating of solar panels currently available in the market ranges from 250W to 350W. As the technology has matured in recent years, prices have fallen dramatically, and the lifespan of new solar panels is now more than

25 years. Wattblock recommends the use of 280W panels in the high-quality range as a balance between investment cost and available rooftop space.

Inverters are used to convert the DC power generated from solar systems into usable 240V AC power, and monitor the performance of the panels. Three main types of inverter exist at present: micro, string, and central [27].

Microinverters form a distributed inverter system, where each solar panel has its own small inverter to output AC power independently of other panels. These produce slightly more power than a similar system with string inverters, but at an increased cost of approximately 23% of the total system price. They are most beneficial where shading is a major concern.

Typical solar systems use string inverters, where each inverter connects to a string of solar panels. One or more of these can be used for each building which houses solar panels. This is the type of inverter recommended for this project and used in payback calculations.

Central inverters are used for large-scale solar arrays of 500kW or more, and are not considered in this analysis.

6.4 Battery storage systems

Battery storage systems, such as the Tesla Powerwall, are able to store excess solar power generated during the day, rather than feeding this back into the electricity grid in return for a nominal amount of 'feed-in' income. The excess solar power stored into the battery can then be used at night time, reducing the amount of peak energy usage from grid supply.

Battery storage is still in its infancy and the lifespan of the common lithium ion battery solutions is between 5 and 15 years [28]. Newer systems like the sonnenBatterie have a service life of 20 years [29]. At present, there is not a strong return on investment due to the high upfront battery costs and bulk electricity purchase at Jade.

However, a key advantage of Battery Storage for an apartment building is energy security. During a power outage, the individual apartments may still have electricity for a period of time, if the battery is sufficiently charged when the power goes out. If there is a power outage for an extended period of time, a battery can charge up off a solar panel installation to provide energy at night.

Table 16: Battery storage system advantages and disadvantages

Advantages	Disadvantages
✓ Energy security – if battery is charged during a power outage, internal apartments can run for a period during a grid power outage ✓ Allows a larger solar system to be installed, getting economies of scale on solar installation ✓ Allows excess solar to be stored during the day, to be used at night (after solar generation ceases) ✓ Ability to charge battery at off-peak rates and power apartments during peak rate periods, saving money	× Lithium Ion batteries are a Level 1 Fire Hazard and cannot be installed in a domestic building, within 1m of an access, egress area or under any part of a domestic building × Lifespan of batteries is ~10 years and in conjunction with solar are approximately a 'break-even' payback over this period

In considering the deployment of a battery storage system, thought also needs to be given to the installation location. Draft legislation on battery storage suggests that they should not be installed inside domestic buildings, and be spaced from access and egress points by at least one meter. Further discussion on battery storage regulation is contained in Appendix section 8.7.

6.5 Seasonal variation in solar power collection

During winter months, the sun traces an arc along a lower position in the sky than in summer. This seasonal variation in sun angle has implications for solar power generation by photovoltaic arrays. During summer months, more power can be expected to be produced than in winter months. Patterns of energy demand will likewise shift as more power is used for heating and cooling. This variation is considered in the calculations of annual solar system output in the scenarios below.

6.6 Jade Utility Management Rights

Both the residents of Jade and the body corporate purchase power from Jade Utility Management Rights (Jade UMR), who are contracted to provide energy utility management services to the complex. Common property energy bills provided to SSKB show a power pricing of 26c/kWh plus GST (28.6c/kWh total). The solar savings rate per kilowatt hour will be less than this, however, as the rate at which Jade Utilities purchase power from the energy market will be lower, owing to the bulk purchase of power granted by the embedded electrical network. For the purpose of this analysis, the effective solar savings rate is estimated to be 16c/kWh.

An update to the power purchase contract will be required to negotiate the sale of energy produced by the complex between the body corporate and Jade UMR.

6.7 Array scenarios

Three scenarios are considered for solar energy production at Jade. Overall system sizing for the scenarios is based on current energy consumption. Scenario 3 has been added to illustrate the opportunity for the solar energy system to be scaled up now or in the future with the addition of battery storage. Similarly, the number of solar panels might also be increased in the future to accommodate electric vehicle charging or to increase participation in energy trading.

Scenario 1 is a 100-kilowatt array with all panels placed on the rooftop of Lotus.

Scenario 2 is a 200-kilowatt array with panels situated on all buildings except Sage.

Scenario 3 is a 500-kilowatt array with panels on all four buildings, and a battery storage system to store excess power for use outside of daylight hours.

For each scenario, a payback period and cashflow is calculated which considers the various costs and savings associated with solar power generation.

Costs include:

- Initial investment in project
- Maintenance and cleaning of solar panels to reduce losses

- Solar inverter replacement – expected after 12 years
- Battery replacement (scenario 3 only) – expected after 12 years

Savings and returns include:

- Reduction in purchased grid power, and expected changes in pricing over time
- Government rebate schemes

Solar energy utilisation

As shown in the Energy Efficiency section of this report, common property energy usage averages a baseline of 887kWh/day. Residential energy is estimated to average 2573kWh/day. A solar array will produce a variable quantity of usable power throughout the course of a day. Matching this generation pattern to the load profile of energy assets at Jade provides useful data on the suitability of an array to generate power for the local network. In the scenarios below, an hourly profile of common property and residential energy use is shown along with the portion of this energy that could be supplied by the solar array.

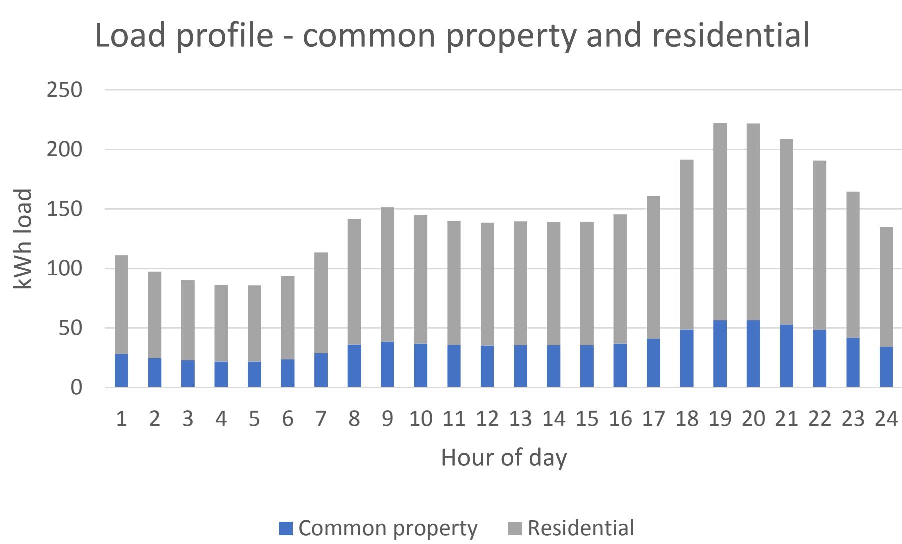


Figure 23: Hourly energy use, residential and common property

Scenario 1: 100kW

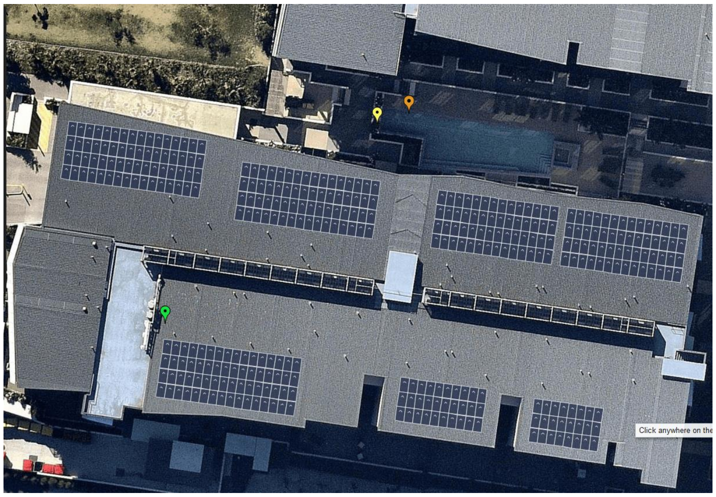


Figure 24: 100kW solar array conceptual layout

In this scenario, all panels are placed on the Lotus rooftop. This placement reduces the overall cost of the array compared to later scenarios with panels on multiple rooftops, as the installation and labour takes place in the same building. Tilt frames are used for panels on the south-facing portions of the roof to improve coverage. This system uses 358 panels to generate 142,623 kWh per year.

The initial project cost is $114,820, with a payback period of 5.2 years. For the lifetime of the system, this array is expected to save $581,689 in energy bills.

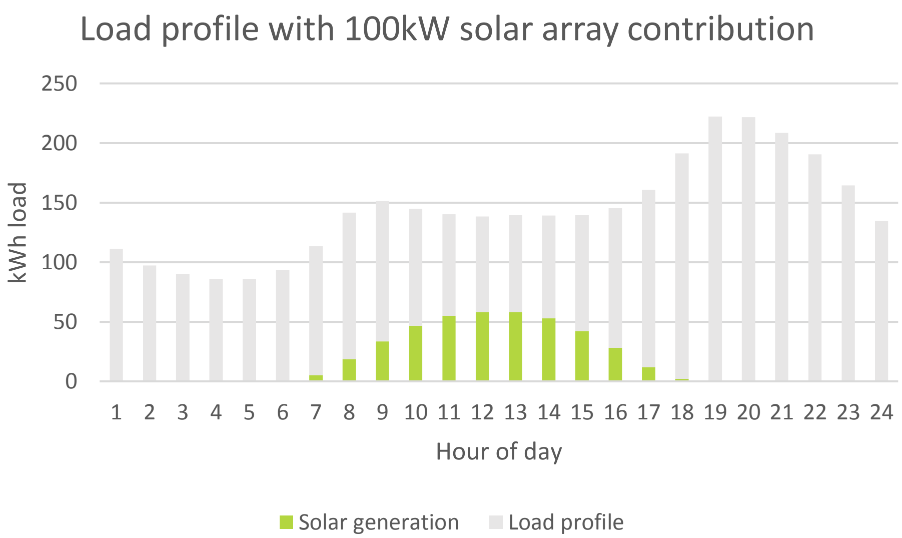


Figure 25: 100kW system utilisation

Scenario 2: 200kW

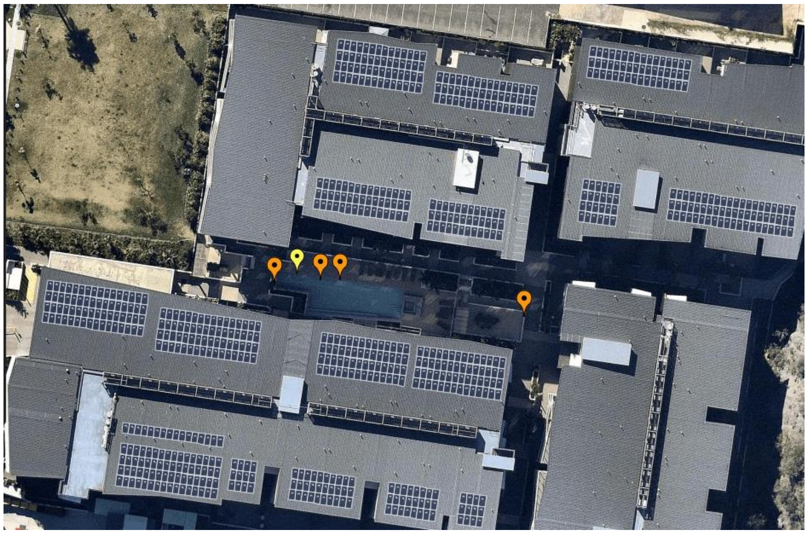


Figure 26: 200kW solar array conceptual layout

In this scenario, panels are placed on the rooftop of all buildings except Sage. Tilt frames are used for panels on the south-facing portions of the roof to improve coverage. This system uses 715 panels to generate 285,246 kWh per year. Modelling suggests that all of this energy will be consumed within Jade, but a small quantity may be wasted if demand does not always exceed peak production.

The initial project cost is $348,980, with a payback period of 7.0 years. For the lifetime of the system, this array is expected to save $1,128,292 in energy bills.

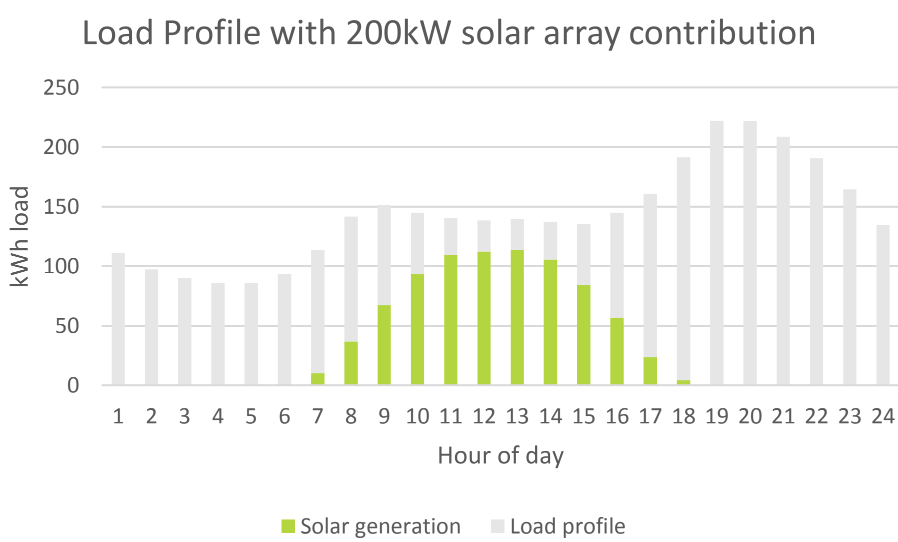


Figure 27: 200kW system utilisation

<u>**Scenario 3: 500kW**</u>

Figure 28: 500kW solar array conceptual layout

In this scenario, all available rooftop space is utilised to produce the maximum solar energy output. Tilt frames are used for panels on the south-facing portions of the roof to improve coverage. This system includes some east and west-facing panels, which will, respectively, generate slightly more power in the morning and evening compared to north-facing panels, but slightly less overall than if they were facing directly north. This system uses 1786 panels to generate 716,622 kWh per year.

For each system, the generated solar energy can be used within Jade between the common property and residential networks, with little to no excess production. In scenario 3, 840kWh of battery storage smooths out the usage of generated solar energy by charging when there is an excess of power from the array, and discharging as the sun falls, reducing the power required from the grid during peak hours.

The initial project cost is $1,115,820, with a payback period of 12.7 years. For the lifetime of the system, this array is expected to save $1,825,152 in energy bills.

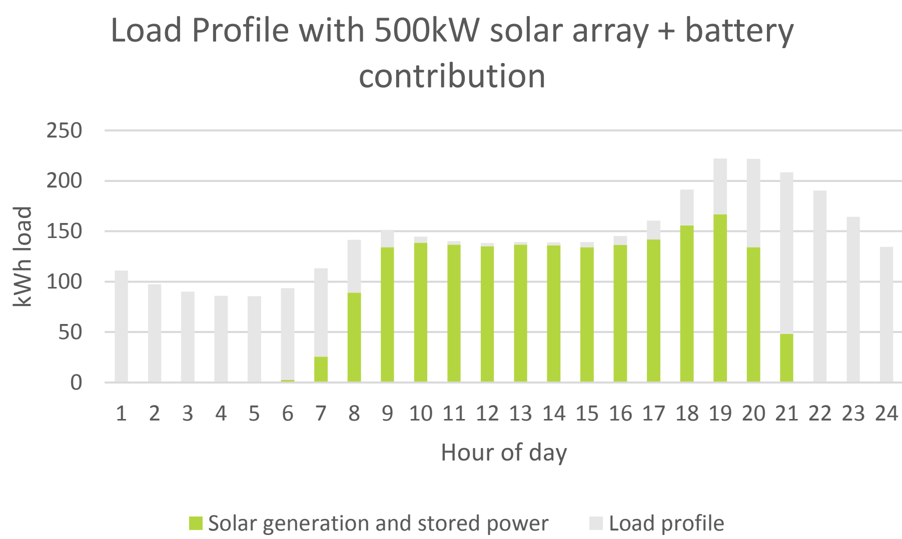


Figure 29: 500kW system utilisation

Scenario cashflow comparison

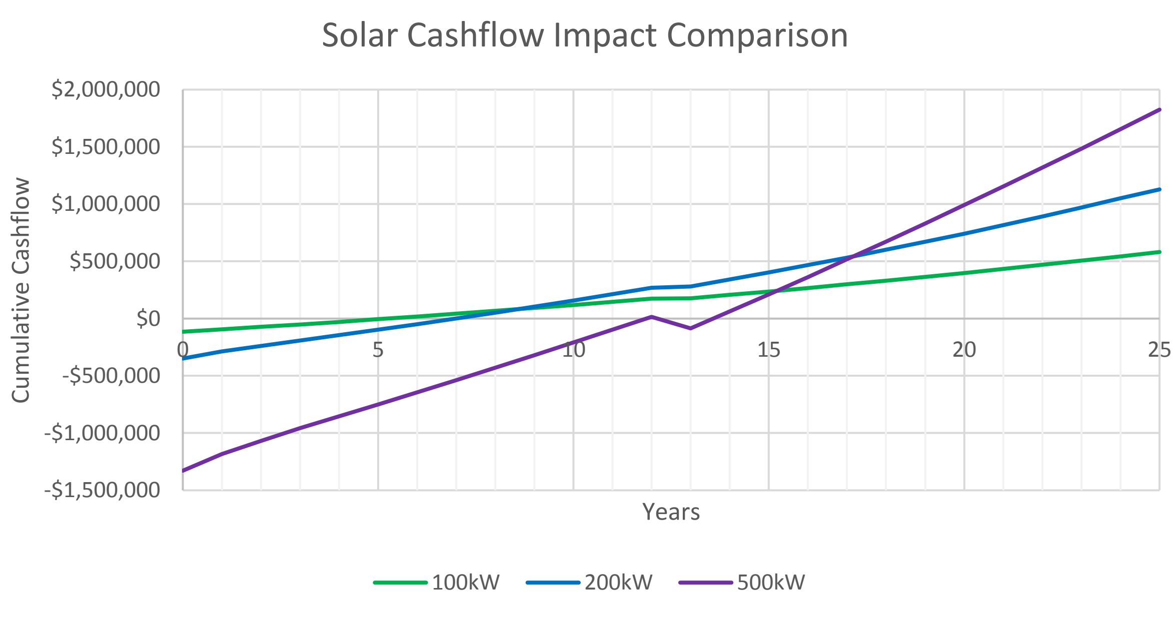


Figure 30: Scenario cashflow comparison

Scenario 1 offers the fastest payback at 5.2 years, and will generate positive cashflow for the remaining 19.8 years of its lifespan.

Scenario 2 produces the maximum amount of solar energy that can be utilised locally. Cashflow between this and scenario 1 is matched after 8.2 years, with cumulative return nearly doubled after 25 years.

Scenario 3 takes longer to break even, with a battery replacement needed at around the point where cashflow becomes positive. Wattblock anticipate that large scale energy storage technology will improve significantly by this point, and replacement batteries will cost less than the original. Although having fewer years of positive cashflow, this system saves the most in energy bills over its lifetime.

A future possibility for battery storage exists around network peak demand levelling. Large battery storage systems could be used to supply the outside network with electricity at a rate higher than present feed-in tariffs. This opportunity does not exist currently, but may become available in the near future [30].

The NABERS pre-assessment result would be positively affected by the inclusion of a solar system, with all scenarios improving rating from 5.5 to the maximum 6 stars.

Table 17: Scenario financial comparison

Scenario	Total investment cost	Payback period	Cumulative return after 25 years	Difference in return between scenarios
1, 100kW	$114,820	5.2 years	$581,689	-
2, 200kW	$348,980	7.0 years	$1,128,292	$547,240
3, 500kW with battery	$1,115,820	12.7 years	$1,825,152	$696,860

Additional scenario: 200kW staggered installation

To make best use of current government rebates and future technology advancements, an alternate installation option for scenario 2 is considered here.

Installation of a 200kW system could be staged across several years. One option would be to proceed with a 100kW array in the near future, and deploy an additional 100kW after 10 years. This has the benefit of reaching the earlier break-even point of the 100kW scenario against the full and immediate installation of the 200kW array, along with the greater production of that array at a later time when energy demand and prices can be expected to be higher.

Upfront rebates offer the best return for systems not exceeding 100kW (see section 6.9), which scenario 2 would not be eligible for. A staggered install would, however, be able to take advantage of these rebates.

The overall lifespan of the system will be longer as well, and after 35 years the staged 200kW system would provide approximately $400,000 of additional positive cashflow. For the purpose of this investigation, estimates on solar panel output are not estimated past their expected lifespan.

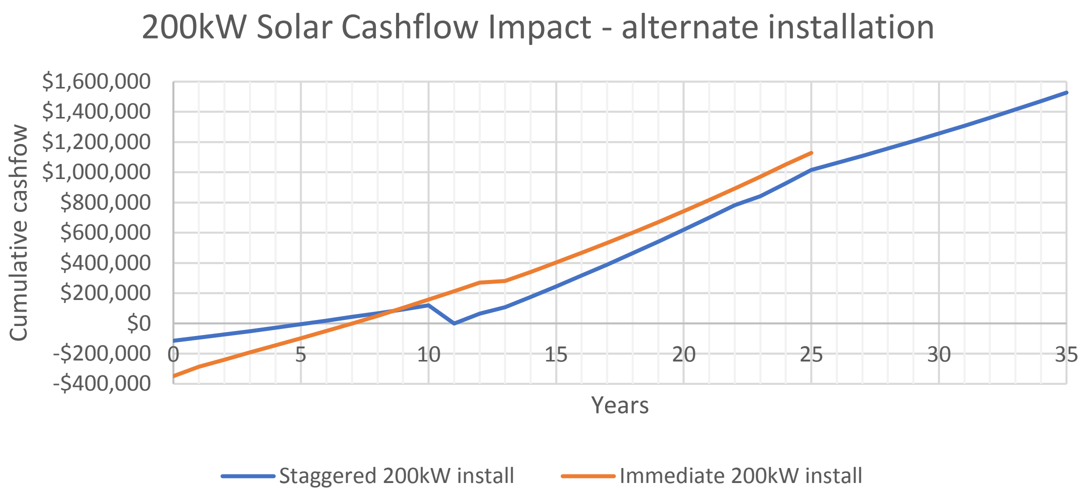


Figure 31: Cashflow comparison for 200kW installation options

6.8 Grid feed-in considerations

Generated solar energy can be fed back into the grid at a rate determined by the utility. Current rates in Queensland range from 6 to 10.5 cents per kilowatt hour [31], whereas energy provided to Jade is charged at a rate of 28.6c/kWh. This price difference means that any generated solar power is best used in-house to reduce energy bills if a demand exists on the premises.

Additionally, there is a limit to how much power can be fed back into the grid as defined by Australian Standard 4777.2:2015. This limit is linked to the system size, with different network providers setting the limit between 5 and 30kW [32]. Beyond this point, grid-protection devices are required to manage power flow into the utility network, which require approval from the energy provider on a case-by-case basis.

While scenario 2 and 3 may produce a slight excess of power at times where electrical load at Jade drops below solar generation, there is little incentive in selling this power back to the grid.

6.9 Financial Considerations

Besides attractive financial payback, there are many additional financial considerations. In this section we cover government incentives, project financing options and valuation impacts.

Eligibility for government rebates

Scenario 1 is eligible for an upfront Small Technology Certificate (STC) rebate. This rebate has already been factored into the financial assessment. Upfront STC rebates are available for systems up to 100kW.

The STC program typically reduces the upfront system cost by as much as 40% or $70,000 for a 100kW system. Because of the STC program, solar energy systems up to 100kW typically offer the fastest financial payback. However, the STC program is gradually being phased out between 2017 and 2030, with reduced rebates each year. Furthermore, in July 2018 Australia's competition regulator ACCC proposed to abolish the subsidy by 2021 [33]. It is therefore recommended that, should scenario 1 be considered, your strata scheme should install solar early to maximise the available solar rebate.

For solar systems above 100kW, the STC rebates are superseded by the Large Generation Certificate (LGC) rebate scheme. For each megawatt-hour of solar energy produced, an LGC can be claimed. These certificates are traded as a commodity, with varying value according to supply and demand. As of August 2018, these certificates are sold from $78.50 to $79.25.

It is expected that the value of these certificates will fall steadily over the coming years with the Clean Energy Regulator targets being met and the scheme ending in 2030. By 2022, LGCs are expected to be valued at $5.15 each [34], with prices dropping to zero soon after, unless the renewable energy target is raised.

The LGC scheme does not provide an immediate rebate in the same fashion as the STC scheme, instead generating income over time. For a 200kW system installed in 2019, it is estimated that LGCs worth $31,342 could be generated by 2023. For a 500kW system, $78,815 in LGCs could be generated in the same time span. These figures are considered when calculating the payback periods in the above scenarios.

These schemes do not favour solar systems over 100kW but less than 200kW, as the savings provided by the additional energy produced do not offset the STC rebate sacrificed in larger installations. Additionally, the value produced by the LGC scheme in this kW range is not enough to bring the payback period into parity with a smaller system.

Protection against any future rise in electricity price

Electricity prices have more than doubled in Australia over the past 10 years. A solar system can provide insurance against any future price rise. This is because the system is expected to last for more than 25 years, generating free energy for the building. Any rise in electricity cost simply means the solar system is generating more savings for the building. In each scenario, an average annual price rise of 3% is assumed for payback calculations.

Low-risk investment for strata

The installation of solar is an attractive investment option for the Owners Corporation as it can often generate a financial return of greater than 10%. This is a lot higher in comparison with the interest rate available for the capital works fund/sinking fund, typically in the range of 0% - 2.5%. In addition, solar power is considered a low risk investment for superannuation funds [35]. This is a significant factor as super funds need to be a reliable source of income for retired citizens and their capital must be invested in projects with a guaranteed return on investment and long-term sustainability.

Valuation surge for green properties

In addition to the financial benefits of using a solar system to offset the rising energy costs, green buildings can also attract higher market values [36] and improved marketability to buyers and renters. A project conducted by LendLease in 2013 recorded that an installation of a solar system to the value of $1,500 on a per apartment basis increased the sale value of the apartments by over $10,000. This effect will continue as the Federal Government recently announced funding for the NABERS star rating system to standardize the environmental performance of apartment buildings [37]. This was launched nationwide in June 2018.

6.10 Solar feasibility conclusions

Jade possesses many characteristics that make it ideal for generating solar power, having large open areas of unused rooftop and ideal positioning with no shading from surrounding buildings.

Investment in solar generation for residential strata is a low-risk strategy for reducing the quantity of power purchased from the utility. Market conditions and the changing state of government rebates suggest that a solar project, if considered, would generate greater financial return if implemented sooner rather than later.

Smaller systems will benefit from the STC rebate scheme, but save less in energy over the course of their lifespan. Larger solar systems produce greater financial returns over time, but take longer to reach their payback period, and also miss out on upfront rebates. The falling value of LGC certificates reduces their weight as a positive financial factor for large scale solar generation.

Three solar system scenarios are presented, each modelled to fit within the load profile of Jade's common property and residential energy demand. The existing embedded network allows for solar power to be distributed locally, but negotiation is required with the network manager before installation can proceed.

7.0 Conclusions and Recommendations

Jade Albion exhibits reasonably good energy and water efficiency based on our assessment of the development. The NABERS for Apartment Buildings pre-assessments estimates of 5.5 stars for energy and 4.5 stars for water are consistent with expectations. However, the review period includes abnormal consumption as a result of recent development works and the site having below full occupancy. In order to obtain a formal NABERS for Apartment Building assessment the building will need to provide 12 months of data at full or near full occupancy and without abnormal usage loads would be preferable.

There is an ongoing water usage dispute which remains unresolved at the time of writing. Based on our assessment of the water services for common areas and apartments the overall volume of water consumption should be much lower than it is. It seems likely that the issue is either a billing and/or metering error or there has been some abnormal water usage or leakage. Assuming this is resolved the building should achieve a good water efficiency rating. Generally, water efficiency initiatives identified are internal to apartments including for example the use of water efficient shower heads.

Energy efficiency initiatives identified for common facilities include dimmable LED lighting for the underground carpark area and heat pump technology for the central hot water system. The LED lighting project would achieve the best payback outcomes with direct payback to the Owners Corporation via reduced common area power bills. The heat pump initiative offers tremendous energy savings, but savings are most likely to be passed on to residents through reduced hot water gas billing. This depends on the commercial arrangements that can be negotiated for the installation of the heat pump system.

The electric vehicle survey demonstrates very high future demand for electric vehicle charging facilities. This should be taken into consideration when planning potential EV charging investments. Most residents want individual chargers on their car spaces. Furthermore, in the absence of any plans, residents are likely to resort to charging their vehicles via standard 10 Amp general power outlets in the basement car park which have otherwise been made available for vacuum cleaners for example. It is therefore recommended to implement some strata bylaw adjustments to outline any agreed rules on the use of common power.

The greatest sustainability opportunity for Jade Albion is clearly Solar PV. Jade has an extensive roof area for solar that is easily accessible for installation works. Furthermore, the existence of an embedded electrical network at the site means that a solar array can easily be connected up to the gate meter to supply the electricity demands of both common areas and apartments. Such as investment requires further investigation and consultation with Jade UMR. It should be possible to structure commercial terms in such a way that direct payback to the Owners Corporation can be achieved. It is also likely that a variety of financing options would be available to mitigate or avoid upfront cost altogether.

As a final note, sustainable buildings are not only good for the environment and in reducing operating costs. There is increasing evidence that 'green' buildings are attracting premium valuations. Solar PV is the most visible expression of green credentials and Jade has the option of installing solar that feeds into apartments. For environmentally conscious buyers this is currently a very rare find. If Jade invests in electric vehicle charging infrastructure in the future it will also be possible to feed solar energy to vehicle chargers. We expect this will have high appeal to early EV adopters for which environmental considerations are likely to have been a key influence in the purchase decision.

8.0 Appendix

8.1 Background on electric vehicles

According to AEMO Insights, by 2035-36 Australian EV sales are forecast to reach 277,000 vehicles a year (27.1% of vehicle sales) and total EVs on the road are estimated to reach over 2.8 million (18.4% of all vehicles). With more people moving into apartments, many of these EV owners will live in strata. Charging an EV at home is convenient, but for many apartment residents, this is a challenge due to the concern in regards to the overloading of common area power supply, how to pay for the use of electricity and expensive charger installation costs.

Types of Electric Vehicles

The majority of the passenger vehicles on the road today are Internal Combustion Engine Vehicles (ICEV). Electric vehicles were first produced in the 19th century and out-numbered gasoline-based vehicles. This shifted in the 20th century with the rise of oil. In recent years there has been a growing interest in Electric Vehicles (EV) as being more socially and environmentally conscious combined with advances in battery and charging technology.

Hybrid Electric Vehicle (HEV) – Hybrid technology uses conventional combustion engines in conjunction with battery power to maximise the time an engine operates close to the point of maximum efficiency. Eg Prius. In these vehicles the battery for the electric engine is charged from the motion of the vehicle.

Plug-in Electric Vehicle (PEV) – Vehicles can be recharged from an external source of electricity with the electricity stored in a rechargeable battery that contributes to drive the wheels. Three broad sub categories include:

Battery Electric Vehicle (BEV) – Vehicles that are powered entirely from an on-board rechargeable battery, generally re-charged through plug-in. e.g. Nissan Leaf, Mitsubishi iMiev.

Plug-in Hybrid Vehicle (PHEV) – Conventional hybrid vehicle that has a battery that can be re-charged from mains electricity. E.g. Holden Volt.

Neighbourhood Electric Vehicle (NEV) – Low speed all-electric vehicle.

Electric vehicles also encompass motorbikes, mopeds, buses, trucks and generally all types of vehicles. Many special purpose vehicles have long been electric, such as golf buggies and fork lifts. This research report is focused on passenger vehicles typically found in the basement car parking of residential strata. Other than electrically powered mopeds, EVs are in the very early stages of adoption by strata residents.

Benefits of driving electric vehicles

Research has found that people choose to drive electric mainly for the reasons below:

Cost Savings

- Electricity cost for charging EVs is about $400 p.a., typically 2-3 times lower than gas.
- Conventional cars use an internal combustion engine which has more than 2,000 moving parts, while EVs use less than 20 which drives significantly lower maintenance costs.
- Driving electric can save $13,000 over the life of an EV. (Union of Concerned Scientists, 2015)

Environmental Benefits

- No exhaust while driving, providing cleaner air for cities and high traffic roads.
- Potential to cut greenhouse gas emissions in half or more, depending on how electricity is generated where drivers live.

Techie

- EVs have cutting-edge software and the latest features.
- Completely quiet and fun to drive.
- Quick acceleration with instant torque.

- Have the ability to park themselves in the future.

Popular electric vehicles

Table 18: Popular electric cars in Australia [38]

Vehicle	Battery Range	EV Type	Upfront Cost	Seats	Body Type
Mitsubishi Outlander PHEV	53km	Hybrid	$46,000 (2017) $62,000 (2018)	5	SUV
Nissan Leaf	175km	Pure Electric	$40,000	5	Hatchback
Tesla Model S	407km	Pure Electric	$120,000	5	Sedan
BMWi3	300km	Pure Electric	$64,000	5	Hatchback
Mercedes-Benz C350e	17km	Hybrid	$56,000	5	Sedan
Audi A3 e-tron	50km	Hybrid	$62,500	5	Wagon

8.2 Capital Works Plan

In a medium-large size strata it is likely that you already have one or more Plug-in Hybrid Electric Vehicles in the building. Electric Vehicles are predicted to reach 25% of new Electric Vehicle sales within the next 10 years. This means your 10 year Capital Works Plan (formerly Sinking Fund plan) should be updated now to cater for Electric Vehicle charging upgrades to common areas.

The key items to be added to the Capital Works plan are:

- Installation of cable trays throughout the carpark roof to facilitate fast connection and disconnection or chargers to individual car spaces
- Set-up of distribution boards with restricted access for car chargers on different levels of the car park not less than 60 meters from the farthest car space
- Higher amp cabling of all basement carpark areas
- Set up of an energy management solution and possible third-party billing service
- Upgrade of capacity for existing electrical switchboards or to connect a new grid link into the building

8.3 Electrical Infrastructure

Electrical Layout Options

Generally speaking residential apartment building energy supply is split between resident energy meters and common area services. Common area services are usually further split between Essential and Non-essential services, both of which sit behind one or more common area energy meters. Services are connected off busbars with circuit breakers that limit the Amperage load within Australian Standards.

In planning for electric vehicle charging facilities it is possible to set-up dedicated distribution boards running off either the apartment busbar or the common area essential or non-essential services busbars. We recommend connection to the non-essential services busbar. Firstly, this limits any potential disruption to essential services in the building such as the lifts. However, secondarily the common area supply is recommended because there is no need to set up a new power supply contract and capacity can be directly impacted by improving energy efficiency of other common area services.

If the Owners Corporation wants to investigate setting up electric vehicle charging distribution off the apartment busbar, keep in mind that a new meter would need to be installed, similar to adding a new apartment meter. Furthermore, a new energy supply contract would need to be established and paid for by the Owners Corporation for that meter. The electricity rate for supply to the new meter will be higher than the existing common area meter due to the bulk rate discounts available. On the plus side, this may make overall energy cost more transparent for electric vehicles and assist in cost recovery. However, keep in mind that the apartment busbar and circuit breakers have been sized for apartment energy usage. The growing demands from electric vehicle charging may risk disruption of energy supply to apartments over time.

For the purpose of cost recovery there are multiple solutions available. Generally speaking the solutions, costs and administrative effort will be the same regardless of whether the EV chargers run from the apartment busbar or common area busbars.

In the case of some smaller buildings it may be practical to connect an EV charger directly to the apartments existing individual energy supply. In this case the problem of installing a distribution board and administering a user pays system is eliminated. However, it is recommended that the building continue to monitor energy demands on the overall apartment busbar and potentially upgrade capacity over time to avoid disruption to apartment power supply.

Switchboard analysis

For the installation of individual chargers, a major factor that can impact the cost is the distance between the resident's car space and the closest electrical board with sufficient capacity to accommodate the EV charging equipment. This should be considered in determining the best location for electric vehicle charging circuits.

In the absence of any EV charging consideration or governance, we examine the risks of unchecked behaviour of EV owners. From a risk perspective, we must consider probabilities with respect to types of charging installed and usage frequency and timing. Most EV owners are going to prefer higher 32-40 Amp charging installations, so we must consider this a likely choice. It has further been proven that EV owners have successfully negotiated with building management and Owners Corporations to install their high amp chargers on available spare poles on existing distribution boards. The physical set-up of the distribution board itself provides a limit both in terms of the number of free poles as well as the rated amperage of the given distribution board.

Our analysis considers the probability of all vehicles being plugged in and charging at the same time. Given behavioural consideration that EV owners are more likely to plug in during 'after work' hours, it is almost certain that all EV chargers will operate concurrently at some point over the course of a year. Based on this analysis it is estimated that 34 high amperage electric vehicle chargers represent a risk to other building services.

As covered in the body of the report, this limit can be mitigated dramatically via suggested low-cost measures, including simply putting in place a by-law to limit individual charger amperage. The analysis that follows further examines capacity demand impacts where basic measures have already been put in place.

8.4 How to set up EV charging equipment

EV owners who live in apartment buildings need to work with building management or Owners Corporation to get approval and to find the best solution for installation of the charging equipment.

- Evaluate installation options
    - Location of the charger (visitor parking vs private car parking)
    - Type of charging system (power sockets vs EV charger vs EV charger with power management)
    - Maximum charging speed of the EV charger (16 Amps vs 40 Amps or other)
    - Method to set up cabling (user pays vs strata pays for all residents)
- Evaluate payment options
    - Common power (strata pays)
    - Common power with a “flat rate annual fee” (owners pay, minimum administration)
    - Private sub-meter off common power (owners pay, requires administration for billing)
    - Residential meter (tenants/residents pay)
    - Third party billing system (owners pay, minimum administration)
- Engage a licensed electrical contractor
    - Obtain quotes for the electrical job
    - Validate the agreed solution of the Owners Corporation through a capacity assessment report. This is only recommended for setting up a large number of EV chargers. The capacity assessment report will depend on the size of the building and cost from $1,000 to $12,000.
- Include Electric Vehicle charging in the following strata documents
    - 10 Year Capital Works Plan
    - Strata By-laws

8.5 Flat Rate Fee

Below is an example of a flat rate fee that could be applied to users of electric vehicle recharging facilities.

Table 19: Recommended annual flat rate fee

Weekly Driving Distances	Up to 50km	Up to 100km	Up to 200km	Up to 400km	> 400km
Annual Fee	$119	$218	$417	$814	$1,210

Recommended fix charges are calculated based on average driving distances of a standard Electric Vehicle and the electricity rates of the common area. A small administration fee for strata management is also included.

Owners charging with control equipment during off-peak hours can receive a 50% discount off the standard annual fee. Hybrid Electric Vehicle owners may also be able to negotiate for a discount.

8.6 Further EV reading

An in-depth EV recharging study performed by Wattblock is available online at https://www.wattblock.com/ev-report.html [39].This study examines current EV charging solutions for residential strata, commercial models, strata by-laws, and government incentive programs to promote uptake. The report covers issues such as how to bill owners for charging, which location is the best, how to set it up, types of charging equipment, and risks around overloading the common area power supply. The report also provides some analysis around the location and impact of public charging stations as well as the carbon impact with the deployment of electric vehicles.

8.7 Battery storage regulation

The following Australian Standard DRAFT AS/NZS 5139, relevant to batteries, was announced in June 2017 as a draft. It has implications regarding fire safety for different types of batteries as well as where batteries can be located.

The most common type of battery which could be considered for Jade Albion is a lithium ion battery, which is rated as a Level 1 Fire hazard in the draft standard. For fire hazard level 1 batteries, there are further suggestions in the DRAFT standard for where they should NOT be located being:

1) Within a domestic building

2) Within 1m of any access/egress area

3) Under any part of a domestic building

Standards Australia had proposed the necessity for a battery ‘vault’ or enclosure in the draft standard. In September, consensus on the DRAFT standard was reached with the Clean Energy Council at the Australian Battery Storage Standards Roundtable that a separate battery enclosure should NOT be required.

8.8 Project Planning

Methodology

This case study was approached through a combination of research, calculation and analysis, as well as tools and templates provided by Wattblock. The project is broken down into ten sections, with strategies and deliverables listed for each. The list of tasks, timings and dependencies is given in the Gantt charts following this section.

Section	Summary	Strategies	Deliverables
Introduction and planning	Induction and familiarisation with Jade Albion and NABERS Preparation of Planning Report	Use NABERS tool to find energy and water ratings for sample buildings, check for correctness with Brent Clark (Wattblock CEO) Use IAP planning report template Use MS Project to produce Gantt chart	NABERS assessments Utility bill summaries Project planning report
Data collection	Site visits Obtain plans and maps of buildings Obtain utility bills	Contact Ben Messina of Arden Property group to arrange site visits and collect bills and strata plans Contact Shaun Beck of Hutchinson Builders to collect electricity and hydraulic maps and plans	Site visit data analysis
Water investigation	Monitor ongoing water use dispute with Queensland Urban Utilities	Analyse bills and meter reading data using MS Excel Seek updates from Sally Ferguson of Queensland Urban Utilities regarding main water meter test Work with Jacky Zhong of Wattblock to compare and contrast existing analysis	Water data analysis Efficiency assessment Leakage assessment
NABERS assessment	Conduct NABERS assessment for	Use NABERS tool and latest utility data to produce an energy and water rating for Jade Albion	NABERS energy and water rating

	Jade Albion complex		
Solar feasibility study	Conduct research into most suitable solar setup for Jade Albion and make suggestions	Research into the types of panels and inverters available today Check suitability of rooftop areas in regards to insolation and load bearing, calculate angles and areas of shading throughout day Research battery types and regulations Determine type of connection: will the solar panels power the whole building or just the common property, will it power EV chargers, will excess power be sold into the grid, will owners have a share of the solar rights and responsibilities Determine cable length and types Use Wattblock templates and software (Nearmap) to check and confirm own work against	Scenario analysis and modelling
EV Charging	Gauge residential interest in electrical vehicle charging and provide solutions	Provide a survey (Google Sheets, survey produced by Wattblock) to residents and owners of Jade Albion apartments Analyse results of survey Research EV charging technologies Research commercial EV options Review building electrical maps to determine best location for chargers	Residential survey EV charging technology review Building infrastructure review: electrical and physical (carpark) Present report
Energy efficiency	Look into existing infrastructure and determine overall efficiency	Analyse results of carpark lighting count report Research energy characteristics of existing infrastructure: common area lighting and facilities, carpark ventilation, central water services, mechanical systems Research improvements to infrastructure and predict energy savings Estimate daily energy use profile Research energy efficiency grants and certifications	Existing infrastructure report Energy use profile Report on replacement lighting types and sensors Suggest energy-saving improvements

		Estimate energy savings from the implementation of energy-saving improvements	
Financial considerations	Provide insight into payback periods of improvement projects	Look into power purchase agreements, bulk buying options Estimate valuation improvements from suggestions Research renewable energy certificates	Cost-benefit analysis of suggested improvements
Applicable regulations and processes	Provide advice on relevant regulations and approval processes	Research strata scheme resolution requirements, council approvals, energy regulatory requirements	Report on any changes needed Report on any council approvals required Report on regulatory requirements
Case study collation	Assemble case study	Complete writeups of sections and sub-sections in parallel to the research and calculations for those sections Use MS Word templates provided by Wattblock to structure report, proofread and edit as each section is completed	Writeups on each section, proofing and publishing

Project timetable

The below Gantt charts show the scheduling of each case study section as covered throughout the project timeline.

Task Mode	Task Name	Duration	Start	Finish	Pred
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Energy efficiency	**15 days**	**Mon 20/08/18**	**Fri 7/09/18**	
	Financial considerations	**3 days**	**Mon 10/09/18**	**Wed 12/09/18**	**55**
	Applicable regulations and processes	**3 days**	**Wed 12/09/18**	**Fri 14/09/18**	
	Case study collation	**45 days**	**Mon 23/07/18**	**Fri 21/09/18**	
	Project end	0 days	Mon 24/09/18	Mon 24/09/18	65

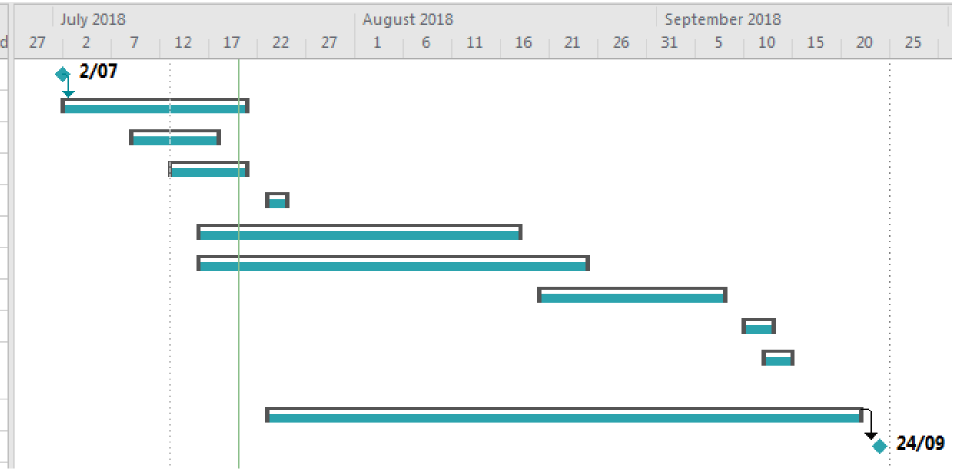


Figure 32: Project overview

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	NABERS induction	3 days	Mon 2/07/18	Wed 4/07/18	
	Analysis of electricity and water bills and data collected so far	3 days	Wed 4/07/18	Fri 6/07/18	
	Project planning report	7 days	Thu 12/07/18	Fri 20/07/18	
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Site visit with Ben Messina	1 day	Mon 9/07/18	Mon 9/07/18	4
	Data analysis from site visit	2 days	Tue 10/07/18	Wed 11/07/18	7
	Data collection from Liam Coulson (Energy + water bills and strata plan)	2 days	Wed 11/07/18	Thu 12/07/18	
	Data collection from Shaun of Hutchinsons (lighting map, emergency lighting map, electrical diagrams - single line and layout)	2 days	Mon 16/07/18	Tue 17/07/18	
	Data collection from Ben Messina (residential water and energy use)	2 days	Mon 16/07/18	Tue 17/07/18	

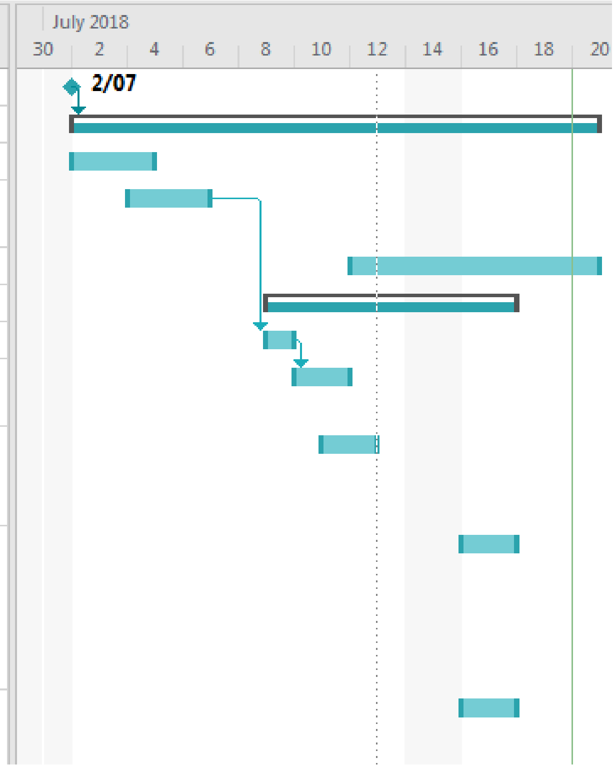


Figure 33: Introduction and Planning, Data Collection sections

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	Site visit with Ben and Shaun from Hutchinson Builders	1 day	Fri 13/07/18	Fri 13/07/18	8
	Water data analysis	1 day	Wed 18/07/18	Wed 18/07/18	9
	Efficiency assessment				
	Main water meter test by QUU	1 day	Wed 18/07/18	Wed 18/07/18	
	Metering efficacy	1 day	Thu 19/07/18	Thu 19/07/18	16
	Leakage assessment	1 day	Fri 20/07/18	Fri 20/07/18	16
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Energy and water rating	1 day	Mon 23/07/18	Mon 23/07/18	
	Update with latest bills	1 day	Tue 24/07/18	Tue 24/07/18	9

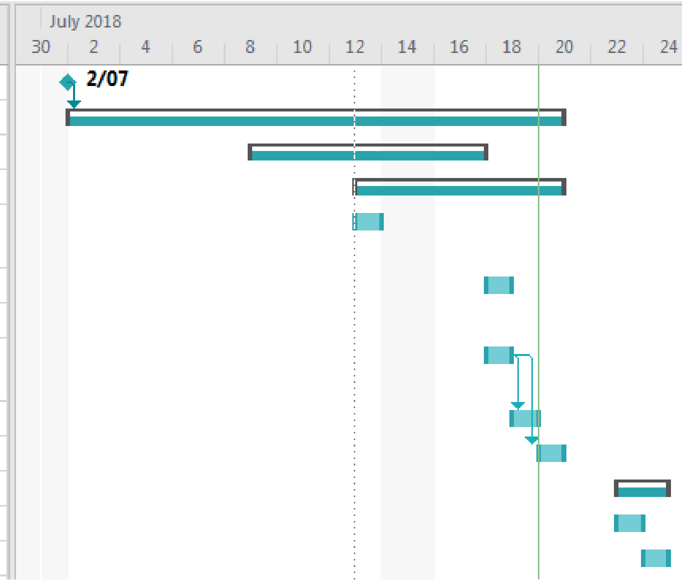


Figure 34: Water Investigation and NABERS assessment sections

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	Types of solar panels and inverters	2 days	Mon 16/07/18	Tue 17/07/18	
	Rooftop structural analysis	2 days	Wed 18/07/18	Thu 19/07/18	10
	Location of panels + shading	2 days	Fri 20/07/18	Mon 23/07/18	10
	Battery types and regulation	2 days	Tue 24/07/18	Wed 25/07/18	
	Cabling	2 days	Thu 26/07/18	Fri 27/07/18	
	Grid connection	2 days	Mon 30/07/18	Tue 31/07/18	
	Cleaning and maintenance	2 days	Wed 1/08/18	Thu 2/08/18	
	Solar access rights	2 days	Fri 3/08/18	Mon 6/08/18	
	Community solar sharing	2 days	Tue 7/08/18	Wed 8/08/18	
	Energy trading and emerging technology	2 days	Thu 9/08/18	Fri 10/08/18	
	Scenario analysis and modelling	5 days	Mon 13/08/18	Fri 17/08/18	23,25,24,26,27,29,28,3

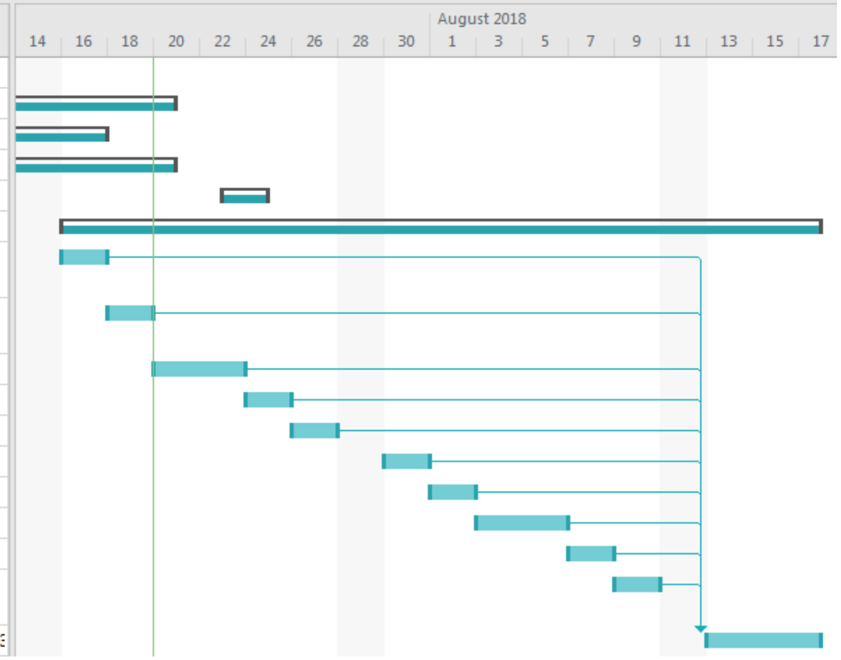


Figure 35: Solar Feasibility Study section

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Request permission from committee	1 day	Mon 16/07/18	Mon 16/07/18	
	Conduct survey	26 days	Tue 17/07/18	Tue 21/08/18	35
	Research: EV charging technology review	2 days	Wed 25/07/18	Thu 26/07/18	
	Research: Commercial EV options	2 days	Fri 27/07/18	Mon 30/07/18	
	Building infrastructure review: electrical and physical	2 days	Tue 31/07/18	Wed 1/08/18	10
	Collect and present results	3 days	Wed 22/08/18	Fri 24/08/18	36,37,38,39

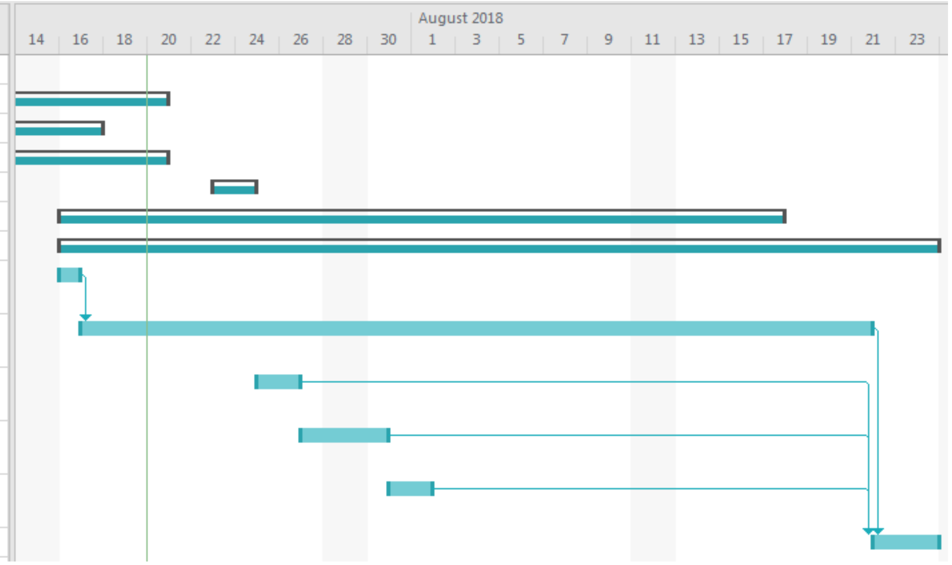


Figure 36: EV Charging section

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Energy efficiency	**15 days**	**Mon 20/08/18**	**Fri 7/09/18**	
	Obtain results of car park light count from Dan	1 day	Mon 20/08/18	Mon 20/08/18	
	Report on exisiting infrastructure				
	Common area lighting	1 day	Tue 21/08/18	Tue 21/08/18	42
	Common area facilities	1 day	Wed 22/08/18	Wed 22/08/18	
	HVAC	1 day	Thu 23/08/18	Thu 23/08/18	
	Central water services	1 day	Fri 24/08/18	Fri 24/08/18	
	Mechanical systems: lifts and gates, sensors and regenerative drives	2 days	Mon 27/08/18	Tue 28/08/18	
	Power factor	1 day	Tue 28/08/18	Tue 28/08/18	
	Energy supply: tariffs and bulk buying	1 day	Wed 29/08/18	Wed 29/08/18	
	Current energy consumption	1 day	Thu 30/08/18	Thu 30/08/18	43
	Energy use profile	1 day	Thu 30/08/18	Thu 30/08/18	
	Research: lighting types and sensors, make suggestions	1 day	Fri 31/08/18	Fri 31/08/18	
	Research: Energy efficiency grants, certification equivalents	1 day	Fri 31/08/18	Fri 31/08/18	
	Predict energy savings	5 days	Mon 3/09/18	Fri 7/09/18	51,52,53,54

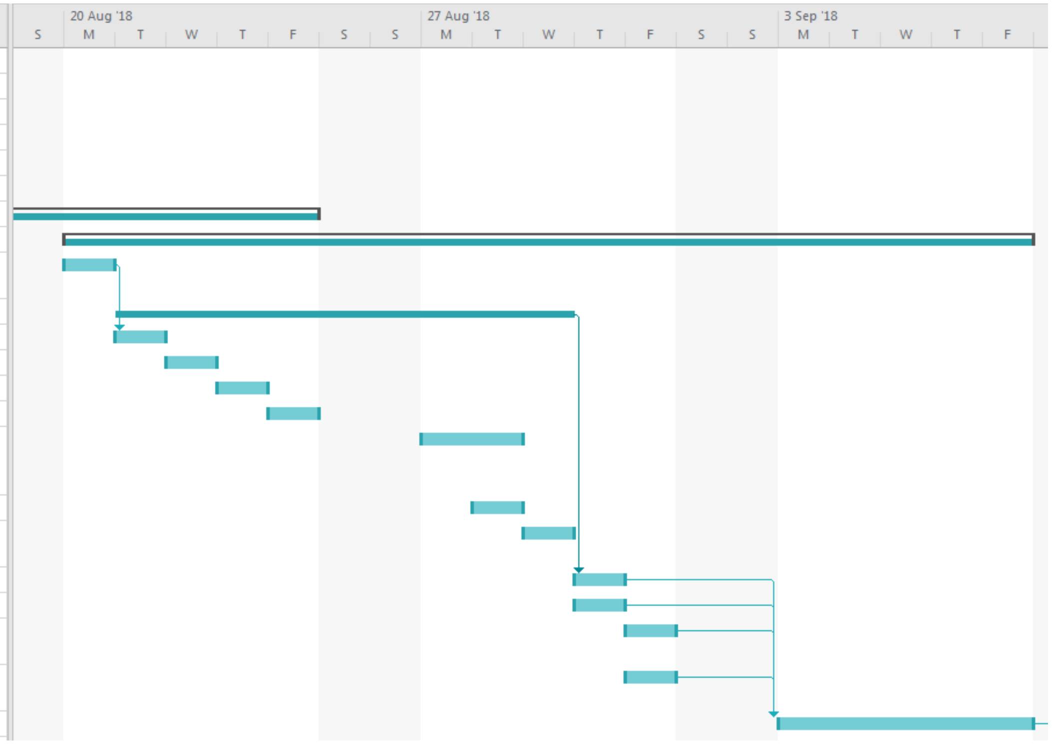


Figure 37: Energy Efficiency section

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Energy efficiency	**15 days**	**Mon 20/08/18**	**Fri 7/09/18**	
	Financial considerations	**3 days**	**Mon 10/09/18**	**Wed 12/09/18**	**55**
	Cost-benefit analysis	3 days	Mon 10/09/18	Wed 12/09/18	
	Green property valuation improvements	1 day	Mon 10/09/18	Mon 10/09/18	
	Power purchase agreements	1 day	Tue 11/09/18	Tue 11/09/18	
	Renewable energy certificates	1 day	Wed 12/09/18	Wed 12/09/18	

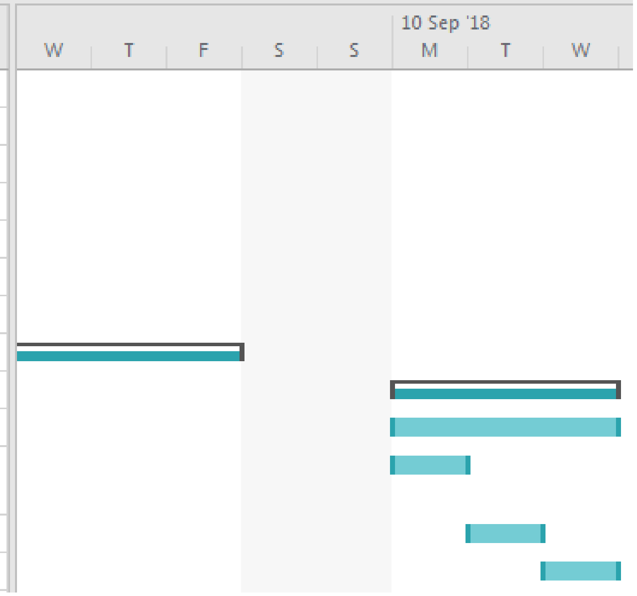


Figure 38: Financial Considerations section

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Energy efficiency	**15 days**	**Mon 20/08/18**	**Fri 7/09/18**	
	Financial considerations	**3 days**	**Mon 10/09/18**	**Wed 12/09/18**	**55**
	Applicable regulations and processes	**3 days**	**Wed 12/09/18**	**Fri 14/09/18**	
	Strata scheme resolution requirements	1 day	Wed 12/09/18	Wed 12/09/18	
	Brisbane City Council approvals	1 day	Thu 13/09/18	Thu 13/09/18	
	Australian Energy Regulator requirements	1 day	Fri 14/09/18	Fri 14/09/18	

Figure 39: Applicable regulations and processes section

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Project start	0 days	Mon 2/07/18	Mon 2/07/18	
	Introduction and planning	**15 days**	**Mon 2/07/18**	**Fri 20/07/18**	**1**
	Data collection	**7 days**	**Mon 9/07/18**	**Tue 17/07/18**	
	Water investigation	**6 days**	**Fri 13/07/18**	**Fri 20/07/18**	
	NABERS assessment	**2 days**	**Mon 23/07/18**	**Tue 24/07/18**	
	Solar feasibility study	**25 days**	**Mon 16/07/18**	**Fri 17/08/18**	
	EV Charging	**30 days**	**Mon 16/07/18**	**Fri 24/08/18**	
	Energy efficiency	**15 days**	**Mon 20/08/18**	**Fri 7/09/18**	
	Financial considerations	**3 days**	**Mon 10/09/18**	**Wed 12/09/18**	**55**
	Applicable regulations and processes	**3 days**	**Wed 12/09/18**	**Fri 14/09/18**	
	Case study collation	**45 days**	**Mon 23/07/18**	**Fri 21/09/18**	
	Water investigation writeup	2 days	Mon 23/07/18	Tue 24/07/18	12
	NABERS writeup	2 days	Wed 25/07/18	Thu 26/07/18	19
	Solar feasibility study writeup	5 days	Mon 20/08/18	Fri 24/08/18	22
	EV Charging Survey writeup	5 days	Mon 27/08/18	Fri 31/08/18	34
	Energy efficiency writeup	2 days	Mon 10/09/18	Tue 11/09/18	41
	Financial considerations writeup	2 days	Thu 13/09/18	Fri 14/09/18	56
	Applicable regulations and processes writeup	2 days	Mon 17/09/18	Tue 18/09/18	61
	Proofing	3 days	Wed 19/09/18	Fri 21/09/18	66,67,68,69,70,71,72
	Project end	0 days	Mon 24/09/18	Mon 24/09/18	65

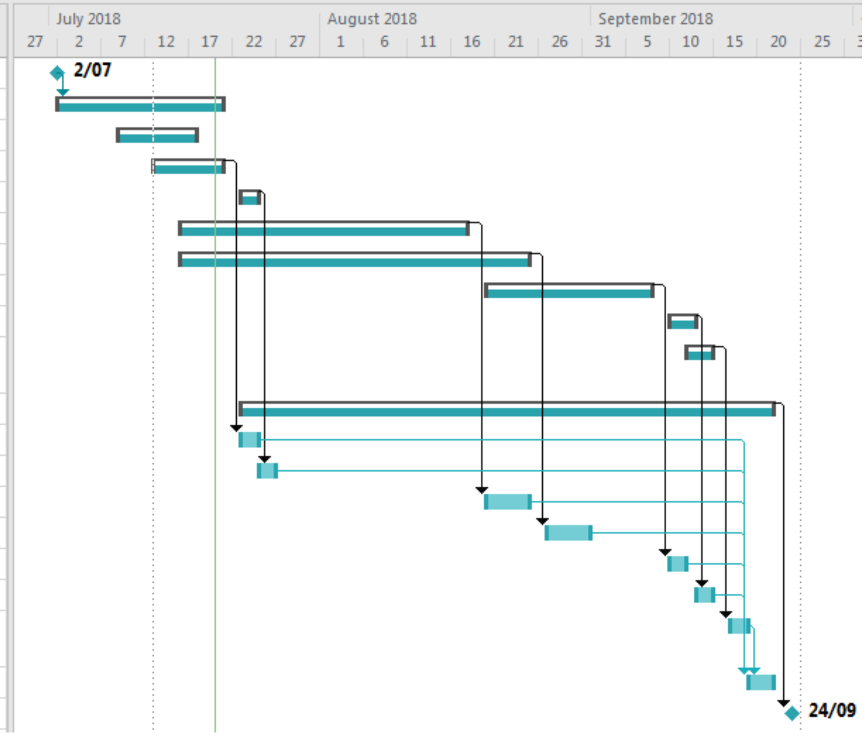


Figure 40: Case study collation section

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WATTBLOCK

Who is Wattblock?

Wattblock was co-founded by Brent Clark and Ross McIntyre in 2014. They are joined by Jacky Zhong and Wilson Huang solar engineers plus a team of solar and low energy buildings specialists.

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 70 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 100 strata buildings have participated in electric vehicle recharging studies.

Who is partnering with Wattblock?

NSW Innovate, Advance Queensland, North Sydney Council, Microsoft CityNext, Telstra's muru-D, the University of NSW, Griffith University, University of Queensland and 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.

Wattblock Awards

Innovation of the Year - Strata Community Australia (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 Michael Crouch Innovation Centre at UNSW in Sydney.