LOW CARBON LIVING CRC

East Village

A sustainable urbanism project by LandCorp

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The report summarises and draws on the work of the LandCorp team and their consultants (particularly Josh Byrne & Associates and TABEC) commissioned as part of the design and development of the project. Importantly, the report also draws on work undertaken by the RENew Nexus Smart City project – involving Curtin University, Power Ledger, City of Fremantle, Cisco, CSIRO/Data 61, Murdoch University, Synergy, Western Power, Water Corporation and the Australian Energy Market Operator.

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- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the author(s).

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Acronyms

PV - Photovoltaic

WGV - White Gum Valley

ZEH - Zero Energy Home

EV - Electric Vehicle

PAW - Private Access Way

UWMP - Urban Water Management Plan

BUWM - Better Urban Water Management

Executive Summary

This report documents the innovations related to sustainable urbanism incorporated into the LandCorp WA Government land development agency) project called East Village, within the Knutsford Precinct, approximately 1.5 km east of Fremantle. The project on 1.5ha consists of 36 townhouses established within a survey strata framework, plus two adjoining apartment sites for 60 dwellings. The project represents a significant innovation in residential development in Perth, Western Australia. (see https://www.landcorp.com.au/Residential/Knutsford/Innovation/).

The project is the result of integrated design and systems thinking with considerable attention to issues of low carbon design East Village features the latest innovations aimed at total electric living, including electric vehicle fast charging, solar panels and battery storage, provision for an electric vehicle car share scheme, waterwise homes and private and public gardens.

The project incorporates Australia's first blockchain ready homes, with new residents participating in leading trials of this new technology providing the opportunity for residents to access 100% renewable energy. The project has been designed and modelled to deliver energy and water savings, renewable energy revenues and a range of homes with adaptable spaces for home offices.

The key features that have been incorporated into the 36 townhouses within East Village are outlined below.

Design and Delivery Innovations

The project created a design for 36 townhouses as an integrated package of built form within the property title framework of survey strata – meaning that the properties are designed so that common services such as sewer, water and power can be shared, as well as access to common property. This enables many aspects of the ongoing management of the innovations proposed can more easily become the responsibility of the strata management company owned by the future purchasers of the homes. This is not necessarily unique, but it is not that common for developments of this type. The innovation here was to use the survey strata framework as the basis for integrating quality-built form product including multiple innovations in low carbon living that start with passive solar architecture and integrated landscape design.

Energy Innovations

The energy innovation includes the incorporation of key passive solar design features and 5kW PV panels on each of the dwellings and the integration of that system with an onsite shared 670kwh battery. The battery will be configured to import and store electricity for the purpose of minimising the electricity consumed from the grid. The system allows for peer to peer trading to buy and sell their excess power between each of the dwellings and the battery using a blockchain system. All homes will be totally electric and incorporate provision for overnight electric vehicle charging and provision of a fast charging facility. The homes are designed to be Zero Energy Homes (ZEH) that produce more energy than they use over an average year, while achieving high levels of comfort and amenity.

Water Innovations

Every one of the 36 townhouse sites has a 7,000-litre rain-water tank installed, which are being installed below the driveway and carport. These tanks have been determined by detailed modelling to enable the right size to make the most of winter rainfall in Perth. The aim has been to size the tanks to get the most of that infrastructure, in relation to the cost and also in terms of energy intensity of construction and installation.

Water from the rainwater tanks will supply the toilets and washing machines, which is the safest way to use rain that comes off roofs, similar to other projects such as the nearby WGV by LandCorp. However, in this case, the rainwater will also be run through the solar energy powered heat pump hot water systems, to sterilize that water and provide that water back into the home for use in showers.

These features supplement scheme water supply to the highest indoor water use in Perth homes. In the Perth context as the house blocks become smaller and the proportion of garden water use reduces, it makes it even more critical to start focusing on providing fit for purpose alternate water sources indoors as well. This is a first for the Department of Health approvals for a Western Australian multi-lot residential development.

In terms of non-drinking water for irrigation, a strata bore is being installed just alongside the community battery. The strata bore will be owned and operated by the strata company. It will supply groundwater from the superficial aquifer to every single lot to be used for irrigation, both for irrigation systems and also for hand watering of gardens. With the taps properly colour coded and labelled for hand watering. This is very important for smaller courtyard style gardens, where people like to hand water pots plants and cottage style gardens.

Importantly, the strata bore is using groundwater that is being recharged through locally harvested and infiltrated stormwater: 100% of the storm water that will fall within this development site, will infiltrate back into the ground within the site, including the one in 100 years rainfall events. The overall approach to water management is referred to as water sensitive urban design, where the stormwater that falls on the ground, firstly in paved areas will infiltrate through strips of porous paving. Those early flows go into the subsoil and recharge soil moisture, to be used by trees and other landscaping.

Bigger rainfall events will flow over land into rain gardens, where they can help recharge water around the larger established trees. Once that subsoil is saturated, the water then infiltrates down into the aquifer. Any additional flow is directed into shallow infiltration

galleries, dispersed all throughout the site, which recharges the clean water into the ground water. This all aims to provide a positive recharge to the groundwater, allowing for managed extraction of the groundwater for irrigation even in Perth's dry climate.

The mains water demand is thus significantly reduced as it is not being used for toilets, washing machines, and showers when there is rainwater available to substitute it. Demand is further reduced through highly efficient fixtures and appliances that are specified into the homes, to make sure that water is used as efficiently as possible.

All three of these water sources are metered with smart meters and they're wired up to the digital platform, that Power Leger has developed, to make sure that water use can be tracked very closely. The mains water use and the strata bore water use will be billed accordingly by the strata manager but at a lower price than they would pay for mains water. The metering and sensors mean that ongoing evaluation can occur of the whole water balance of the site – thus documenting what is being used, what is infiltrating into the groundwater and most importantly, the reduced amount on the mains water supply network.

Landscaping Innovations

The landscaping features are a critical part of the design. As this is a former industrial precinct there were no trees on the site, therefore the project seeks to be an example of regenerative landscaping. This involves transforming a barren site into one that provides shade for cooling, that provides biodiversity for urban wildlife and human benefit, in terms of integrated design. There are also opportunities for food production incorporated into the design.

As the project has been established as a strata development, there is greater flexibility with the design of the streetscapes and the public access ways to create an engaging landscape, that not only captures water but one that also sustains a thriving landscape. The target is to achieve a 30% tree canopy coverage across the whole precinct. Through careful positioning of the trees, there will be no shading of the solar panels. This is an important consideration in urban infill sites. As development sites become smaller, there is no reason why liveability and quality of life needs to be compromised and this development illustrates smarter design responses. The homes and courtyard spaces that have been designed by the architects, interface thoughtfully with a network of public access ways, proving good permeability where these courtyards will open up into these public access way spaces.

These public access ways ensure good permeability from the surrounding communities through the new development where there is shade, opportunities for food production and connection with greenery. There will also be a network of sensors to better understand the benefits of the landscaping approach which will act as a hydrated landscape environment for urban cooling, to illustrate how to tackle the urban heat island effect.

Integration, Monitoring and Visualisation

The integration of energy, water and landscape innovations have multiple ways that they help each other. In terms of low carbon living the reduction in water has significant reductions in energy as there are large energy impacts from water use in Perth due to the large desalination load; landscaping that reduces energy use through cooling the site is also clearly of benefit. Such interactions will be monitored to ensure that the full benefits can be quantified.

These systems allow for detailed monitoring of the data on energy, water use, and microclimate, and this provides the opportunity for a virtual system that overlays all of these physical systems. To take advantage of all this monitoring there will be a purpose-built Living Lab facility, that is currently under construction at the Fleetwood Construction yards. This facility will house a state-of-the-art data visualisation facility, established by Curtin University, where there will be the opportunity to see real-time data from the systems at East Village, but will also provide an opportunity to network into other projects including WGV, and the Josh Byrne's house project. They are all part of this network of CRC LCL Curtin research projects.

This data will be able to be visualised, and accessible to industry partners, the government, and to the community in a way that has never been done before. Upstairs above the living lab data hub centre, will be an innovation maker space, where the doors will be open to innovators, to continue to progress in new ways of thinking about how we make cities better.

The key findings from the analysis of the design for the 36 town houses are:

- The townhouses will be carbon positive >100% reduction in residential emissions relative to a comparable code compliant development. This reduction is largely achieved by the PV Instillation and battery.
- There will be a 40% reduction in electricity peak demand across the development due to the efficiencies, solar PV and battery.
- The instillation of the battery means that most of the energy produced on site by the PVs is stored on site, however there is still in the order 200kWh of export to the grid occurring on typical summer day, with no export in winter.
- More than 40% reduction water consumption is expected relative to a comparable code compliant development. Reductions are achieved from the rainwater reuse and community / strata bore water use for irrigation.
- These results give an expected 35% reduction in household utility expenditure on water and energy relative to the Perth average. This represents in the order of a $1,300.00 per year saving to the householder.

Further, although design development has not occurred for the apartments modelling provides an expected 20% reduction in household utility

expenditure on water and energy relative to the Perth average, providing approximately $500.00 in household savings.

1. Introduction

The purpose of this report is to document the sustainable urbanism innovations incorporated into the East Village at Knutsford project (previously referred to as the Museum Site, Lot 1819 Knutsford Street, Fremantle) being developed by LandCorp within the Knutsford Precinct approximately 1.5 km east of the Fremantle city centre.

The East Village site involves development of a 1.52 ha brownfields site into 36 townhouses within a survey strata lot configuration of house and land packages (constructed by one builder) and sale of two adjoining apartment sites. The East Village project is part of LandCorp's commitment to its 'Innovation through Demonstration Program'.

The project builds on learnings and experience of LandCorp and its research partners at the nearby WGV project and aims to deliver a leading edge example of sustainable urbanism. In particular this project extends the so-called Citizen Energy Utility (or Energy Governance Model)1 developed at WGV for apartment complexes and applies the model within a survey strata complex of 36 townhouses to manage solar power, battery storage and local water systems.

The report summaries and drawn on the work of LandCorp and their consultants commissioned as part of the design and development of the project2. Importantly, the report also draws on work undertaken by the ReNew Nexus Smart City project – involving Curtin University, Power Ledger, City of Fremantle, Cisco, CSIRO/Data 61, Murdoch University, Synergy, Western Power, Water Corporation and the Australian Energy Market Operator.

This report has been prepared at the point in the project where land development level design and approvals have been completed and earth works for the development have commenced. This report is therefore a useful summary of the project intent, at a key milestone and can serve as reference for the ongoing research and investigations that will occur as this project moves from the design and delivery phase and into occupation.

The report is part of project funded by the Cooperative Research Centre for Low Carbon Living – Project RP 3043 – Beyond White Gum Valley.

1 Green, J. & Morrison, G. (eds) (2018) Citizen Utilities: Unlocking Australian Strata Development to the benefits of Solar and battery storage innovations - A report for the Australian Renewable Energy Agency. Arena Industry Report.

2 The reader should refer to the supporting documents referenced in this report if further technical information is required.

2. Innovation Focus

The East Village project by LandCorp within the Knutsford precinct is a commercially focused development which provides the built form context for investigating:

a) Climate resilient passive built form design
b) Battery storage and solar energy generation
c) Water sensitive urban design in terms of rainwater harvesting, localised stormwater infiltration, community groundwater extraction (strata bore) and low water use landscape design
d) Application of blockchain system for water and energy trading
e) Reduction in development costs
f) Application of the One Planet Living sustainability framework.

Development of the site by LandCorp will demonstrate sustainable, integrated homes with improved outcomes compared to Knutsford Stage 1 – a nearby development site delivered by the Knutsford Joint Venture, which is a LandCorp and private sector partnership which is now being discontinued (shown in Figure 2 below). Subdivision of this site will yield approximately 92 dwellings (comprising the 36 townhouses and adjoining apartments) ranging from one bedroom apartments to three bedroom homes with optional separate home office / fonzie flat, delivering a range of dwelling sizes that will be offered to the market in 2019 by LandCorp as a leading edge example of sustainable living.

3. Location

The Knutsford Precinct is approximately 1.5 Km east of the centre of Fremantle and from a planning perspective encompasses the Swanbourne Street Structure Plan and the Knutsford Street East Structure Plan. It comprises approximately 23 ha of re-developable area (see Figures 1 and 2 below). The area has a range of land owners and land uses, with a mixture of land parcels and ownership arrangements. The planning frameworks (structure plans) in place provide for mixed use and residential development that could accommodate in the vicinity of 950 to 1380 new dwellings. Those planning frameworks have articulated the intent to implement sustainable planning principles and practices. The East Village site is shown as Lot 1819 – in the North East corner of the site within Figure 2

Figure 1 Context plan - Highlighting the East Village site (Source: LandCorp)

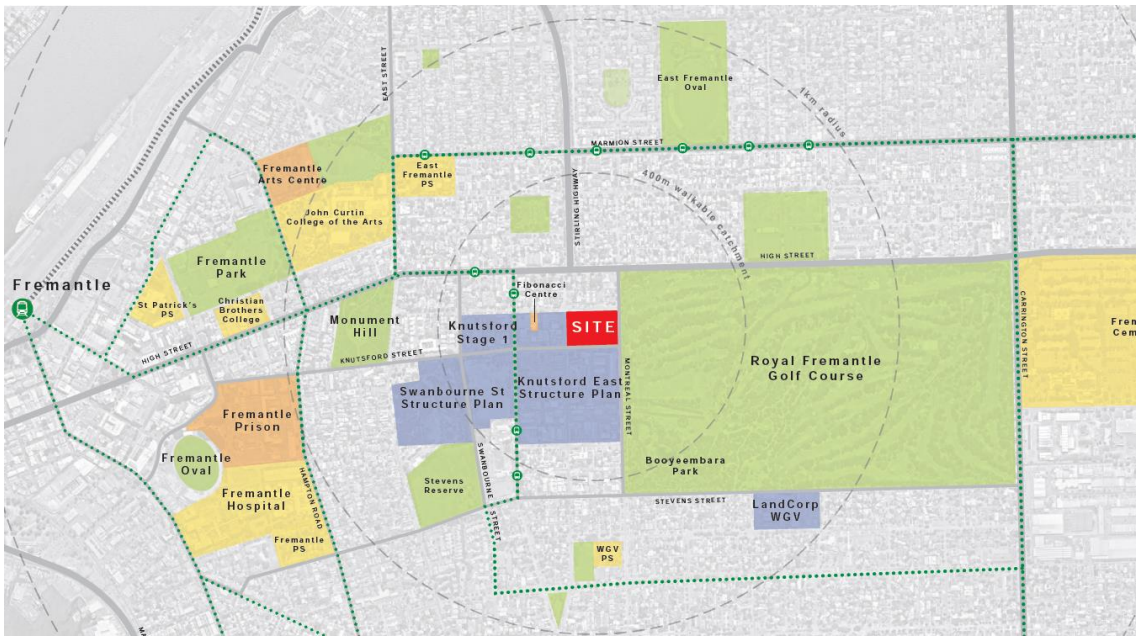


Figure 2 Knutsford Street East and Swanbourne Street Structure plan - East Village is shown as Lot 1819 (Source: LandCorp/ JBA)

4. Project Description – East Village

The main features of the proposed East Village development (as depicted in Figure 3), incorporating a range of innovations, including:

a) A 36 lot survey strata subdivision (of lots ranging from 200 to 270 m2) for the development of an innovative townhouse project which will demonstrate the following:
   a) Private internal servicing for reduced servicing costs
   b) Solves storm water management 'internally' as no external stormwater sump is available
   c) Permits low cost, strata owned shared ground water bore for non-potable water supply to irrigate all gardens
   d) Incorporates precinct scale battery storage and solar energy generation.
   e) Energy and water use will be managed at the strata level using a distributed ledger platform, enabling real-time understanding of resource flows and system optimisation.
   f) The project is also going to incorporate a temporary 'Legacy Living Lab' which will that will be used as both a display facility for the development and a location to visualise and review the data generated from the innovations (see Section 10)
g) Two apartment sites of around 1,900 square metres each located opposite the golf courses on Montreal Street, will be developed separately via an Expression of Interest process conducted by LandCorp ensure design quality and commitment to sustainable development.

The main focus of this report is to summarise the key innovations associated with the 36 Survey Strata Townhouses developed within the East Village project. Features of the survey strata subdivision include the incorporation of a private road and two private lanes, public access way (PAW) spaces, and an area to the northeast of the townhouses for the shared battery, transformer and any related plant.

For other information about other aspects of the wider research project, the reader is referred to other reports – such as "Beyond White Gum Valley: Knutsford: Integrating energy, water and built form solutions in an urban regeneration and infill precinct". That report includes an appendix related to the potential provision of Trackless Trams in the precinct.

Figure 3 East Village - Knutsford - illustrating the 36 strata dwellings and the two apartment lots to the east of the site and the area depicted red is the precinct battery (Source: LandCorp/ JBA)

5. Design and Development Process

This section provides a description of the design and delivery process and concludes with some reflections on the challenges associated with incorporating the innovations into the project which could not have come about without the partnership arrangements.

5.1 Integrated design process

Delivering an innovative project is team process that requires a combination of leadership, perseverance and wiliness to push the boundaries within the constraints of delivering a commercially viable and marketable project. This section summaries some of the key features of the design and development process that make this a unique project.

The design and development of the was undertaken under the leadership of LandCorp's experienced Senior Development Manager Warren Phillips and Development Manager Naomi Lawrance , who coordinated a team from within LandCorp and external consultants, plus involvement of researchers associated with the various components of the research innovations associated with the project . The process of design development was coordinated through a series of fortnightly project meetings and associated design meetings

LandCorp Team

- Marketing - Jason Vivian
- Community Relations - Claire Paddison
- Design Manager - Anna Evangelisti
- Sustainability - Greg Ryan
- Innovation - Nivia Guiffre

Consultant Team

- Civil Engineers - Tabec
- Landscape Architect, Urban Water Specialist, and Sustainability Consultants - Josh Byrne & Associates
- Architect - Spaceagency
- Planning Consultant – ElementWA
- Geotech - Douglas Partners
- Urban Design - ElementWA and spaceagency
- Real Estate Agent - Dethridge Groves
- Built Form & Valuation - BFP
- Surveyors – Veris
- Electrical Engineers – 3E Consulting Engineers

Research partners

- Murdoch University – input into water systems design
- Curtin University – input into the energy and battery storage
- University of WA – input into the architectural, built form design

The City of Fremantle has had both its normal approval role as well as being a partner in the research initiatives associated with the precinct.

5.2 Delivery process

The development is being delivered by LandCorp as a fully designed 'built form delivery' approach that will ensure all 36 townhouses developed as package, ensuring coherent built form and landscape quality, as well efficient delivery of the innovative energy and water services. The earth works and civil works are being undertaken as this report is being prepared. This will prepare the site for building to commence. Part of the civil works includes innovative on site stormwater management techniques (Discussed in Section 7 below).

The 36 survey strata lots to be released in batches of four or six as 'house and land packages', delivered by a builder engaged by LandCorp. There are six alterative house designs configured on 9 and 7 metre wide lots, plus corner dwellings on slightly wider lots. There will be options for home office/fonzie flat (studio apartment) options to be incorporated into the wider lots.

House and land prices will be confirmed once Development Application drawings are prepared, however they are likely to be set at prevailing market prices (indicatively in the range from $750,000 to $950,000, with additional cost for the studio apartments – if incorporated).

One builder will be engaged by LandCorp via an Expression of Interest process that will be undertaken once the final design has been completed. The delivery contract will include:

a) Indicative turnkey build price for each house type
b) Marketing strategy including collaboration with LandCorp and their agent
c) Pre-start process including facilities and client liaison before, during and after build
d) Financial capacity to work across multiple lots
e) Site office and compound requirements
f) Recycling, waste management
g) Other conditions and requirements as per other LandCorp builder EOIs.

It is expected that the delivery model will produce market competitive prices.

5.3 Cost Comparison

The project involved a cost compassion process with the alterative design options for a similar development configured as green title development. Appendix 1 documents those cost comparisons which illustrate the benefits of the design innovations incorporated in this development. In this case, the comparison is being made between an equivalent green title subdivision of a comparable configuration to the 36 townhouses being developed as a survey strata complex. It is very important to note that a direct comparison of cost is not

always straight forward, however this analysis illustrates that apart from the Battery cost – which was subsidised the typical capital expenditure was better or comparable to typical a development.

5.4 Partnerships and innovation experience

The innovations in this project could not have been achieved without a commitment to a partnership approach between LandCorp, its research partners, interested agency partners and consultancy team involved in this project. Figure 4 depicts the array of partners within the design and delivery process.

A key point stressed by the Senior Development Manager Warren Phillips is that you cannot fully communicate the value of the partnership and innovation process at the beginning of the journey. He points out that "it is the collaboration that ends up creating the value". This approach is sometimes at odds with typical mind set of the agencies involved in the development process.

It was also pointed out that the marketing assessment undertaken for LandCorp highlighted that if the innovations where well marketed and explained, market acceptance would be high and a good price would be achieved. This assertion will obviously be tested as part of the sales process.

Figure 4 Logos of the key organisations involved in the Partnership

6. Built Form

The built form outcome is a key feature of the East Village precinct. This section documents the key features of the design.

Early in the design process it was identified that there would be value in continuing to work with Michael Patroni from the local Fremantle architectural firm – spaceagency – who have continued to provide urban design and architectural for a range of processes associated with the Knutsford precinct for LandCorp over the past 12 years. They were also appointed by the Knutsford JV (LandCorp's built form development partner) for the development of Stage 1 – Knutsford (Lot 1354) a 1.65 hectare development with 90 plus dwelling incorporating apartments, green title houses, townhouses and duplexes. The built form at Knutsford Stage 1 achieved a range of awards including the National AIA award for multi-residential development. Although there is acknowledged architectural merit in that development the joint venture partners did not place an emphasis on sustainability features, apart from passive design features. Therefore, LandCorp have placed an emphasis on building these features into this complex.

This phase of the project involved - spaceagency - designing the homes, site planning, preparing elevations, and obtaining Development Approval for the 36 townhouses as part of the survey strata subdivision. It should be noted that for survey strata subdivision built from is generally required to be resolved at the stage subdivision application, which is not required for normal green title subdivision.

The architectural development leverages the learning of urban design and efficient compact, climate responsive housing from Stage 1, however a unique theme is being developed with the architects utilising alternative materials and colour schemes in a bid to respond to the built form character requirements of the local structure plan to explore industrial themes. The built form is expressed in the following diagrams (see Figure 5).

Figure 5 East Village Built Form cross section and perspectives (Source: spaceagency architects)

The marketing pitch for this East Village complex is as follows:

"… *as part of the Knutsford urban regeneration the East Village precinct represents an evolution in the delivery of state of the art sustainable housing with efficient design, innovative servicing and local identity at its core".*

The proposed built form reflects the industrial heritage (particularly through the sawtooth roof forms) of the area whilst acknowledging the materiality of more recent local development. The townhouses have been designed to be climate responsive and incorporate integrated renewable energy and water systems. Public and private greenspaces are linked to provide open space, shade and connectivity

The typical layout of the 9 m and 7 m town house configurations are presented in Figures 6 and 7 below. The designs are referred to as an 'upside-down house' typology, with the main living area on the upper floor, which maximises winter sun and passive heating. This configuration indicates that the main requirements will be lower level heating in winter and, possibly, upper level cooling in summer.

Figure 6 An example of the design for the larger dwelling type on the 9m wide block showing optional studio apartment / home office

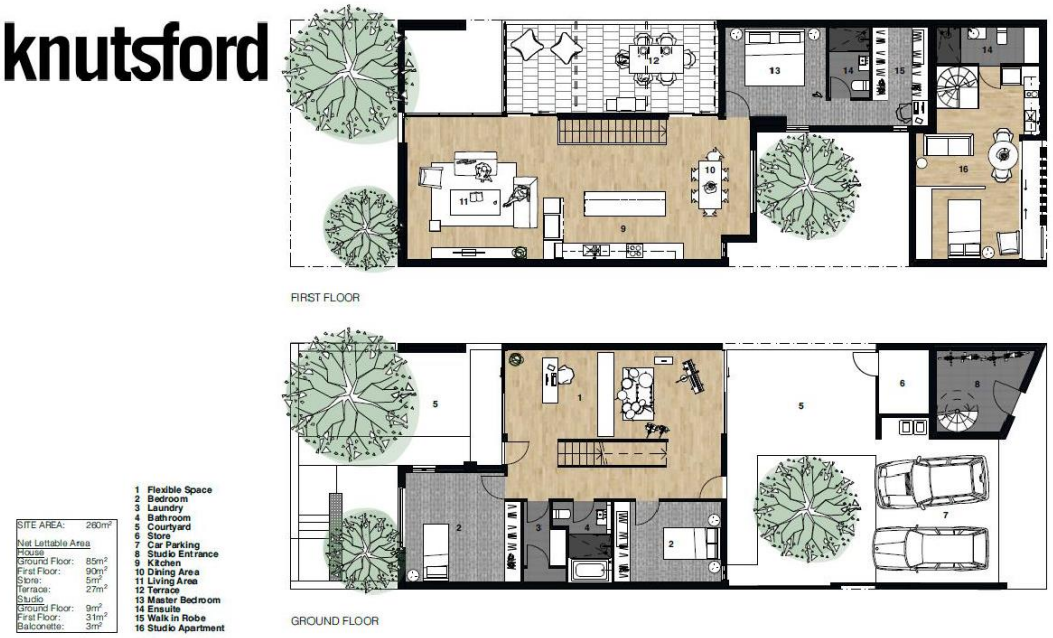
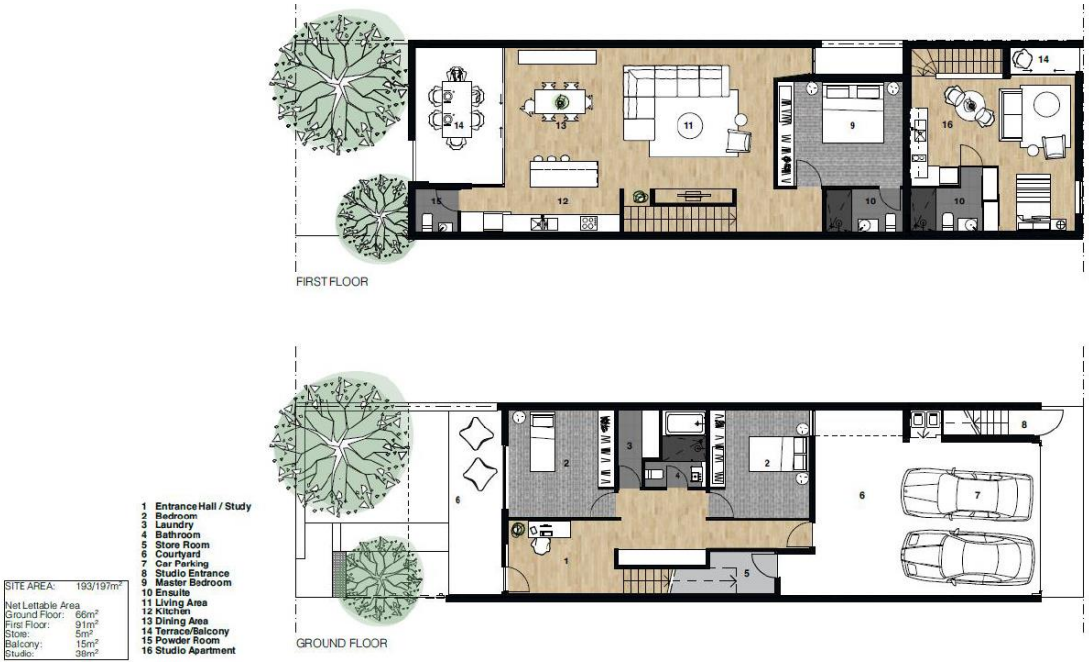


Figure 7 Figure 7: An example of the design for the smaller dwelling type on the 7m wide block showing optional studio apartment / home office



7. Energy System[3]

The energy system for the 36 strata lot precinct with East Village has been designed around the following energy vision:

a) Zero Energy Homes (ZEH) that produce more energy than they use over and average year, while achieving high levels of comfort and amenity. These will be all-electric, no gas homes.
b) An embedded network with a shared energy storage system that allows the homes to share excess onsite energy with neighbours to maximise local consumption of locally produced renewable energy. A citizen energy trading scheme to be enabled.
c) An Electric Vehicle (EV) ready development that allows for home charging of EVs. The electrical design allows for vehicle charging at the high end of home-charging rates, and energy requirements of EVs have been considered in the setting of targets and objectives for the project (with provision for electric bicycles and scooters are part of the overall strategy).

The system design process included comprehensive energy modelling to test outcomes and determine optimal sizing, particularly for photovoltaic and energy storage systems.

7.1 Energy system design and features

The design and conceptualisation of the energy system is summarised in Table 1: Summary of Energy System Configuration

Table 1 Summary of Energy System Configuration (Source JBA, 2018a)

Typology	Qty	Energy servicing
Site level (Survey strata section of the overall site)	1	Strata body holds the utility electricity account over the main utility meter. A shared battery sits on part of the common land in the survey strata, connected behind the utility meter to the embedded network. The survey strata manager operates the battery supported by PowerLedger as the billing provider.
Lots in the survey strata boundary Areas range approx. 200-270m2.	36	Private 'embedded' network within the survey-strata, private meters at each lot. No gas.
Townhouses (two frontage sizes: 7m, 9m)	36	Metering: Sub-metered for import and export of electricity. Billing: Billed by the strata body. Onsite energy: Mandatory/included PV system (5kW). Hot water: Heat pump. HVAC: Split AC to living areas. NatHERS: 7.5-star
Guest suites – additional living/sleeping spaces that could become ancillary dwellings if the lot owners seek approval from the City.	12	Metering: Sub-metered for import of electricity. Billing: Billed by the strata body (via the lot owner). Onsite energy: No PV. Hot water: Small electric storage unit – potentially in house. HVAC: Split AC. Covered in townhouse NatHERS rating.
Flexible spaces – integrated spaces that could be home	12	Powered from the townhouse electricity supply. Serviced as part of the townhouses.

3 This section draws directly from report by JBA (2018a) – Lot 1819 Energy Strategy – Review of Energy Options and Outcomes – prepared for LandCorp and RENeW Nexus- Smart Cities and Suburbs Program, July 2018.

Typology	Qty	Energy servicing
office or additional living space.		
Private road and two private lanes, public access way (PAW) spaces, and an area to the northeast of the townhouses for the shared battery, transformer and any related plant.	Common spaces	Public lighting will be private – expected to be wall mounted or bollard lighting, potentially with some streetlights on the private road. Assumed to be all LED and on sensors for motion and light levels. A shared bore will provide irrigation water for both the public and private green spaces, based on a sustainable yield that is designed to use less water than is infiltrated on the site over the year. A battery system will be connected to the embedded network to absorb excess PV generated electricity from dwellings and redistribute it within the strata.

The energy system involves the design and delivery of an embedded network that will service the 36 Townhouse survey strata site, with each lot being able to import from and export to the local network. The shared battery system will sit on common land and will import from and export to the local network according to a programmed algorithm. This energy strategy requires that an algorithm is designed to target maximum renewable energy use onsite.

In the future the 2 apartment (multi-residential) sites that could potentially be connected to the survey strata embedded network. This could be achieved virtually, or with a physical connection, if regulations and utility policies can be adapted to enable this configuration to be achieved.

All homes will install PV systems rated at 5-kilowatts minimum. This results in a total installation of 180-kilowatts for the site. This is sufficient for the site to achieve 'Zero Energy' status – producing more electricity than it consumes in private and common loads combined, on average across each year. These systems where considered at the earliest stages of architectural design and have been integrated into roof and shading design for the best aesthetic and functional outcome. To achieve the best balance of passive and active solar outcomes, the systems will be tilted to the north at around 20 degrees.

The key features of the designed in the project to manage energy demand profile is further summarised in Table 2 below which documents passive and mechanical / technology energy related systems.

Table 2 Passive and mechanical / technology energy related systems

Feature	Comment
Thermal performance	Designed to be 7.5 Star NatHERS rating
Orientation	Most dwelling oriented East West and designed as overall group to maximise north sun penetration
Insulation	Insulation of walls and roof to meet NatHERS rating (probably R5.0 roof and R3.0 walls depending on final assessment)
Glazing	Glazing selected to meet 7.5 start (LowE, higher spec single glazing)
Cross ventilation	Lay out provides for optimum air circulation
Thermal mass	Slab floors and masonry walls on south side to optimise winter heat retention (however open to builders proposing other construction methods/solutions)
Shading	Fixed shading systems to optimise summer sun protection
Building Sealing / infiltration testing	A sample of homes to be tested. Build will target 7-ACH50.
Landscape integration	Landscape design integrated into overall design to help ameliorate microclimate
Heating Ventilation and Air-conditioning (HVAC)	Split AC systems
Hot Water systems	Heat pump' is the proposed system. Most likely these will be split units with the condenser on the roof and storage tank on the ground,
Common area lighting	Lights to be LED with motion sensors
Common water pumping loads	Water for irrigation of public and private spaces will be supplied by a community groundwater bore – using a variable speed pump and control of pumping times to make optimum use of renewable energy
Electric vehicle charging	EV charging will occur at home and there will be a fast charge facility that can be used by any one located within the facility
Appliances	A "Smart appliance package" for some household white goods is being considered as part of the home package
Monitoring	Comprehensive information on energy and water use and potentially on other metrics will be supplied through an online interface. Residents will have the option of sharing their data with researcher, subject to rigorous ethics controls, to ensure learnings from this project are captured.
Education	Living Smart, or similar course in sustainable living course to be offered to all purchasers / residents
PV	5-kilowatt rooftop PV arrays, connected to the private embedded network though a 5-kilowatt inverter.

Battery / energy storage	An embedded network based energy storage system consisting of a battery with a 670kWh storage capacity with 100kW maximum power

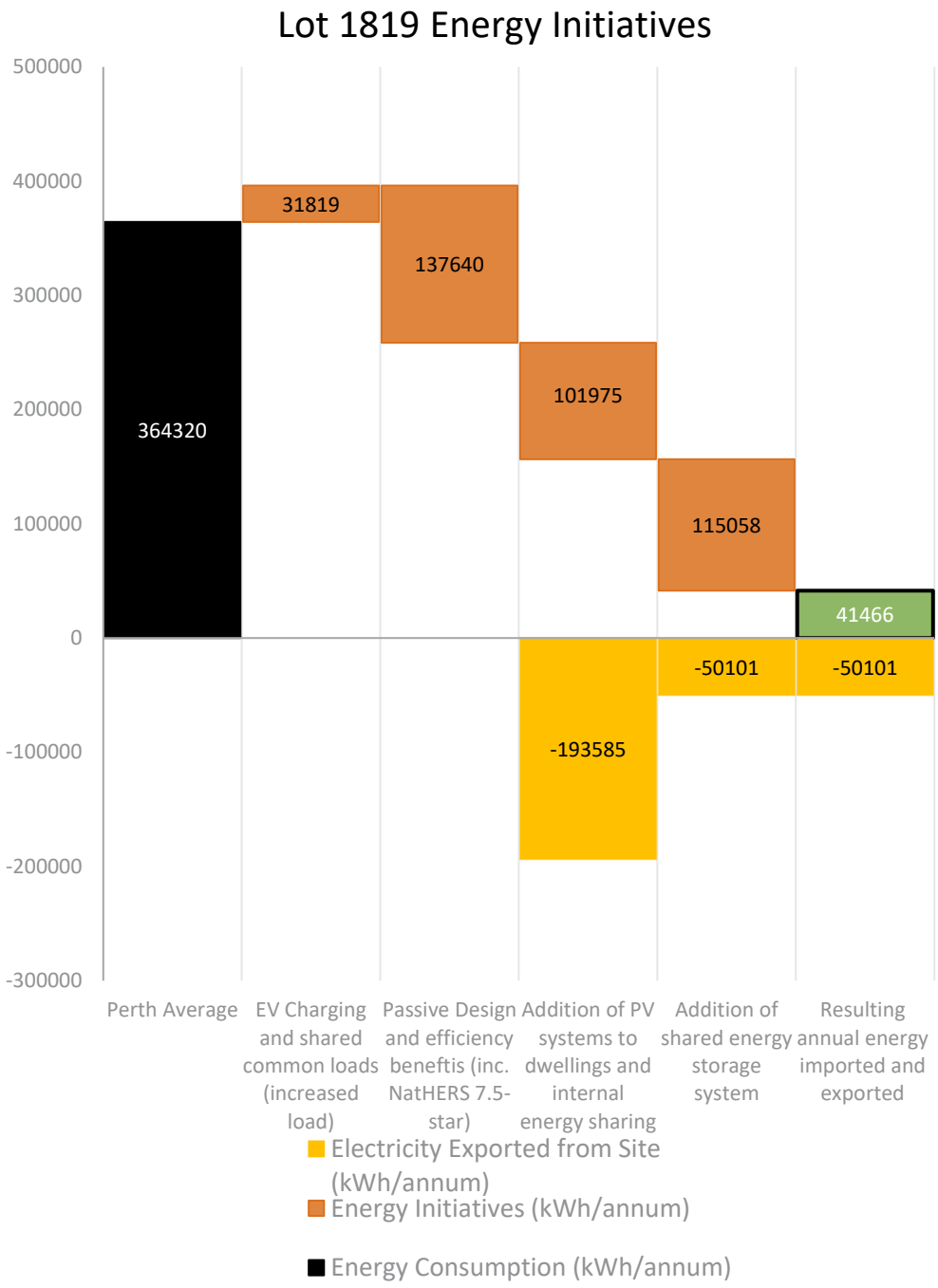
7.2 Modelled performance

The performance of the systems has been modelled based on the assumptions and configuration outlined above and shows is a slight increase on business-as-usual due to the common lighting and water pumping loads that are shared by residents, and because of the anticipated EV charging loads. The Figure 8 below shows the three main performance improvement elements of this strategy:

a) Dwelling design and systems choices, such as the 7.5-star NatHERS rating and smart appliance choices, reduce electricity imports by around 35%. The development is grid reliant for 65% of electricity requirements.
b) Solar photovoltaic (PV) systems meet loads directly while the sun is shining and, because of the embedded network, can be exported directly to neighbours. Electricity imports are reduced by up to a further 26%. Grid reliance has been reduced to 49%. Around 60% of the PV electricity generated on site is exported at this stage.
c) The battery system enables the locally produced renewable energy to be stored and drawn on when required by households within the embedded network. Grid reliance is expected to be approximately 20% in winter months.

Electricity exports exceed imports by approximately 17%, meeting the commonly used definition of a ‘Zero Energy Development’ in that more onsite energy is produced than is consumed on an annual average.

Figure 8 Energy Strategy Waterfall Chart (Source: JBA 2018a)



The modelling results based on this energy strategy are shown in the Table 3 below.

Table 3 Modelled Performance Highlights (Source JBA 2018a)

Metric	Quantity
Annual consumption	258 MWh/year
Energy imported from grid	42 MWh/year
Energy exported to grid*	50 MWh/year
Renewable energy fraction (load met by renewable energy)	84%

*If permitted by regulations. This could also be energy sold on through a trading platform such as PowerLedger's.

8. Water system[4]

The water system design for the East Village site has been a key element of the design and innovation process. This section provides a summary of these features as well as documenting modelled performance.

8.1 Water system design and features

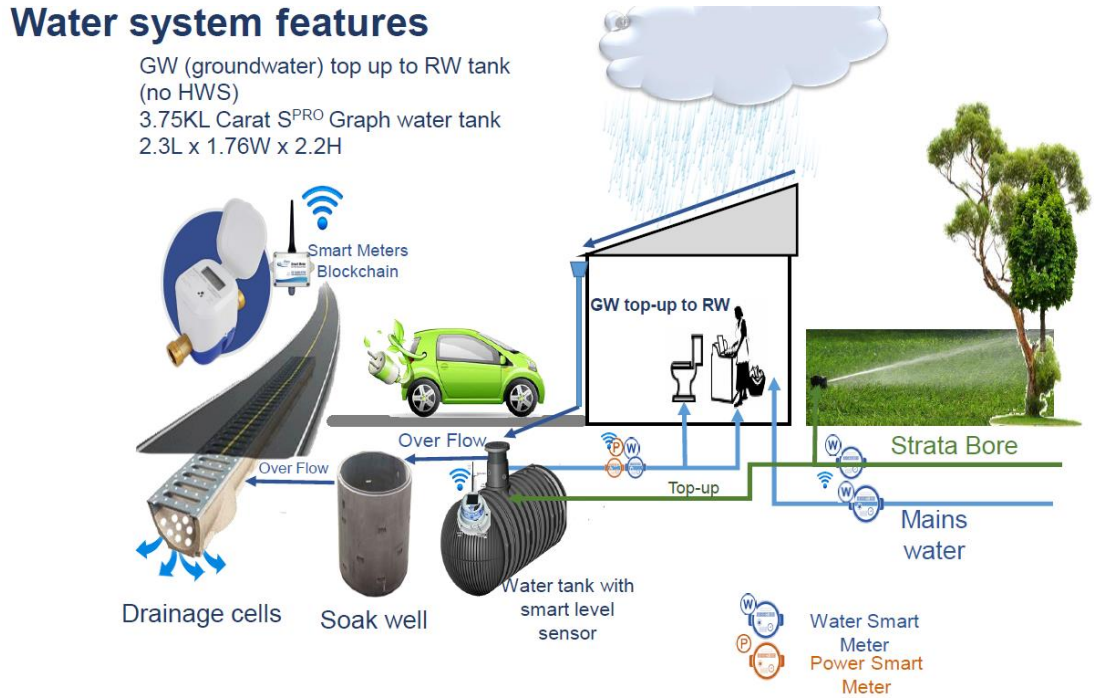
As part of the approval process an Urban Water Management Plan (UWMP) has been prepared in line with the Better Urban Water Management (BUWM) guidelines of the Western Australian Planning Commission (WAPC, 2008). The UWMP describes water efficiency and innovative measures, groundwater and stormwater design and management as well as identifying monitoring requirements for the site in addition to the on-going research and data gathering process.

Outlined below in Table 4 are the key features of the water system design set out against the requirements of the UWMP. The initiatives developed for the 36 townhouse component of the development were derived from a comprehensive analysis of options ranging from 'on-site only' systems (e.g. greywater reuse, plumbed rainwater) through to whole-of precinct scale wastewater recycling and aquifer recharge schemes. A range of criteria were used to rank the options and it included estimated water savings, site suitability, regulatory constraints, risk management and estimated costs to install and maintain. A water balance model was developed and uses as part of the systems comparisons and design process. A graphical representation of key features of water system is presented in Figure 9 below.

The confined nature of the site has meant that opportunities for vegetated infiltration solutions to manage stormwater are limited. In response, subterranean infiltration galleries beneath the street and both laneways in associations with plumbed rainwater tank systems to all townhouses are being installed. This will be combined with limited vegetated WUSD features as part of the landscape treatments.

A comprehensive sub-metering program, with real-time data display, will be included in the development as part of the proposed block chain peer-to-peer water (and power) trading platform. This represents a first in WA (and possibly globally) and will provide a unique on-going dataset of water consumption, which can be used to inform improved water management and efficiency. The mains water savings resulting from alternative water sources in residential dwellings will be assessed, as will the performance of the supporting technologies including strata (shared) bore and plumbed rainwater systems.

Figure 9 Graphic illustrating of key elements of the water system at East Village (note final design was slightly modified) (Source JBA presentation material)



4 This section draws directly from report by JBA (2018b) – Urban Water Management Plan for Lot 1819 Blinco St, Fremantle - prepared for LandCorp and RENeW Nexus- Smart Cities and Suburbs Program, August 2018

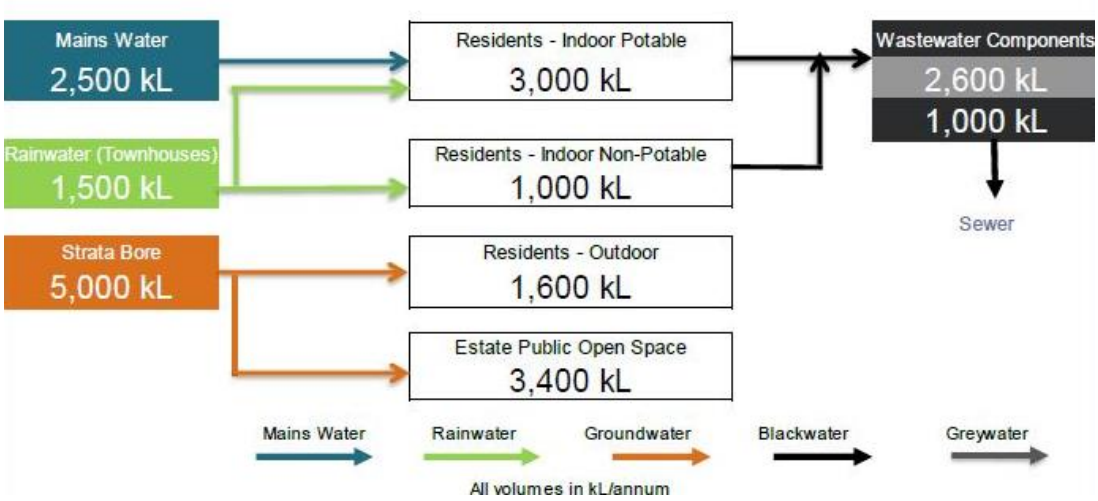
Table 4 Water System design objectives and measures (Source JBA 2012b)

Design Objective	UWMP Compliance
	Water Sustainability Initiatives
No potable water to be used outside of homes.	Achieved through the installation of a strata owned and operated shared bore reticulated with sub-metering to all lots and common spaces for irrigation.
Mains water consumption target of less than 40kL/person/year.	A per capita mains water consumption of 23kLpa is achieved through an integrated combination of a 7kL below ground rainwater tank plumbed to toilet, washing machine and hot water system; water efficient fixtures and shared bore supply for irrigate on, for each townhouse.
	Stormwater Management
Maximise on lot infiltration of stormwater using WSUD.	Up to the 20-year ARI (average recurrence interval) rainfall event will be retained and infiltrated within all individual lots except for corner lots.
Maximise whole of site infiltration of frequent stormwater using WSUD.	Permeable paving will be installed in the two laneways and street and stormwater directed into the public access ways (PAW). The 5-year ARI event for road runoff will be conveyed within the piped network and larger events conveyed within the road reserve.
Manage the critical 100-year ARI event using WSUD.	The 100-year ARI event road runoff will be retained in underground infiltration cells beneath the road and laneways.
	Groundwater Management
Construction water.	No dewatering for construction is required.
Ensure sustainable use of the local shallow aquifer.	A whole of site water balance allowing for rainwater tank demand, groundwater abstraction (shared bore), evapotranspiration and stormwater infiltration indicates that recharge exceeds abstraction by approximately 500kL in an average rainfall year.
	Management of Subdivision Works
Best practice management of subdivision works.	Dust management, erosion and sediment controls and maintenance of infrastructure will all be implemented to ensure the impacts of construction are minimised.
	Monitoring
High quality water-based data to help inform future developments.	Smart metering of all water sources (mains water, rainwater and bore water) will be embedded throughout the development to capture real time data for research and performance monitoring of initiatives.

8.2 Modelled performance

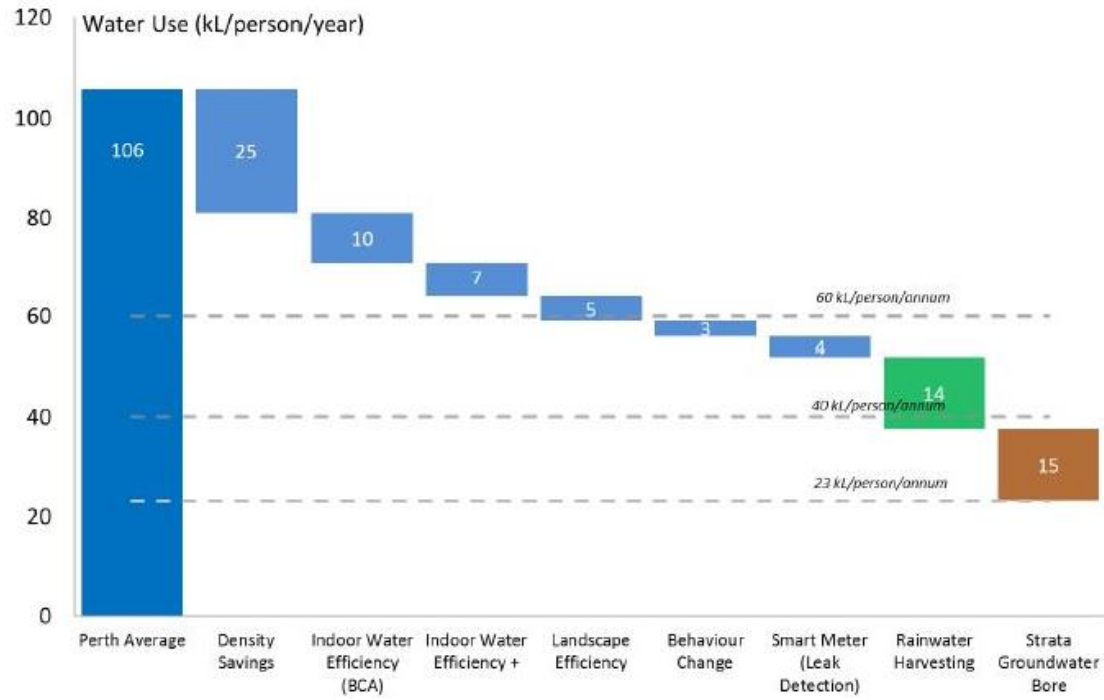
As indicated above a detailed water balance was developed and analysed as part of the options analysis process. Figure 10 provides a schematic of the water balance for the Townhouse component of the East Village site, highlighting water sources and calculated usage on an annual basis.

Figure 10 East Village Site Water Balance – Townhouse component (Source: JBA 2018b)



The modelled per person reduction is scheme water is established at 40 kl / annum / person, which is 60% predicted reduction. Figure 11 provides a water fall chart illustrating the modelled savings.

Figure 11 Residential per person water consumption illustrating efficiency measures and calculated savings against Perth Average per person (Source: JBA 2018b)



9. Precinx Modelling

Modelling of the energy and water performance was also undertaken independently, of the as designed project by Kinesis (see www.keneis.org) as documented in a report titled “KNUTSFORD EAST VILLAGE PRECINX Analysis Report”. The key findings of that analysis are summaries below. The full report is provided in Appendix 2.

The Townhouses – Findings

The townhouses will be carbon positive >100% reduction in residential emissions relative to the reference case – which is a code compliant equivalent development. This reduction is largely achieved by the PV Instillation and battery.

There will be a 40% reduction in electricity peak demand across the development due to the efficiencies, solar PV and battery.

The battery limits the solar PV export, but 200kWh of export is still expected in a typical summer day, with no export in winter.

More than 40% reduction water consumption is expected relative to the reference case. Reductions are achieved from the rainwater reuse and community / strata bore water use for irrigation.

These results give an expected 35% reduction in household utility expenditure on water and energy relative to the Perth metro average.

The Apartments – Findings

There is a modelled 17% reduction in residential emissions relative to the reference case - – which is a code compliant equivalent development. This reduction is largely driven by the solar PV instialtion on the adjoining townhouses, which will supply suplus energy to apartments via the battery.

There will be a reduction of 40% in electricty peak deman across the development expected due to efficiencies.

There is an expected 10% reduction in water consumption relative to the reference case from efficient fixtures and the bore water use for irrigation.

There will be an expected 20% reduction in household expenditure on energy and water realtive to the metro average.

Summary

This summary and the more detailed analyse presented in the appendix illustrates a good degree of consitency between the modelling undertaken by JBA as documented in the eaalier sections of this report.

For the apartments the expected 35% reduction in household utility expenditure on water and energy relative to the Perth average represents in the order of a $1,300.00 per year saving to the householder.

Further, although design development has not occurred for the apartments modelling provides an expected 20% reduction in household utility expenditure on water and energy relative to the Perth average, providing approximately $500.00 in household savings.

A further point not fully assessed in this process are the affordability benefits of those residents who take up EVs, making their life style almost fully off grid and close to carbon neutral for household and family transport.

10. Legacy Living Lab[5] and Mirreco

Another key innovation being incorporated in the East Village project is a research/innovation hub/modular facility referred to as the Legacy Living Lab (or L3). This section provides a brief description of the concept at the point where detailed design has been complete and approvals are presently being initiated.

This facility is being developed as partnership between Fleetwood Australia (a modular construction company), LandCorp and Curtin University. The facility will be a modular construction which will demonstrate the circular economy principles, providing an example of a building designed for disassembly and adaptable reuse. It is envisioned that its first life cycle will commence in 2019. It will be constructed on a townhouse site in adjacent to the location of a battery facility. It will occupy this location until the site is required for development when it will be disassembled and re located – potentially to another part of the Knutsford Precinct. Figure 11 below provides an indication of the facility style and appearance.

From the project point of view, among other functions (e.g. research facility, start-up incubator and accelerator etc.) the facility provides some initial activation of the East Village site and will provide a venue for visualisation, demonstration of various innovations being incorporated into the East Village Townhouse complex. There will be the ongoing opportunity for industry and research partners to work together on circular economy, and modular building products. For example, the industry partner commitments include:

Jason Windows are considering the use the facility to test a range of double glazing window techniques including testing systems for modifying and adapting existing window systems;

Armstrong Flooring aim to test a new vinyl flooring system built decreasing material consumption and take back the flooring to recycle;

Interface Carpets are suppling used product from other projects and will foster closed-loop supply chain approach through a take back policy;

Weathertex's external timber cladding is made out of Australian timber, no glues, binders or formaldehyde used;

Quantify home automation systems will show the building thermal performance (electricity consumption/temperature etc.). Its integration with Amazon Alexa permits energy saving through smart homes functionality.

L3 has been designed to provide space for visualisation, commercial – or co- worker space, prototyping and display space for the adjoin townhouse and apartment developments. The facility will also be equipped with smart visualisation technologies in the first phase of a nationally networked research collaboration referred to as iHUB. Examples of the data that will be visualized are: data gathered from the peer-to-peer energy and water trading, energy accumulated in the shared battery, benefits related to the application of the circular economy principles, the building electricity consumption, internal/external temperature and so forth. The iHUB is a nationally networked digital platform that will enable researchers from Swinburne University, University of New South Wales, Monash and University of Queensland to collaborate on urban research projects.

Adjoining the L3 complex will be the temporary installation of MIRREC's 'Lumecast' display dwelling made from MIRRECO™CAST (Carbon Asset Storage Technology) Hemp 4.0 building panels. This project will display the company's hemp polymer panel product that is being developed for for the floors, walls, partitioning and roofing. The display seeks to test the CAST panels which can be manufactured (site-ready) in less than an hour, and are greener, cleaner and faster than anything else in the market.

5 This section is based on material provide by Roberto Minunno and Tim O'Grady, Curtin University PhD candidates who have developed and facilitated the concept with the support of Professor Greg Morrison, the Director of CUSP.

Figure 12 Renders of the Legacy Living Lab and its location at the East Village - Knutsford

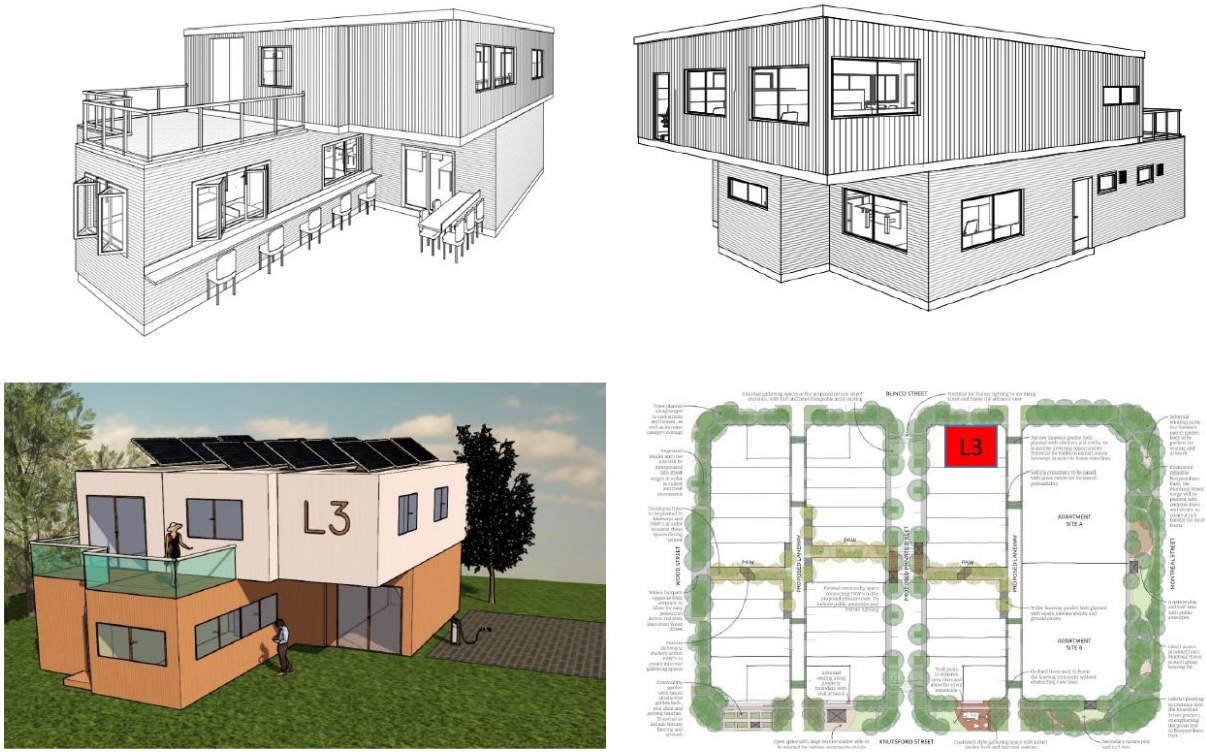
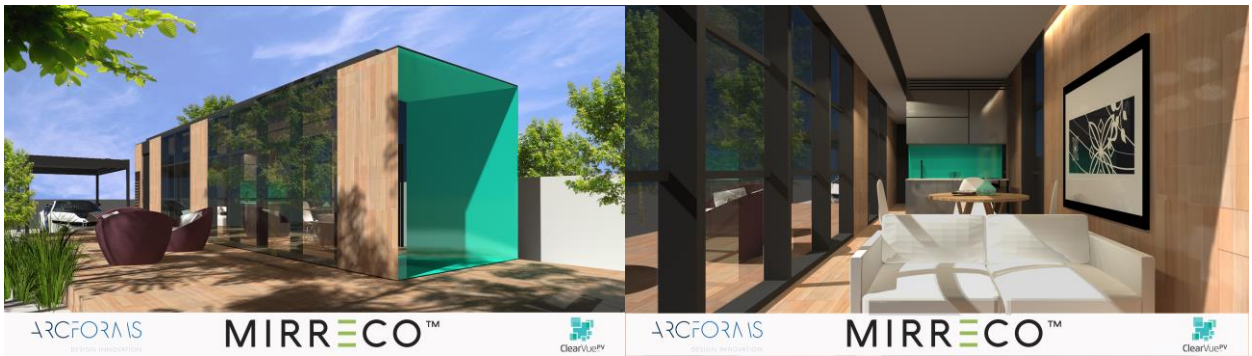


Figure 13 Renders of MIRRECO's 'Lumecast' display dwelling – constructed from



11. Governance – Citizen Utility

One of the key innovations in this project is the application of the Citizen Utility model developed as part of the WGV project for apartments managed as built from strata arrangements. In particular this project extends the so-called Citizen Energy Utility (or Energy Governance Model) 6 developed at WGV for apartment complexes and applies the model within the survey strata complex of 36 townhouses. This governance arrangement manages solar power, battery storage and local water systems. In schematic form the overall systems are depicted in Figure 12.

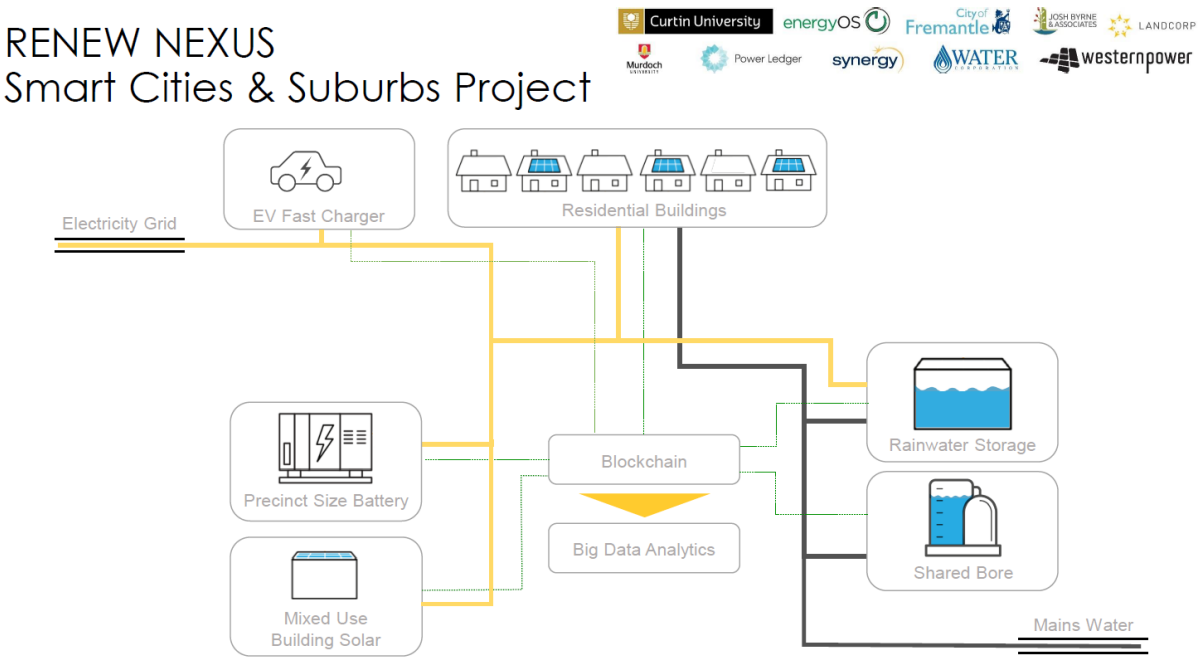
Stata management arrangements for survey strata complexes are nothing particularly new. What is innovative and demonstrated here is addition of number of 'utility' type functions within the management agreement established for the complex.

The key features are:

- East Village will be an embedded network/microgrid - 1 master meter connected to the Western Power network with 40 sub meters behind it (36 homes, 1 battery, 1 solar on battery, 1 common supply and 1 for EV fast charger)
- The microgrid will be owned by the Strata company (owners)
- PV systems on each of the townhouses will export excess PV energy production to the embedded network and the battery, which will then make that energy available to meet loads in other townhouses, and at other times when demands are high.
- The battery will be configured to import and store electricity for the purpose of minimising the electricity consumed from the Western Power network
- An Electricity Retailer for this site will be established as part of the strata management arrangements.
- Battery - 670 kWh with 100 kW inverter
- Assembled and commissioned in WA - currently onsite in Knutsford
- Battery will be owned and operated by Power Ledger under a Service Agreement with the Strata at East Village
- Residents of East Village (and surrounding apartments over time) will buy storage space in the Battery from Power Ledger - pricing arrangements are not yet finalised
- Each home will have a 5 kW Solar system
- Each home will include an EV charging circuit to the garage.
- The complex will have a dual use fast charge EV Charger
- There will be a Living Lab (see section 10) on site from the second half of 2019 which will store and display the data and information on both East Village and WGV projects.

6 Green, J. & Morrison, G. (eds) (2018) Citizen Utilities: Unlocking Australian Strata Development to the benefits of Solar and battery storage innovations - A report for the Australian Renewable Energy Agency. Arena Industry Report.

Figure 14 Schematic representation of the physical elements of the citizen utility model overall at East Village



12. Summary

The outline of the East Village complex documented above illustrates a leading-edge commitment to sustainable and resilient urbanism.

It illustrated a commitment by LandCorp to ongoing demonstration of innovation.

The key features of this project are:

a) A development that integrates built form, landscape, water and energy systems in innovative way
b) Use of the survey strata system a method of governing innovative water and energy systems within a Citizen Utility model
c) The value of partnerships and relationships between industry and research to deliver innovative projects at the leading edge of innovative design and technical innovation.
d) The commitment of a project team under the guidance of committed leadership at LandCorp to test and progressively de-risk a series of innovation within the project illustrated what can be achieved.

APPENDIX 1 – East Village – Knutsford Infrastructure cost comparisons

The table below presents a summary of cost comparisons between the 'as designed construction costs' and estimates of built as usual (BAU) development. In this case, the comparison is being made between an equivalent green title subdivision of a comparable configuration to the 36 townhouses being developed as a survey strata complex. It is very important to note that a direct comparison is not always highly relevant and a commentary is provided which is an explanation of reasoning of the key design solution implemented. Acknowledgment: Information provided by TABEC and JBA – consultants to LandCorp.

Infrastructure element	BAU – estimated costs for equivalent green title complex of 36 Townhouses	East Village – as designed costs for 36 Townhouse – survey strata	Commentary
Power	Cost assumptions to provide power to each lot and road lighting	Internal power and lighting costs work with the strata complex	
	Power supply and street lighting allow $7,000/lot. So 36 townhouses x $7K = $252,000	Power supply to meter -$128,719	
	Payment to Western Power to remove the existing overhead power cables on the boundaries of the project, allow $140,000.	Payment to Western Power to remove the existing overhead power cables on the boundaries of the project, allow $140,000.	Same requirement
	Estimated sub-total: $392,000	Costed sub-total excluding local energy system : $268,719	Base case comparison
		Local energy system elements Battery system, plus Site Main Switchboard etc: $510,000 Solar panels for each dwelling estimated at $3,500/5kWp = $126,000	Battery system suppled as part of ReNew Nexus project – outside of project budget. Solar panel cost inside dwelling build price, estimated as bulk purchase contract.
		Costs with Local energy systems: $904,719	

Water - mains	Cost assumptions to provide standard mains reticulated water to each dwelling	Strata development water reticulation costs	
	External mains upgrades and extensions: $137,800	External mains upgrades and extensions: $137,800	Same upgrade requirements
	Internal reticulation: $32,085	Internal potable water reticulation: $57,278	TABEC Comments : more pipework is required internally since all lots must be served through the master meter (rather than direct connections to mains in the street) under a strata development. Also, the extra cost includes the master meter, backflow prevention device and connection.
	Water Corporation Headworks charges $190,000	Water Corporation Headworks charges $128,932	TABEC Comments : The Water Corporation water supply and wastewater infrastructure contributions are based on meter size and flow rate, and Single Residential Equivalents for strata developments, so they are reduced accordingly. See this website for more info: https://www.watercorporation.com.au/home/builders-and-developers/building/fees-and-charges/infrastructure-contributions/meter-based-contribution-table
	Sub-total: $359,885	Sub-total: $324,010	Base case comparison
Non potable water for irrigation	Nil	Non-potable, strata bore water for public and private open space :	
	Nil	Non-potable water supply reticulation to dwellings: $40,527 Allowance for a new bore – estimate-allow $60,000	$60K is for the bore and headworks only (not irrigation) though as mentioned, only 25% of this cost should be applied to the Civil establishment as

		Irrigation cabinet and controller $3,800 Metering - $14,400 (assumes 40 meters at $360 each Telemetry - $12,000 (assumes 40 at $300 each) Sub total $130,327	a bore would have been installed anyway to service normal irrigation.
Sewer	Cost assumptions to provide standard sewer connections to each dwelling	Costs to provide standard sewer connections to each strata dwelling	
	External sewer connection from the site to the existing Water Corporation mains: $103,858	External sewer connection from the site to the existing Water Corporation mains: $103,858	
	Additional mains within development – estimate $38,000	Internal private plumbing to service the strata subdivision is: $44,200	TABEC Comments : TABEC: Additional clean-out and inspection points are included on the internal sewer design, prior to connecting to the Water Corporation sewer in Blinco Street.
	Sub-total estimate for standard de: $141,858	Sub-total: $148,058	
Stormwater Drainage	Cost assumptions to provide standard gully pit and piped system to off-site infiltration sump	Stormwater drainage design includes retention of the 100 year event below ground in storage cells	
	Pits and stormwater pipework: $68,000	Drainage pits, pipes and underground storage cells: $98,795	
	Fenced infiltration sump: allow $25,000, excluding the land take required	Soak wells within lots to offset the storage requirements underground storage cells in road and lanes: $91,850	The alterative in a normal green title project would have normally required the provision of land – approximately 400m2 for the provision of an infiltration sump. No land was available for infiltration sump, however at least $500,000 may have been required in terms of land value if a traditional solution was applied.

	GPT: $35,000	Rainwater collection tanks for re-use: $156,600	
	Sub-total: $128,000	Sub-total: $347,245	

KNUTSFORD EAST VILLAGE

PRECINX Analysis Report

February 2019

www.kinesis.org

KINESIS

Summary

Townhouses

- **Carbon positive townhouses. >100% reduction in residential emissions** relative to the reference case. Reduction is largely driven by solar PV installations in attached dwellings.
- **40% reduction in electricity peak demand** across the development expected from efficiencies, solar PV and battery.
- The battery limits solar PV export but 200 kWh of export is still expected in a typical summer day. No solar PV export will be expected in winter.
- **More than 40% reduction in water consumption** expected relative to the reference case. Reductions are largely driven from rainwater reuse and bore water use for irrigation.
- **Nearly 35% reduction in annual household expenditure** on energy and water relative to the metro average.

Apartments

- **17% reduction in residential emissions** relative to the reference case. Reduction is largely driven by solar PV installations in attached dwellings.
- **40% reduction in electricity peak demand** across the development expected from building efficiencies
- **More than 10% reduction in water consumption** expected relative to the reference case from efficient fixtures and bore water use for irrigation
- **Nearly 20% reduction in annual household expenditure** on energy and water relative to the metro average.

Development Details

Precinct details	
Precinct area	1.52 ha
Road area	0.3 ha
Retail GFA	150 sqm
Number of dwellings	116 dwellings
Attached – townhouses	36 dwellings
Multi unit – apartments	60 dwellings
3 bed apartments	8 dwellings
2 bed apartments	30 dwellings
1 bed apartments	22 dwellings

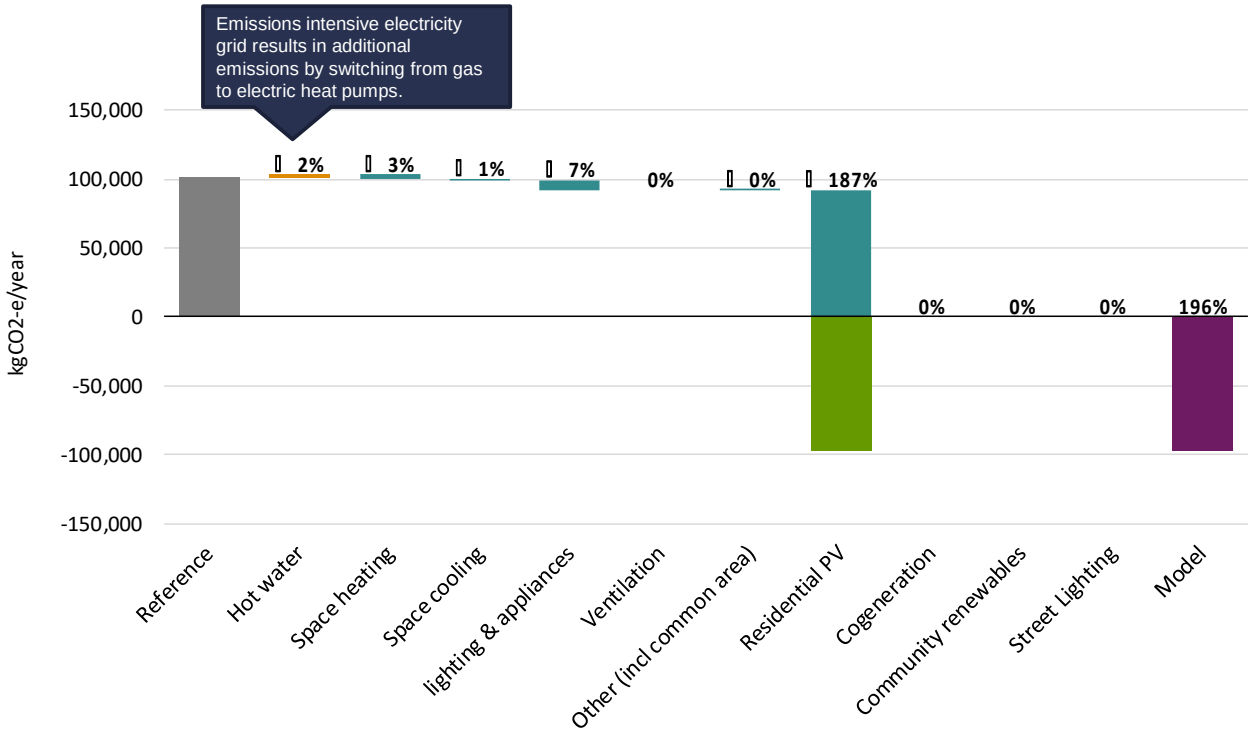
36 Townhouses

Scenario Analysis

Precinct Details	Reference Case	Modelled Case
Energy		
Thermal Performance	6-star	7.5-star
Energy Appliance – Dishwasher	2.5 star Energy	3.5 star Energy
Hot Water	Gas	Electric Heat Pump
Space Heating + Cooling	2.5 star A/C	3 star A/C
Lighting	Standard (Fluoro/ Halogen)	LED Lighting
Solar PV	None	2.5 kW
Battery	None	670 KWh, 100kW
Car park lighting	Lighting motion sensor	Lighting motion sensor
Car park ventilation	None	None
Street lighting	Standard	LED
Water		
Fixtures	Standard	Efficient
Landscaping	Standard	Waterwise
Rainwater reuse	None	7.5 kL tank – hot water, toilet & washing
Community bore	None	Irrigation and street scape

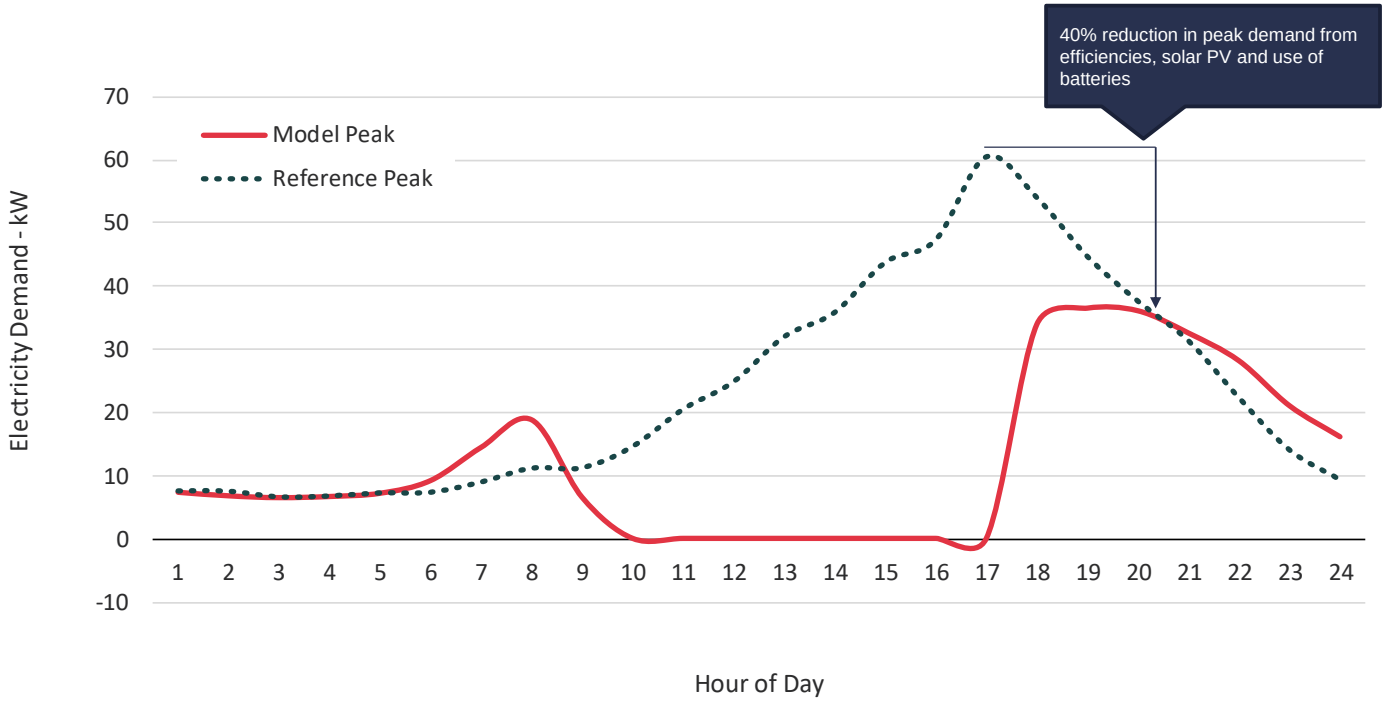
Energy and Carbon Analysis of 36 Townhouses

Residential Emissions Reduction relative to Reference Case



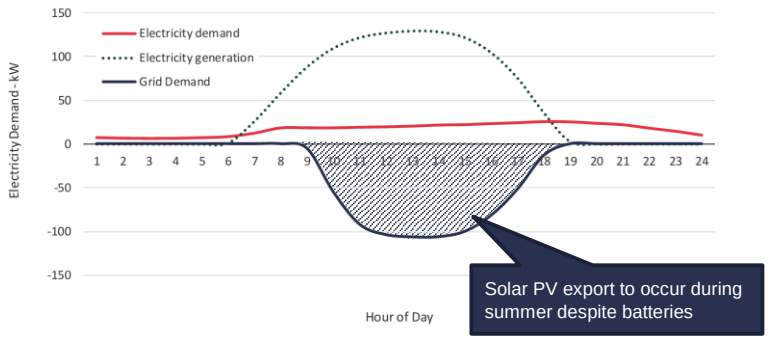
Energy and Carbon Analysis – 36 Townhouses

Peak demand reduction

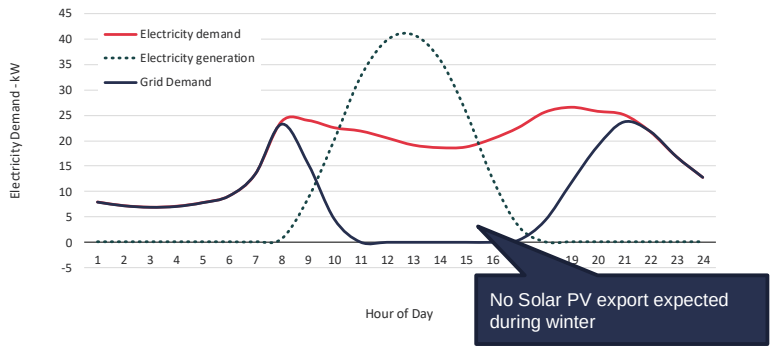


Energy and Carbon Analysis – 36 Townhouses

Summer average load profile

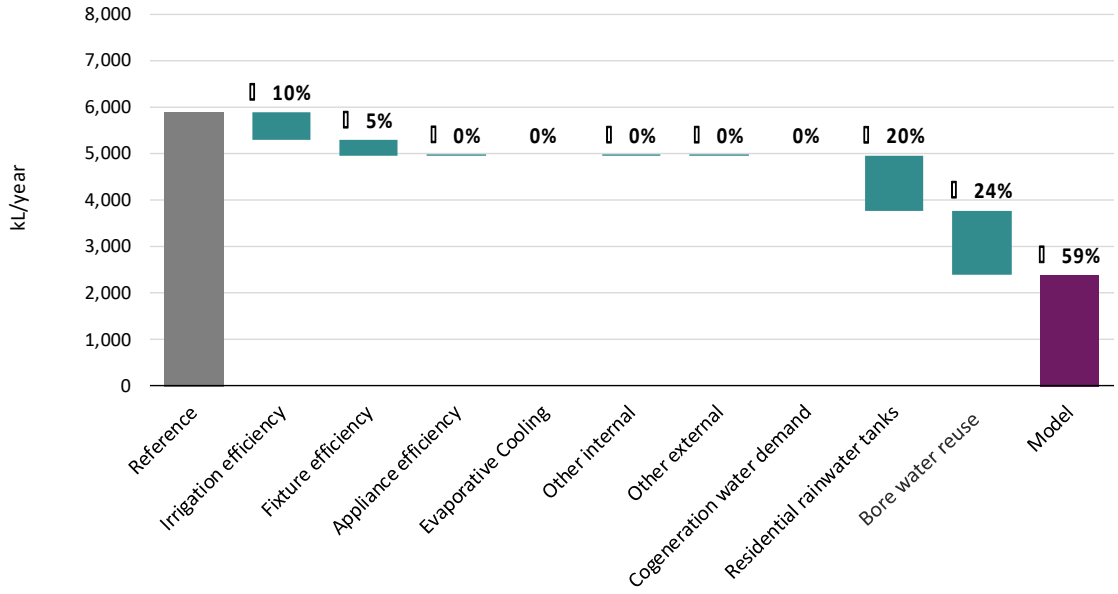


Winter average load profile

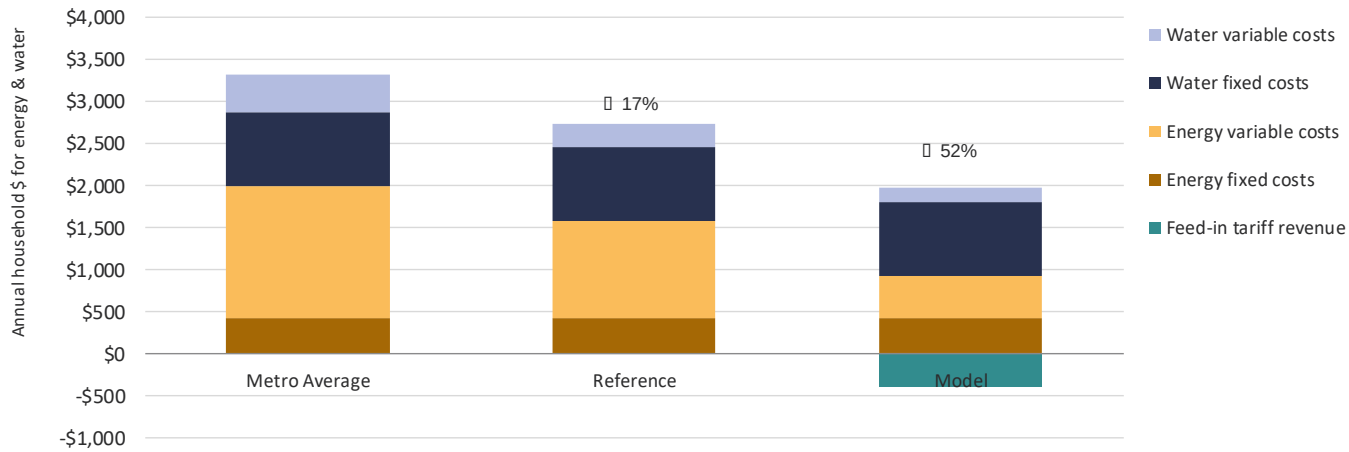


Water Analysis of 36 Townhouses

Residential Water Reduction relative to Reference Case



Affordability Analysis – 36 Townhouses



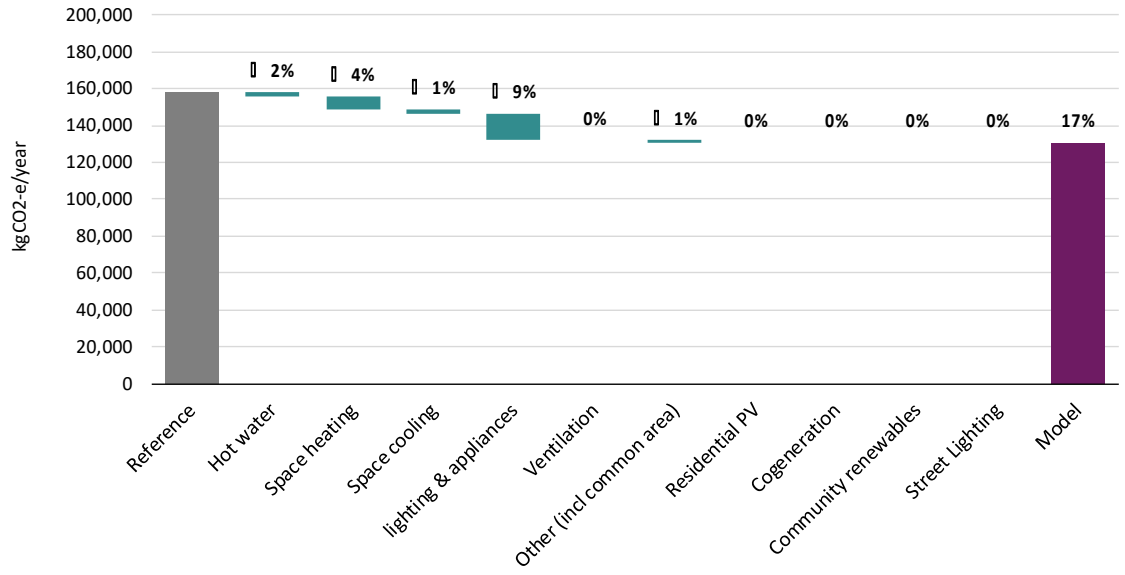
60 Apartments

Scenario Analysis

Precinct Details	Reference Case	Modelled Case (Designed to deliver 4 Green Star Communities Points)
Energy		
Thermal Performance	6-star	7.5-star
Energy Appliance – Dishwasher	2.5 star Energy	5 star Energy
Hot Water	Gas	Gas
Space Heating + Cooling	2.5 star A/C	5 star A/C
Lighting	Standard (Fluoro/ Halogen)	LED Lighting
Solar PV	None	None
Battery	None	None
Car park lighting	Lighting motion sensor	Lighting motion sensor
Car park ventilation	None	None
Street lighting	Standard	LED
Water		
Fixtures	Standard	Efficient
Landscaping	Standard	Waterwise
Rainwater reuse	None	None
Community bore	None	Irrigation and street scape

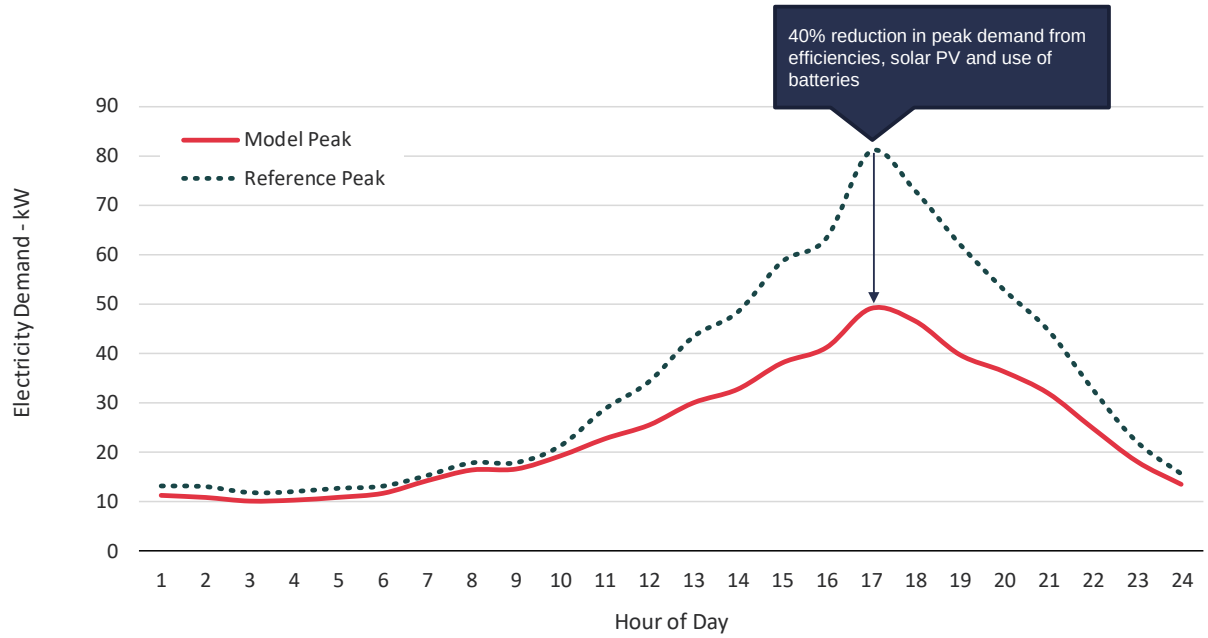
Energy and Carbon Analysis @60 Apartments

Residential Emissions Reduction relative to Reference Case



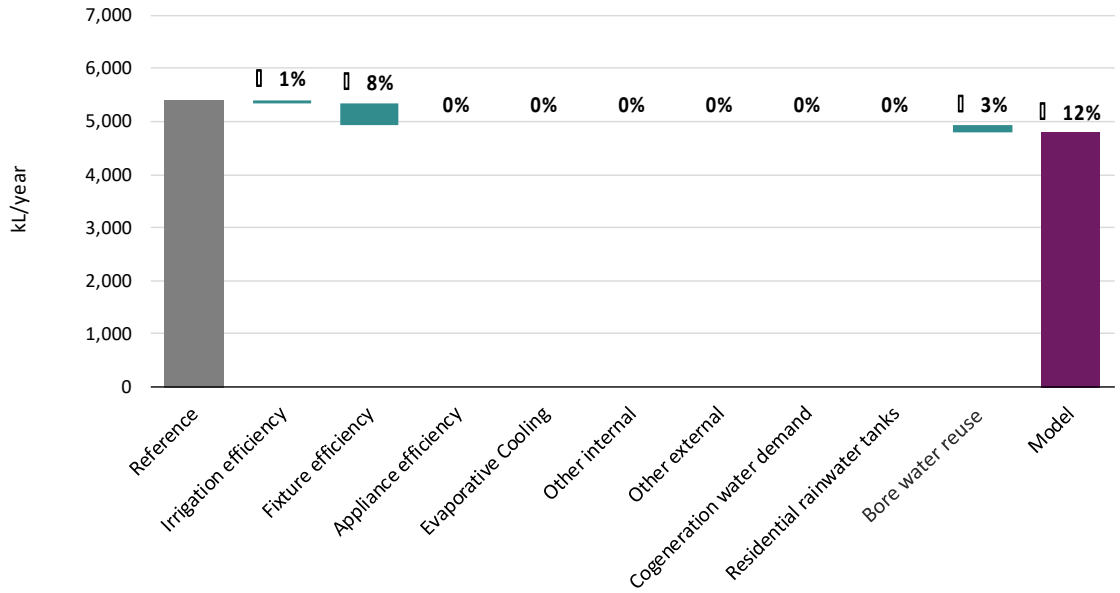
Energy and Carbon Analysis – 60 Apartments

Peak demand reduction



Water Analysis of 60 Apartments

Residential Water Reduction relative to Reference Case



Affordability Analysis – 60 Apartments