CITY OF CANNING

CITY CENTRE C^{CAP} PRECINCT ANALYSIS SUSTAINABILITY REPORT

Prepared by Kinesis for the City of Canning

August 2012

kinesis

Contents

Executive Summary

Kinesis were engaged by the City of Canning to quantify the sustainability performance of the Canning City Centre Structure Plan.

Under a Business as Usual scenario, the Structure Plan is estimated to increase:

- Residential dwellings by **800% to 13,728 dwellings**
- Commercial and retail floor space by **45% to 781,666 m2**
- Increase greenhouse gas emission by **178% to 139,000 tonnes CO2-e/year**
- Increase water consumption by **168% to 2,400 ML/year**

Using the C^CAP Precinct sustainability modelling tool, two stages of sustainability intervention were explored with the City of Canning in a workshop on 17th April 2012 to mitigate the increase in resource consumption across the site (see Table 1):

- **Demand side strategies**, incorporating energy and water efficiencies, improved building thermal performance and household travel mode shift through lower parking rates and improved public transport access. These demand side strategies are achieved through building design specifications.

- **Supply side strategies**, incorporating solar energy, trigeneration and water recycling. These supply side strategies require close consultation with key stakeholders, including land owners and utilities to ensure the appropriate combination of energy and water technologies to meet both the sustainability, financial and network objectives for the site.

Compared to the Business as Usual scenario, these demand and supply side strategies (**Workshop Scenario**) are estimated to achieve:

- **45% reduction** in precinct greenhouse gas emissions

- **49% reduction** peak electricity demand

- **35% reduction** in total water consumption

In addition, under the **Workshop Scenario**, **compared to an average resident in the Perth Metropolitan Area**, a resident living in the Canning City Centre is estimated to:

- **Emit 35% less** greenhouse gas emissions

- **Consume 63% less** potable water

- **Drive 21% less** kilometres

- **Spend 12% less** on energy, water and transport operating costs

The results from this **Workshop Scenario** are achieved at an estimated marginal capital cost of approximately **$90 million** or **$36 per m²** of constructed floor area.

Summary of Scenarios for Canning City Centre

Strategy	Business as Usual Specification	Demand Side Strategies	Demand + Supply Side Strategies
Thermal Efficiency	• Residential 5-star NatHERs rating. • Non-Residential - Building Code of Australia Section J compliant.	• Residential 6-star NatHERs (approximately 70 MJ/m²/year of heating and cooling demand). • Non-Residential - 30% improvement in building thermal demand, equivalent to approximately 300 MJ/m2 /year of heating and cooling demand.	• As per Demand Side Strategies
Appliance + Fixture Efficiency	• 3-star energy refrigerator • 1.5-star energy clothes dryer • 2-star energy clothes washer • 2.5-star energy dishwasher • 2-star WELS clothes washer • 2.5-star WELS dishwasher • 3-star WELS showerhead, toilet and tap-ware	• 5-star energy refrigerator and clothes dryer • 5-star energy clothes washer • 4-star energy dishwasher • 4.5-star WELS clothes washer • 4-star WELS dishwasher • 3-star WELS showerhead • 4-star WELS toilet • 5-star WELS tap-ware	• As per Demand Side Strategies
Irrigation	• Standard practice irrigation demand, equivalent to approximately 0.60 kL/m² of irrigated area per year.	• A 30% improvement in irrigation water demand, through drip irrigation or equivalent, equating to approximately 0.40 kL/m² of irrigated area/year.	• As per Demand Side Strategies
Lighting	• Standard non-residential lighting (largely fluorescent lighting fixtures at approximately 50-65 lumens per watt)	• 30% reduction in non-residential lighting electricity consumption through T5 fluorescent and LED lighting fixtures (80-90 lumens per watt).	• As per Demand Side Strategies
Residential Hot Water	• Gas storage	• Solar gas boost	• See Trigeneration
Trigeneration	• Not applicable	• Not applicable	• 10 MWe centralised system supply residential hot water, and non-residential heating, cooling and hot water
Solar	• Not applicable	• Not applicable	• Potential for 20,000 m2 of solar thermal or solar PV

Strategy	Business as Usual Specification	Demand Side Strategies	Demand + Supply Side Strategies
Recycled water	• Not applicable	• Not applicable	• Rainwater + stormwater harvesting for toilet flushing, laundry and irrigation of open space and playing fields (estimated collection tank of 3,900 m3).
Public transport	• Mode: Train • Average distance to service: 400 m • Average peak frequency of service: 8 min	• Mode: Light Rail • Average distance to service: 200 m • Average peak frequency of service: 4 min	• As per Demand Side Strategies
Residential car parking	• 1.25 car park spaces per dwelling	• 0.7 car park spaces per dwelling	• No change

Table 1: Summary of proposed strategies for the Canning City Centre

Introduction

Kinesis has been engaged by Canning City Council to quantify the energy, water and overall sustainability performance of the Canning City Centre Structure Plan. This analysis is being undertaken using C^{CAP} Precinct.

Originally built by Kinesis for Landcom and now licensed by a number of government land development agencies around Australia, C^{CAP} Precinct is an award winning mathematical tool that models key environmental, financial and affordability indicators for precinct-scale development projects.

C^{CAP} Precinct Workshop

Sustainability analysis of the Canning City Centre Structure Plan was undertaken at a workshop between Kinesis, energy utilities and the City of Canning on 17th April, 2012. At the workshop, two stages of intervention were explored to mitigate the increase in resource consumption across the site:

- **Demand side strategies**, incorporating energy and water efficiencies, improved building thermal performance and household travel mode shift through lower parking rates and improved public transport access.

- **Supply side strategies**, incorporating solar energy, trigeneration and water recycling.

The modelled results for the demand and supply sides strategies contained in this report are compared to the following **benchmarks**:

- **Existing**: the performance of the existing development in the Canning City Centre development area.

- **Business As Usual (BAU)**: the performance of new development proposed for the Canning City Centre development area built to regulatory compliance. This scenario was established in consultation with the participants at the C^{CAP} Precinct Workshop.

- **Metropolitan Average**: average transport, energy and water consumption profiles of existing residents in the Perth Metropolitan Area.

Following this workshop, analysis was refined and a recommended set of sustainability strategies was developed for two scenarios:

This report is supported by:

Appendix 1 – C^{CAP} Precinct Report is a record of the modelling which details the inputs, technology selections and results of the reference and modelled scenario.

Appendix 2 – Qualification and Key Data Sources used within C^{CAP} Precinct.

Precinct Details

The Canning City Centre Structure Plan proposes an additional 12,198 dwellings and 242,336 m2 of non-residential floor space connecting the Cannington railway station to the Canning Civic Centre in Cannington, WA. The details of the development and built form were provided by Canning City Council and refined with updated information at the C[CAP] Precinct workshop (Table 2).

PROPOSED CANNING CITY CENTRE

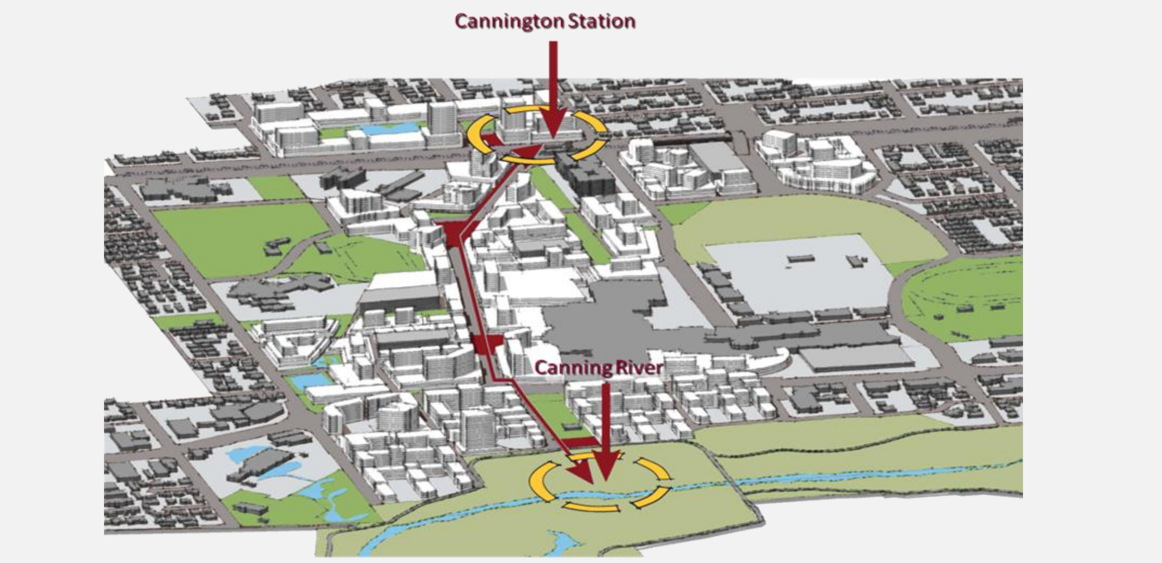


Figure 1: Canning City Centre Structure Plan

PRECINCT DETAILS

Land Use	Existing	Additional	Final
Total Precinct - ha	**332.5**	**332.5**	**332.5**
Residential dwellings - dwellings			
Detached	1,530*	1,449	2,979
Multi-unit	0	10,749	10,749
Total Residential dwellings	**1,530**	**12,198**	**13,728**
Non-residential floor space – m²			
Manufacturing, Storage, and Utilities	58,360	8,880	67,240
Service Industry	22,940	8,270	31,210
Shop Retail	116,740	60,000	176,740
Other Retail	48,450	19,630	68,080
Office Business	62,430	80,510	142,940
Health, Welfare and Community Services	8,750	40,110	48,860
Entertainment, Recreation and Culture	11,130	19,000	30,130
Hotel and Serviced Apartments	2,530	7,580	10,110
Car Park	208,000	-1,600	206,400
Total Non-Residential Floor Space	**539,330**	**242,380**	**781,710**

Table 2: Precinct details for the Canning City Centre

*Note: Exiting dwelling numbers include a small proportion of multi-unit and attached dwellings; however, the City was unable to disaggregate this figure. For the purposes of this report, existing dwellings were assumed to be detached.

Performance Summary

The Canning City Centre Structure Plan was compared to the existing resource demands from the existing buildings within the Canning City Centre development area.

Suburb level data provided by Western Power and ATCO gas was calibrated with existing dwellings and floor space information provided by the City of Canning. This metered data provided a basis for the estimate of existing electricity, gas and water consumption across the site (see Table 3).

The resource consumption implications of the Canning City Centre Structure Plan was analysed under a Business as Usual (or building code compliant) scenario before sustainability strategies were explored.

The **Business as Usual** and **Workshop Scenarios** represent an agreed set of strategies for the Canning City Centre through discussions and analysis undertaken at the C^{CAP} Precinct workshop between Canning City Council, key utility stakeholders and Kinesis on 17th April, 2012.

Two stages of intervention were explored in the **Workshop Scenarios** with the City of Canning to mitigate the increase in resource consumption across the site:

- **Demand side strategies**, incorporating energy and water efficiencies, improved building thermal performance and household travel mode shift through lower parking rates and improved public transport access.

- **Supply side strategies**, incorporating solar energy, trigeneration and water recycling.

The key results of these scenarios are outlined Table 3.

SUMMARY OF SUSTAINABILTY PERFORMANCE

Key Metric	***Existing***	***Business as Usual***	***Workshop Scenarios*** *Demand Side Strategies*	*Demand + Supply Strategies*
ENERGY				
Total precinct CO2 - tCO2-e/year	51,000	139,000	105,000	77,000
Reduction against BAU	-	-	**25%**	**45%**
Total precinct electricity demand - MWh/year	51,000	138,000	108,000	46,000
Total precinct gas demand - GJ/year	76,000	279,000	148,000	652,000
Total precinct peak electricity demand kW	23,000	60,000	45,000	31,000
Residential CO2 - tCO2-e/year	14,000	78,000	54,000	51,000
Residential peak electricity demand - kW/dwelling	n/a	2.8	2.0	2.0

Key Metric	*Existing*	*Business as Usual*	*Workshop Scenarios* Demand Side Strategies	Demand + Supply Strategies
WATER				
Total precinct water demand - ML/year	**900**	**2,400**	**1,880**	**1550**
Reduction against BAU	**-**	**-**	**21%**	**35%**
Residential consumption – ML/year	300	1,390	1,220	960
Non-Residential consumption – ML/year	600	1,010	670	600
Stormwater discharge - ML/year	1,050	1,860	1,510	0
Sewer discharge - ML/year	640	1,860	1,510	2,670
TRANSPORT				
Residential CO2 - tCO2-e/year	-	54,000	49,000	49,000
Reduction against BAU	-	-	**11%**	**11%**
Vehicle Kilometres Travelled - km/person/day	-	18	16	16
AFFORDABILITY				
Energy, water + transport - $/household/year	$24,100	$16,500	$14,500	$14,500
Reduction against BAU	-	-	**12%**	**12%**

Table 3: Key Results for the existing, BAU and Workshop Scenarios explored for the Canning City Centre.

Energy

The existing residential dwellings and non-residential floor space within the Canning City Centre are estimated to consume 51,000 MWh of electricity and 76,000 MJ of gas, equivalent to 51,000 tonnes of CO_2-e.

Under a **Business as Usual** scenario, the development growth outlined in the Canning City Centre Structure Plan is estimated to increase:

- Greenhouse gas emission by **178% to 139,000 tonnes CO_2-e/year**
- Electricity consumption by **170% to 138,000 MWh/year**
- Peak electricity consumption by **154% to 60,000 kW**
- Gas consumption by **268% to 279,000 MJ/year**

Workshop Scenario Analysis

Reductions in energy consumption and greenhouse gas emissions were explored through the following strategies:

Demand Side Strategies:
- Improvements in thermal efficiency
- The inclusion of energy efficient appliances
- Better building fabric
- Gas storage hot water system to solar boost hot water system

Supply Side Strategies:
- Trigeneration for heating, cooling and hot water
- Solar thermal or solar PV

Compared to the **Business as Usual** scenario, these strategies are estimated to achieve:
- 45% reduction in precinct GHG emissions
- 49% reduction peak electricity demand

GREENHOUSE GAS EMISSIONS

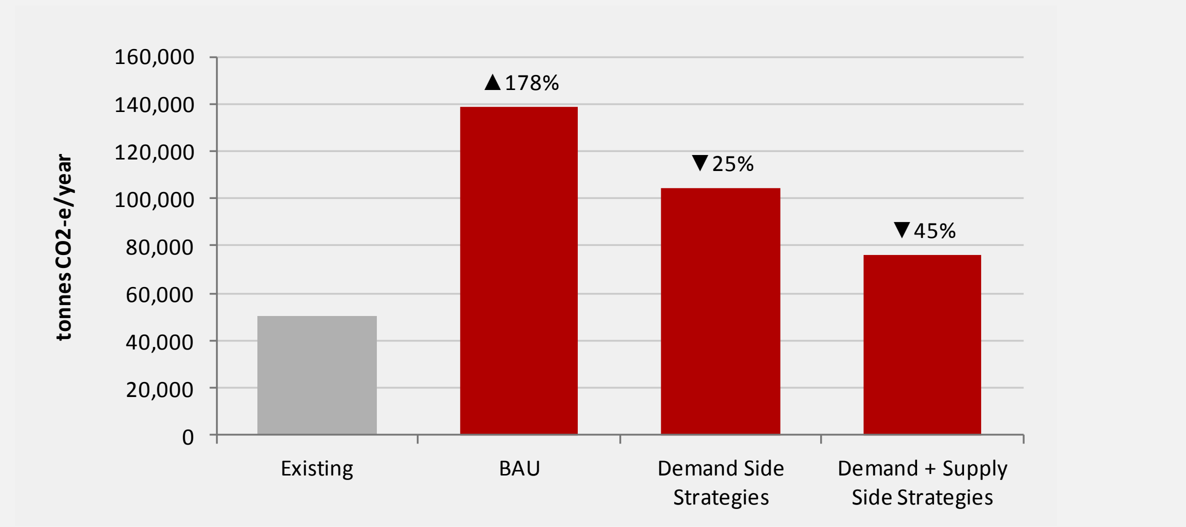


Figure 2: Estimated greenhouse gas emissions from the Business as Usual, Demand Side and Supply Side scenarios compared to the existing Canning City Centre.

The individual and cumulative impact of each technology modelled for the Canning City Centre is shown in Figure 3. The details of each of these strategies are outlined below.

EMISSION REDUCTIONS – SUPPLY + DEMAND SIDE WORKSHOP SCENARIO

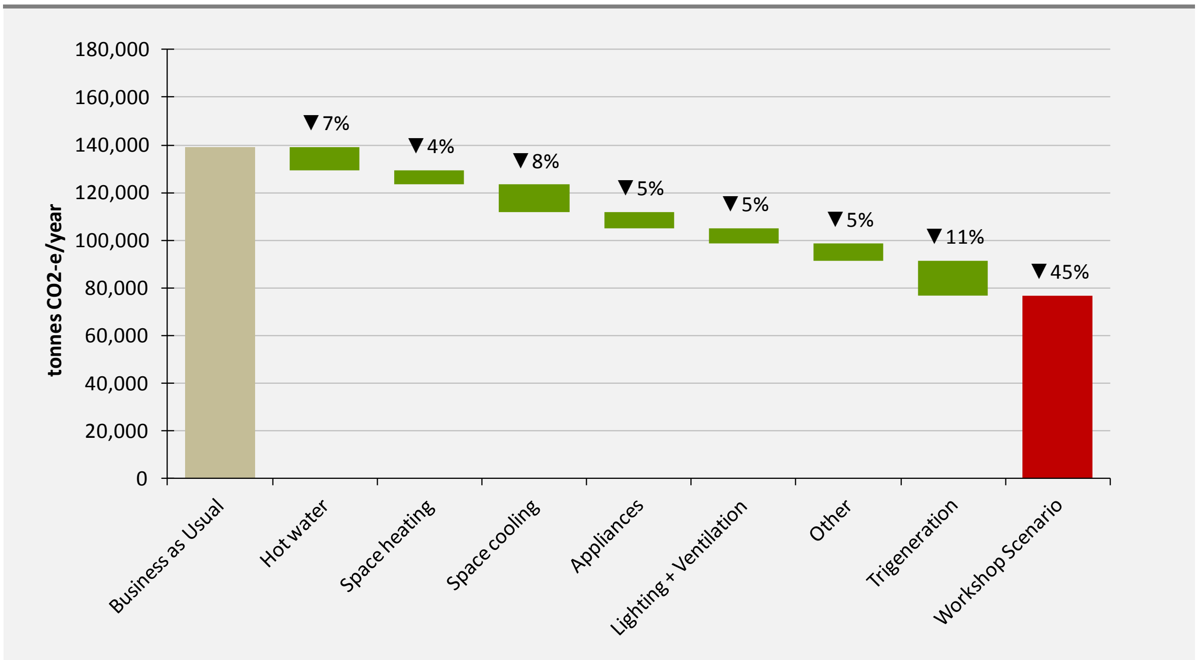


Figure 3: The individual and cumulative impact of each emission reduction strategy for the Canning City Centre compared to the Business as Usual scenario.

Demand Side Strategies

Demand side energy efficiency strategies proposed in the development have been achieved through both improved thermal design and the incorporation of energy efficient appliances. Specifically, these strategies include:

- A 30% improvement in non-residential building.
- A 30% reduction in non-residential lighting electricity consumption through the provision of T5 fluorescent and LED lighting fixtures (80-90 lumens per watt).
- Residential building thermal efficiency from 5-star to 6-star NatHERs (approximately 70 MJ/m²/year of heating and cooling demand).
- Installation of the following energy efficient appliances in each residential dwelling:
  - 5-star energy refrigerator
  - 5-star energy clothes dryer
  - 5-star energy clothes washer
  - 4-star energy dishwasher

Demand side strategies alone contribute to a 25% reduction in greenhouse gas emissions compared to the **Business as Usual** scenario.

The implementation of these demand side strategies are achieved through building design specifications or performance requirements that meet the demand reduction results outlined in this scenario.

Supply Side Strategies

To reduce greenhouse gas emissions and the demand on the local electricity grid, a distributed **trigeneration system** was modelled with the connected loads of residential hot water and non-residential heating, cooling and hot water.

A 10 MW_e trigeneration plant was sized based on the electrical load of the connected residential and non-residential floor space (see Figure 4). This means that the plant is designed to meet the electrical, rather than thermal load. This sizing strategy was adopted to ensure no net annual electrical energy was exported outside the study area and that, in effect, the trigenerated electricity was consumed within the precinct where it can be sold at economic peak and shoulder rates. This system is estimated to:

- Reduces greenhouse gas emissions 28,000 tonnes CO2-e,
- Meet an annual building thermal demand of 126,000 GJ; and
- Generate 55,000 MWh of low carbon electricity.

The high and inconsistent peak thermal load of residential space conditioning means that to size the trigeneration plant to meet these loads would require an additional 4 MW of trigeneration plant to meet an average residential heating and cooling load. As a result, this solution was not proposed for the Canning City Centre.

Solar thermal was explored to provide boost heat energy to the trigeneration system (see Figure 4). A solar thermal system of approximately 20,000 m² of roof space (equivalent to approximately 5% of the total precinct roof space) would save an additional 3,900 tonnes of greenhouse gas emissions each year, or a 3% reduction compared to the Business as Usual scenario.

Due to the high capital cost associated with solar thermal (see Marginal Capital Cost section), **solar PV** was explored as an alternative. Covering the same area (20,000 m² or approximately 2.8 MW) of roof space with solar PV would save an additional 4,600 tonnes of greenhouse gas emissions each year, or a 4% reduction compared to the Business as Usual scenario.

TRIGENERATION + SOLAR THERMAL

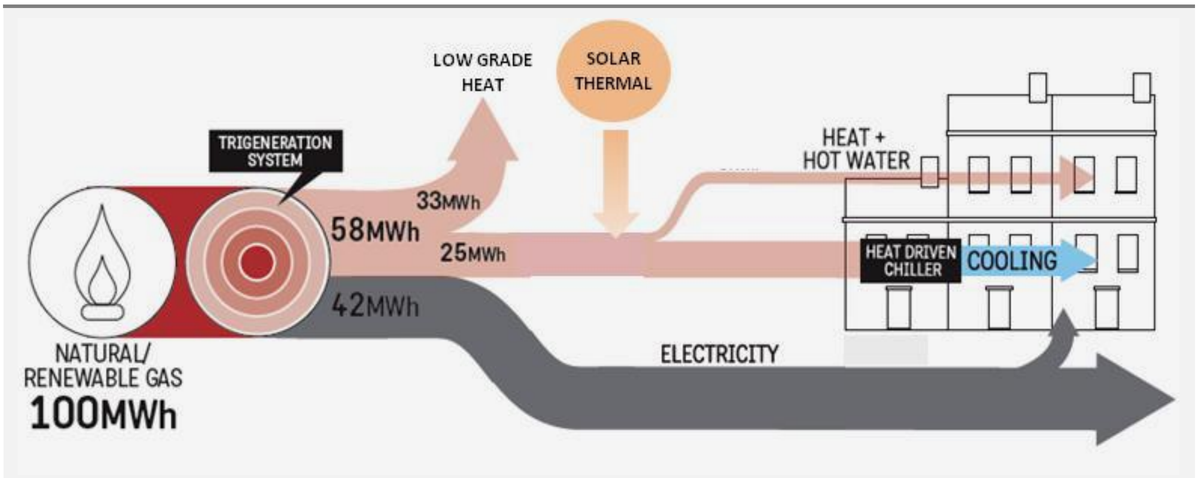


Figure 4: Energy inputs and outputs of a trigeneration system

Geothermal was also explored as a substitute for the heat generated by the trigeneration plant. This is equivalent to approximately 6 MW_{heat} from a geothermal bore with temperatures sufficient to drive an absorption chiller (approximately 90-95 degrees).

Substituting trigeneration with geothermal energy removes the low carbon electricity generated by the trigeneration plant. This additional electricity demand can be met through increased solar PV generation. However, approximately 21 MW of solar PV (equivalent to 150,000 m2 of panel area) will be required to achieve an equivalent greenhouse gas emission reduction from the trigeneration plant configuration outlined above at an additional cost of between $60 million to $100 million.

A combination of the above renewable and low carbon technologies should be explored further once the potential (bore size, depth and temperatures available) for geothermal is established. In addition, the technologies proposed for the Canning City Centre were sized to ensure no net annual electrical energy was exported outside the study area. Investigation of exporting electricity to the broader Canning City Centre and beyond should be discussed alongside electricity network considerations.

Westfield Carousel

The Westfield Carousel contributes to 12% of the existing floor space within the Canning City Centre. In addition, Westfield Carousel is proposing to expand its floor space to approximately 180,000 m2, equivalent to nearly 30% of total floor space and associated building greenhouse gas emissions across the site.

The proposed growth of Westfield provides a significant opportunity to embed low carbon demand side efficiency and supply side strategies to reduce the energy demand and greenhouse gas emissions of the Canning City Centre Structure Plan.

The floor space of the proposed development growth to the Westfield Carousel building was modelled in order to understand the individual contribution of Westfield to meet the overall energy and greenhouse gas emission targets for the Canning City Centre.

- **Trigeneration**: Westfield Carousel will contribute 2.3 MWe of the total trigeneration plant proposed for the Canning City Centre.

- **Solar**: The roof area of Westfield Carousel is estimated to be 50,000 m2, with adequate space to house the 20,000 m2 solar thermal boost or solar PV proposed for the Canning City Centre.

Water

The existing residential dwellings and non-residential floor space within the Canning City Centre are estimated to consume 900 ML of water. Currently, 24% of this water consumption is outdoor irrigation demand.

Under a **Business as Usual** scenario, the development growth outlined in the Canning City Centre Structure Plan is estimated to increase total water consumption by 168% to 2,400 ML/year.

Under the Canning City Centre Structure Plan, a majority of water consumption (84%) will be indoor water demand due to the high density urban form proposed for the site.

Workshop Scenario Analysis

Reductions in water consumption were explored through the following strategies:

Demand Side Strategies:

- Best practice residential fixture efficiency
- Best practice residential appliance efficiency
- High efficiency non-residential water profile

Supply Side Strategies:

- The collection and reuse of stormwater or recycled water for irrigation and indoor uses.

Compared to the **Business as Usual** scenario, these strategies are estimated to achieve a 35% reduction in total water consumption.

WATER CONSUMPTION

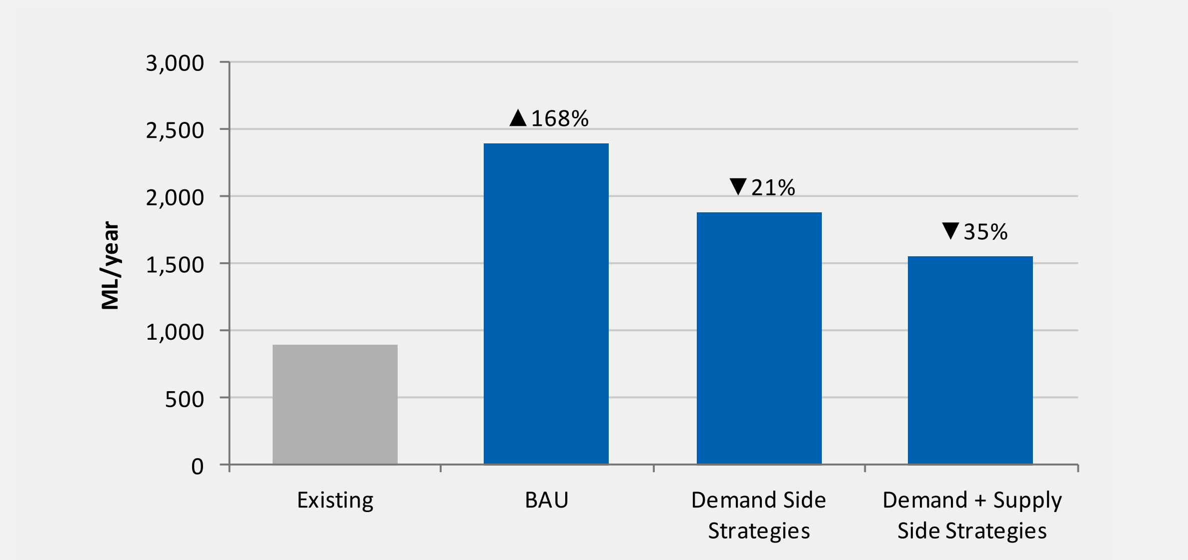


Figure 5: Estimated water consumption from the Business as Usual, Demand Side and Supply Side scenarios compared to the existing Canning City Centre.

The individual and cumulative impact of each technology modelled for the Canning City Centre is shown in Figure 6. The details of each of these strategies are outlined below.

WATER REDUCTIONS – SUPPLY + DEMAND SIDE WORKSHOP SCENARIO

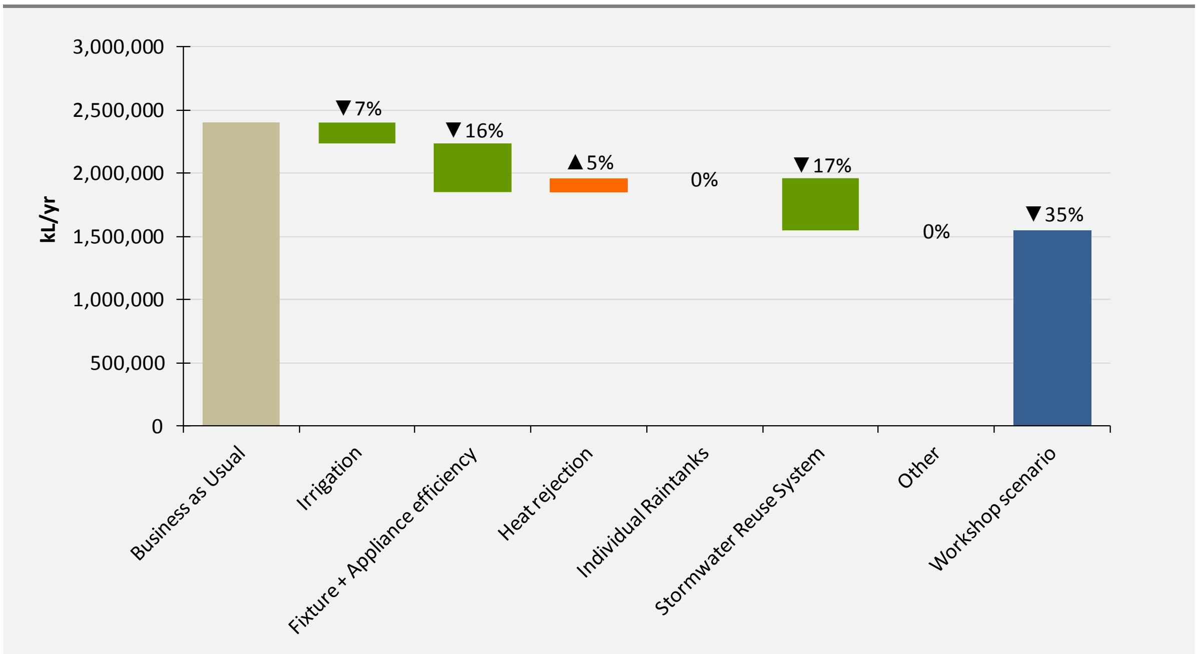


Figure 6: The individual and cumulative impact of each water reduction strategy for the Canning City Centre compared to the Business as Usual scenario.

Trigeneration Water Demand

It should be noted that **trigeneration** consumes high levels of water associated with heat rejection and cooling. The proposed 10 MW_e trigeneration system is estimated to consume approximately 110 ML of water per year, equivalent to a 5% increase in water consumption (Figure 6).

Demand Side Strategies

Demand side energy efficiency strategies proposed in the development have been achieved through both improved thermal design and the incorporation of energy efficient appliances. Specifically, these strategies include:

- A 30% improvement in irrigation water demand, equivalent to approximately 0.18 kL/m^2 of irrigated area per year.
- Installation of the following water efficient appliances in each residential dwelling:
  - 4-star WELS toilet
  - 3-star WELS showerhead
  - 5-star WELS tapware
  - 4-star WELS dishwasher
  - 4.5-star WELS clothes washer

The implementation of these demand side strategies are achieved through building design specifications that meet the requirements outlined above.

Demand side strategies alone contribute to a 23% reduction in water consumption compared to the **Business as Usual** scenario.

Supply Side Strategies

Rainwater and Stormwater

Roof, road and infrastructure surfaces can be drawn on for rainwater and stormwater harvesting, both at the individual building as well as at the community scale.

A rainwater and stormwater harvesting system was configured to capture 100% of the surface water runoff across the site in a central or a series of distributed collection tanks to provide water for residential and public open space irrigation as well as internal toilet and laundry uses. This system is estimated to reduce water consumption by 410 ML per year.

Due to the climate and rainfall pattern in Perth (low summer rainfall and high winter rainfall), a stormwater collection tank of 39,000 m3 is required to provide adequate storage to meet the nominated demands. Despite this significant stormwater collection tank size, the stormwater system will be required to draw on mains scheme water during the summer months when rainfall is low and outdoor water demand is high (see Figure 7).

STORMWATER SYSTEM PERFORMANCE

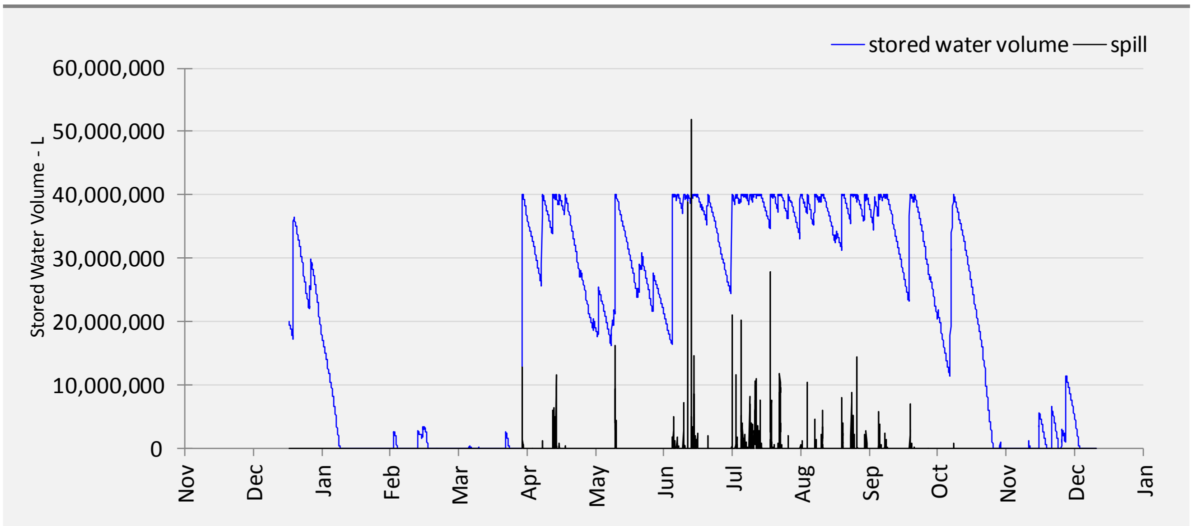


Figure 7: The water inflows and outflows of the proposed stormwater system for the Canning City Centre

Transport

Located 12 km from the Perth CBD and immediately adjacent to the Cannington Railway Station, the Canning City Centre has a significant opportunity to become a low car-use precinct.

Under a **Business as Usual** scenario, private vehicle use and associated greenhouse gas emissions is expected to be **11% lower than the Perth Metropolitan average** at approximately 18 km per person per day.

The **Workshop Scenario** incorporates light rail through the City Centre along Cecil Ave. While the improvements to frequency and location of public transport provided by the light rail do not significantly reduce car use, this strategy should be viewed as the leverage to achieve the high density urban form, land use mix and low parking rates that achieve the low car-use objectives of the site. Under this scenario, private vehicle use and associated greenhouse gas emissions is expected to be **21% lower than the Perth Metropolitan average.**

In addition, low parking rates contribute to increased household affordability due the savings attributed to the costs of purchasing a parking space, and the purchase, registration and insurance costs of owning and operating a vehicle (see Affordability, Figure 9). The transport parameters adopted for the **Business as Usual** and **Workshop Scenarios** are listed in Table 6 and the modelled results are provided in Figure 8.

KEY TRANSPORT VARIABLES

Variable	Business as Usual	Model (Efficiency & Efficiency + Supply)
Land Use Mix (0-1 rating)	0.7	0.7
Precinct employment	Approximately 10,480 jobs	Approximately 10,480 jobs
Car Parking Rates	2 car space per detached dwelling 1.25 car space per multi-unit dwelling	2 car space per detached dwelling 0.7 car space per multi-unit dwelling
Public transport access	Nearest major transport node: 400m Weekday peak frequency: 8 mins Mode: Train	Nearest major transport node: 200m Weekday peak frequency: 4 mins Mode: Light Rail

Table 6: Transport parameters used to calculate the car use of Canning City Centre residents

REDUCTIONS IN CAR USE

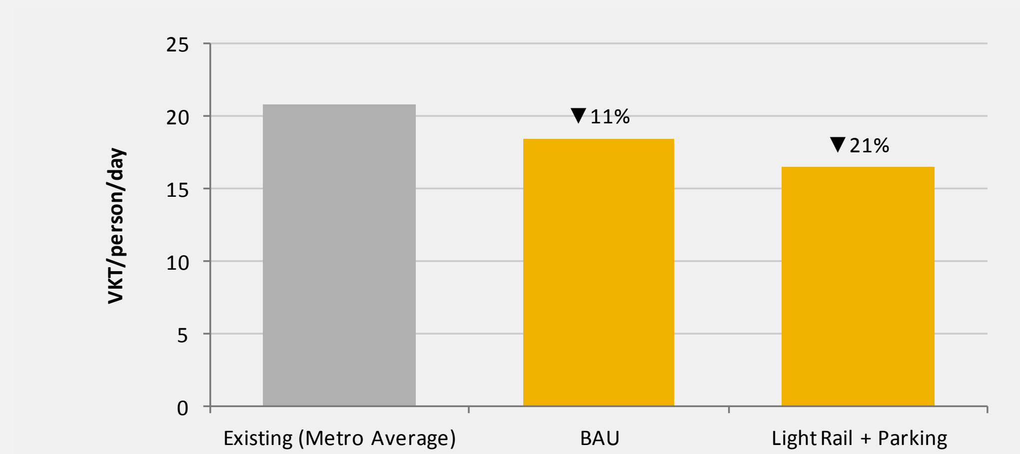


Figure 8: Estimated Vehicle Kilometres Travelled (VKT) per person per day for the Business as Usual and Workshop scenarios compared to the Perth Metropolitan Average

Operational Affordability

The Workshop Scenario outlined in this report achieves a **24% reduction in energy, water and transport household operational costs** against the Perth Metropolitan average (Figure 9).

The affordability implications of the sustainability measures are reflected in the indicative household operating costs from energy, water and transport. Household expenditure includes electricity, gas, thermal, mains water and recycled water costs (excluding sewerage charges). Fixed costs such as service usage and meter costs were excluded as these do not tend to differ from the Business as Usual scenario. The costs of vehicle ownership and use (including financing, registration, maintenance and fuel) were also included in the analysis.

The average Australian household spends approximately 18% of total household expenditure on energy, water and transport costs. At 16% of total yearly household expenditure, transport costs are the third highest costs behind housing (18%) and food (17%)[1].

While the development's land use mix and proximity to public transport have both influenced household expenditure on transport, the greatest reduction in this area has come from lowering the average rate of vehicle ownership. Through limited parking space availability and the implementation of on street parking controls, the Canning City Centre can achieve **household transport savings of 26%**. Due to the magnitude of transport expenditure relative to other household costs, this saving is largely responsible for the overall increase in household affordability.

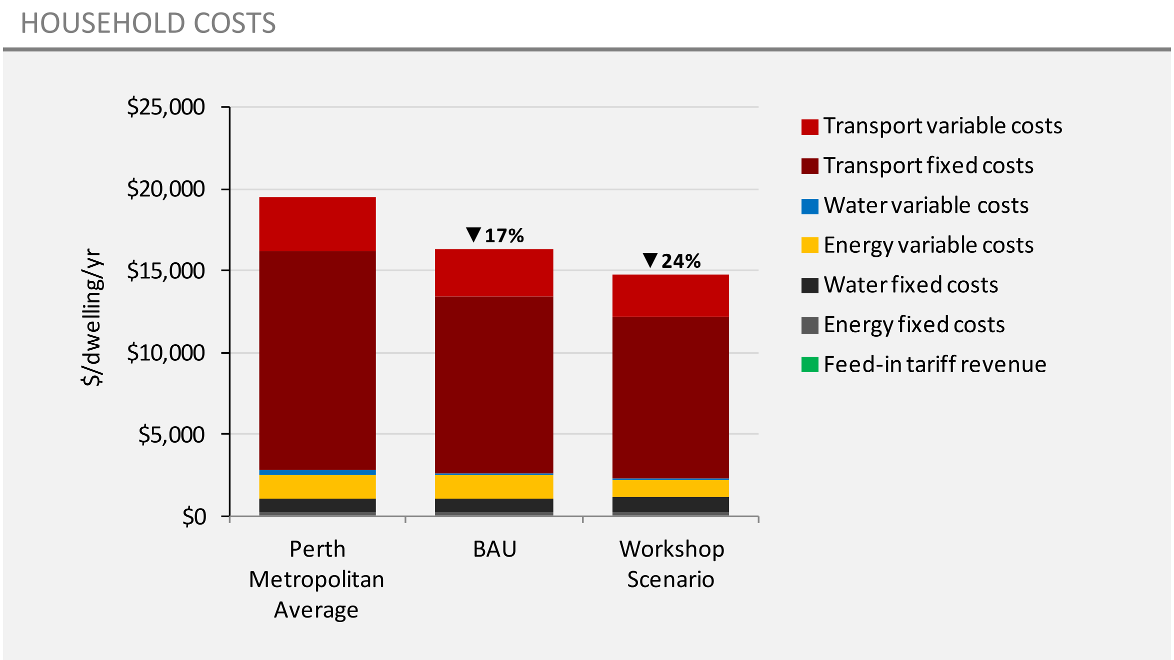


Figure 9: Estimated transport, energy and water costs for residents in Canning City Centre compared to the Perth Metropolitan Average

[1] ABS Household Expenditure Survey, Australia: Summary of Results, 2009-10

Marginal capital costs

The marginal capital costs (i.e. marginal costs above the Business as Usual scenario) for the sustainability features outlined in the **Workshop Scenario** are estimated to be approximately **$90 million** or **$36 per m²** of constructed floor area.

The estimated marginal capital cost of $8.5 million for trigeneration includes the capital costs over and above the cost of providing individual building and dwelling heating, cooling and hot water systems. It accounts for the 10 MW_e cogeneration primary plant, heat driven chiller for non-residential buildings, thermal pipe network and connection costs (see Figure 8 and Table 7).

Costs associated with solar thermal and solar were not included in the sustainability performance and are therefore not listed in the figure or table below. The 20,000 m² solar thermal system analysed to supplement the trigeneration system has a capital cost of approximately $37 million. It should be noted that while solar thermal was included to make best use of the roof space for solar energy and supplement the trigeneration system, the significant marginal capital cost may preclude the use of this technology in the Canning City Centre. The 2.8 MW Solar PV system alternative, on the other hand, has a capital cost of approximately $7 million.

The rainwater and stormwater recycling system specified for the Canning City Centre is estimated to cost approximately $10 million, equivalent to approximately $15/kL of treated wastewater. With a range of wastewater treatment technologies available, the final figure will depend significantly on the chosen system.

CAPITAL COST CONTRIBUTIONS

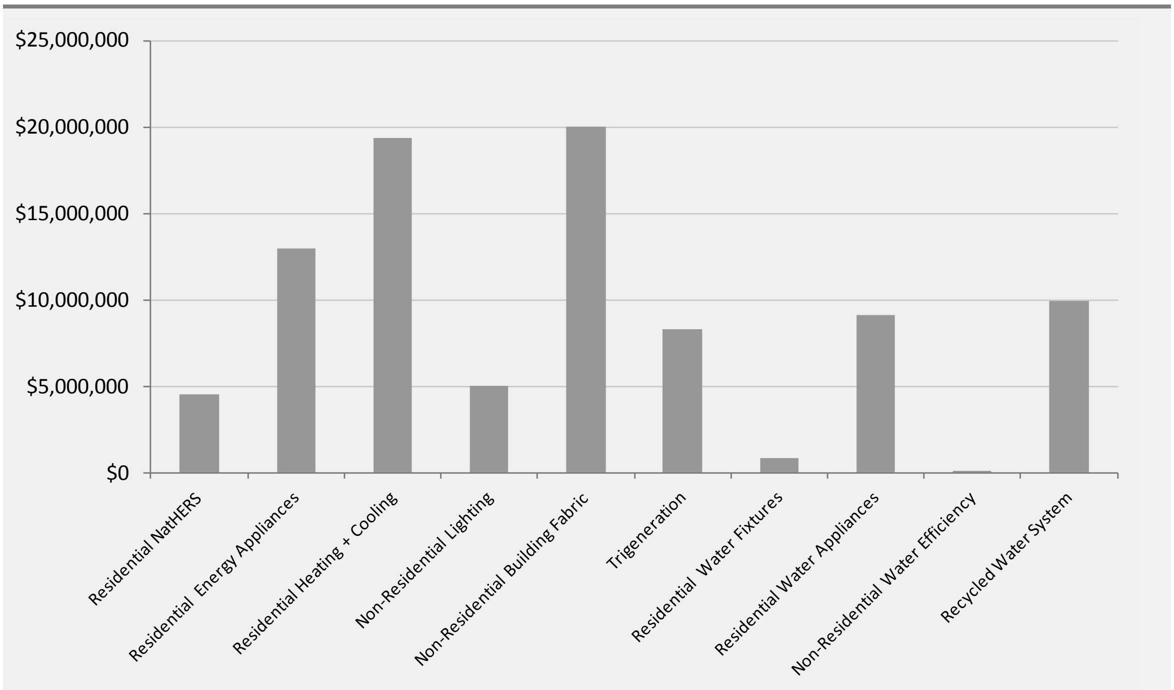


Figure 8: Estimated marginal capital costs of proposed energy and water strategies in Stage 1

Technical specifications for each of the technology listed in Figure 8 are discussed in the Energy and Water sections above. Details of the marginal capital costs are listed in Table 7.

Proposed Strategy	*Marginal Capital $*	*Total Capital $*
Residential NatHERS (6-star NatHERs dwellings)	$4,500,000	-
Residential Energy Appliances (4-5 star appliances)	$13,000,000	-
Residential Space Heating + Cooling (5-star systems)	$19,400,000	-
Non-Residential Lighting (80-90 lumins/watt)	$5,000,000	-
Non-Residential Building Fabric (300 MJ/m2)	$20,000,000	-
Trigeneration (10 MWe, including plant + thermal pipe network)*	$8,300,000	$20,000,000
Residential Water Fixtures (3-4 WELS tap fittings)	$860,000	-
Residential Water Appliances (4-5 WELS appliances)	$9,100,000	-
Non-Residential Water Efficiency	$120,000	-
Rainwater + Stormwater Reuse (For irrigation, toilet + laundry)	$9,900,000	$9,900,000
TOTAL MARGINAL CAPITAL COST	**$90,180,000**	

Table 7: Estimated costs of proposed energy and water strategies in the Canning City Centre under the Workshop Scenario

* The marginal capital cost is lower than the total capital cost to reflect the cost savings from installing individual hot water, heating and cooling systems

The modelled marginal capital costs for the sustainability features included in this analysis were estimated based on Kinesis's project experience and available data from published economic assessments. The estimated costs accord with the size and scale of the energy and water sustainability measures included in the analysis.

Appendix 1: C^CAP Precinct Report

SUSTAINABILITY REPORT

Produced by Kinesis on 6 August 2012

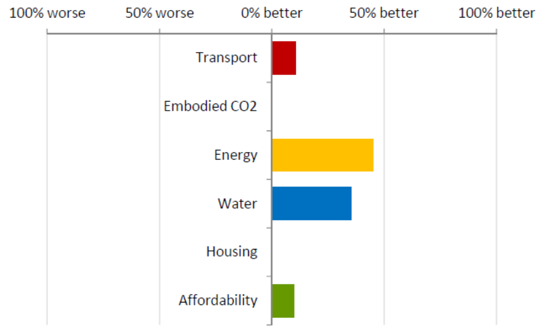
MAIN v4.04, Embodied GHG v4.3, Energy v4.02, Water v4.13, Transport v4.02

PROJECT NAME **Canning City Centre**

KEY PERFORMANCE INDICATORS (COMPARISON TO BAU)

Precinct Performance against Reference (% change)

TRANSPORT	11% better
EMBODIED CO2	n/a
ENERGY	45% better
WATER	35% better
HOUSING	n/a
AFFORDABILITY	10% better



PRECINCT DETAILS

The section below outlines the key elements of the modelled precinct that have been entered into C^CAP Precinct. More details regarding the allocation of floor space between non-residential and mixed use precincts as well as specific dwelling types can be found in the Precinct module of the tool.

PROJECT LOCATION Canning CC FINAL

CLIMATE

NatHERS Zone	13	
Rainfall	705	mm
Evaporation	2,079	mm

TOTAL PRECINCT AREA 333 ha

Non-Developable Area

Riparian Zone	25.0	ha
Conservation Woodlands	5.5	ha
Other Non-Developable Area	8.5	ha
Total Non-Developable Area	**39.0**	ha

Developable Area

Non-Residential Precinct	191.2	ha
Mixed-Use Precinct	0.0	ha
Residential Precinct	102.3	ha
Total Developable Area	**293.5**	ha

Road Area **71.8** ha

Open Space

Playing Fields	9.9	ha
Parks & Public Gardens	13.5	ha
Native Parklands/Reserves	5.5	ha
Public Plazas	0.8	ha
Total	**29.7**	ha

Total Residential Dwellings

Detached	2,979	dwellings
Attached	0	dwellings
Multi-unit	10,749	dwellings
Total	**13,728**	dwellings

Total Non-residential Floor Space

Commercial/Office	142,940	m2
Retail	285,060	m2
Medical	9,772	m2
Light Industrial	98,450	m2
Education	39,088	m2
Community	0	m2
Total	**575,310**	m2

ENERGY

The Energy module of C[CAP] Precinct uses local climate data to model the predicted energy loads and consumption of a building. In doing this, it provides the user with a full set of opportunities for exploring energy efficiency, renewable energy generation and combined cooling, heat and power initiatives.

Gas and electricity use of the precinct, as well as a full account of the precinct's thermal loads in the form of residential and non-residential water heating, space heating and space cooling demands, are calculated and reported below.

The Energy module also provides information relating to the interaction of the precinct with the grid. Peak power demand and the quantity and timing of any exported electrical power are examples of information that is able to be provided by the model to assist with the economic feasibility of any scenario.

The graph on the right of the results below shows the per person greenhouse gas emissions from all sources within the precinct. Any emissions below the line indicate generated or exported low carbon or renewable energy.

ENERGY RESULTS

KEY RESULT **45% better** in greenhouse gas emissions compared to the reference development

	Model			Reference		
	Elec - MWh	Gas - GJ		Elec - MWh	Gas - GJ	
Annual Precinct Energy Import	**45,945**	**651,986**		137,875	278,795	
Annual Precinct Energy Export	**815**	**0**		0	0	
Net Annual Precinct Energy Demand	**45,130**	**651,986**		137,875	278,795	
Annual Precinct GHG Emissions	**76,511**	t(CO2)/yr		138,962	t(CO2)/yr	
Water supply, treatment & pumping	**9,881**	t(CO2)/yr		6,236	t(CO2)/yr	
Annual Residential GHG Emissions	**51,112**	t(CO2)/yr		77,739	t(CO2)/yr	
	1,978	kg(CO2)/(person.yr)		3,009	kg(CO2)/(person.yr)	
Reduction against state benchmark (eg BASIX)	**23%**					

ENERGY INPUTS

EFFICIENCY

	Detached	Attached	Multi	Non-Residential
Thermal comfort	5.0	5.0	6.0	n/a
Appliances	Std Practice	Std Practice	Best Practice	n/a
Hot water	Gas Storage	Gas Storage	District Hot Water	cogeneration - all
Heating	2 Star 1-phase RC Air Con	2 Star 1-phase RC Air Con	5 Star 1-phase RC Air Con	cogeneration - all
Cooling	2 Star 1-phase Air Con	2 Star 1-phase Air Con	5 Star 1-phase Air Con	cogeneration - all

RENEWABLE ENERGY

Private Solar PV	0	kW peak	0	kW peak	0	kW peak
Community Solar PV	0	kW peak				

TRIGENERATION

Cogen electrical size	10,000	kW peak
Annual electricity generation	54,750	MWh
Cogen electrical efficiency (HHV)	41%	
Cogen fuel use efficiency	67%	

SOLAR THERMAL

Solar Thermal Collector Area - m2	20,000
Solar-Thermal energy use efficiency	n/a

WATER

The Water module of C[CAP] Precinct quantifies mains potable and alternative water demands of a precinct and provides opportunities to explore end-use efficiencies, rain/storm water harvesting and water recycling. Responding to housing form and occupancy, the efficiency of water appliances and fixtures, the choice of cooling system, ambient temperatures and the rainfall (in the case of irrigation), the demands quantified by the Water model are able to be met by a user-selectable range of reuse or water harvest measures. These comprise:

- Private rain tanks of user specifiable size, connectable to a specifiable fraction of the dwelling roof
- Community recycled water supply that can be configured for collection of greywater, sewer, stormwater runoff or roof water from residences and/or non-residences
- An off-site recycled water supply

The Water results and inputs used to achieve the results are provided below.

WATER RESULTS

KEY RESULT 35% better in water consumption compared to the reference development

CONSUMPTION RESULTS

	Model		Reference	
Total Mains Water - ML/yr	1,554		2,397	
Residential Mains Water - ML/yr	955		1,390	
Non-Residential Mains Water - ML/yr	599		1,007	
per resident - kL/(pers.yr)	37		54	
Residential reduction against metropolitan average	70%			
Total energy for water supply	11,027	MWh/yr	6,960	MWh/yr

DISCHARGE RESULTS

	Stormwater volume ML/yr	Stormwater max rate kL/hr	Sewer volume ML/yr	Sewer max rate kL/hr
Discharge quantities	0	0	2,666	52,221

	TSS	TP	TN	GP
Stormwater Pollutants - kg/yr	0	0	0	0
concentration - mg/L	0.0	0.0	0.0	0.0

WATER INPUTS

EFFICIENCY

	Detached	Attached	Multi
efficient irrigation?	FALSE	FALSE	FALSE
fixture efficiency	Std Practice	Std Practice	Best Practice
appliance efficiency	Std Practice	Std Practice	Best Practice

Non-Residential Efficiency
high efficiency

RAINWATER TANKS

	Detached	Attached	Multi
connected fraction of total roof area	100%	100%	100%
tank size multiplier (beyond BASIX)	1.0	1.0	1.0
garden	FALSE	FALSE	FALSE
toilet	FALSE	FALSE	FALSE
laundry	FALSE	FALSE	FALSE
hot water	FALSE	FALSE	FALSE
volume of all model tanks - kL	0	0	0
model raintank harvests - kL/yr	0	0	-0

COMMUNITY WATER SUPPLY

Existing Recycled Water Supply 0 L/(hh.day) or 0 kL/day

Community Water Supply	Residential	Non-Residential
rainwater	TRUE	TRUE
stormwater	TRUE	TRUE
all internal wastewater	FALSE	FALSE

Proposed treated water end use	IR + toilet/laundry (TL)
Scheme supply coverage	residential + non-residential

	volume ML/yr	max rate kL/hr
Treated water available for use	1,565	52,002
Demand placed on scheme	659	352
Spill/excess	1,158	51,902
Potable top-up	252	

Reservoir capacity for scheme - m3	groundwater recharge

Stormwater Treatment		
Stormwater detention system capacity	0	m3
Max primary treatment flow rate	0	m/s

	GPT	CDS
Stormwater treatment measures?	FALSE	FALSE
Max inflow rate - L/s	0	

TRANSPORT

The Transport module of C[CAP] Precinct draws the key spatial, land use and socio-demographic variables to assess the transport greenhouse gas emissions and vehicle hours travelled. These key variables include land use mix (walkability), housing density, local employment, distance to regional centre, walk and wait time to the nearest high frequency public transport and household vehicle ownership. From these variables the Transport module quantifies the precinct's:

- Transport greenhouse gas emissions associated with travel from residents within the precinct
- Vehicle kilometres travelled
- Vehicle hours travelled

The land use and locational variables and associated Transport results are provided below.

TRANSPORT RESULTS

KEY RESULT **11% better** in greenhouse gas emissions compared to the reference development

	Modelled	Reference	
Transport greenhouse gas emissions	**48,573**	54,362	tonnes CO2-e/year
Per Person emissions	**1.9**	2.1	tonnes CO2-e/year
Vehicle hours travelled	**4.1**	4.6	hrs/person/week

Public transport access	**5.0**	mins walk+wait time
Walkability	**0.7**	

	Detached	Attached	Multi
Average predicted vehicle ownership	**2.00**	**1.27**	**1.09**

	Detached	Attached	Multi
Predicted carshare takeup rate	**0%**	**0%**	**0%**

TRANSPORT INPUTS

Distance to centre - km	unknown	
Centre	n/a	
Local employment - nr jobs	n/a	(within 5 km radius)
Predicted precinct employment - nr jobs	13,128	(within precinct)
Distance to public transport	200	metres
Public transport frequency	4	minutes

Local housing density - gross dwellings/ha	41.3	(within 2 km radius)
Precinct population density - people/ha	77.7	(within precinct)

	Detached	Attached	Multi
Parking spaces per dwelling	2.0	0.0	0.7
On-street parking controls?	FALSE		
Carshare available?	FALSE	FALSE	FALSE

FINANCIAL ANALYSIS + AFFORDABILITY

The Affordability module of C[CAP] Precinct draws on the inputs and results from the Energy, Water and Transport modules as well as current utility retail prices and transport related costs to quantify the on-going costs associated with living in the modelled precinct. In addition, it provides an estimate of net capital costs associated with each sustainability measure selected in the tool.

The household affordability and financial results are provided below.

AFFORDABILITY RESULTS

KEY RESULT 10% better in household expenditure ($) compared to residents in average new development across the Metropolitan area

HOUSEHOLD EXPENDITURE

average across all dwelling types	Metro Ave	Reference	Model	
Feed-in tariff	$0	$0	**$0**	$/year
Energy fixed costs	$225	$225	**$225**	$/year
Water fixed costs	$873	$873	**$908**	$/year
Energy variable costs	$1,445	$1,362	**$1,037**	$/year
Water variable costs	$300	$124	**$107**	$/year
Transport fixed costs	$13,406	$10,792	**$9,832**	$/year
Transport variable costs	$3,291	$2,918	**$2,607**	$/year
TOTAL	$19,540	$16,294	**$14,717**	$/year

MARGINAL CAPITAL EXPENDITURE

Energy

	Investor marginal capex over 1 years		
R NatHERS	$4,500,000	$330	per dwelling
R Energy Appliances	$13,000,000	$940	per dwelling
R Hot Water	$0	$0	per dwelling
R Space Heating	$9,700,000	$700	per dwelling
R Space Cooling	$9,700,000	$700	per dwelling
R Solar PV	$0	$0	per dwelling
R Street Lighting	$0	$0	per dwelling
NR Lighting	$5,000,000	$6	per m2
NR Building Fabric	$20,000,000	$26	per m2
NR Hot Water	$0	$0	per m2
NR Space Heating	$0	$0	per m2
NR Space Cooling	$0	$0	per m2
NR Street Lighting	$56,000	$0	per m2
Cogeneration	$8,300,000		
Community Solar PV	$7,000,000		
Community Wind	$0		
Solar Thermal	$0		
Geothermal	$0		
TOTAL	$77,256,000		

Water

	Investor marginal capex over 1 years		
R Irrigation	$0	$0	per dwelling
R Water Fixtures	$860,000	$63	per dwelling
R Water Appliances	$9,100,000	$670	per dwelling
NR Water Efficiency	$120,000	$0	per m2
R Raintanks	$0	$0	per dwelling
Recycled Water Supply	$9,900,000		
TOTAL	$19,980,000		

END OF REPORT.

Appendix 2: Qualifications and Data Sources

This report and the information generated in the workshop on 17th April 2012 are provided subject to some important assumptions and qualifications:

- The results presented in this report are modelled estimates using mathematical calculations and are based solely on the activities conducted at the workshop and information provided by Canning City Council. The data, information and scenarios presented in this report have not been separately confirmed or verified. Accordingly the results should be considered to be preliminary in nature and subject to such confirmation and verification.

- Energy, water and greenhouse consumption estimates are based on local climate and utility data available to the consultant at the time of the report. These consumption demands are, where necessary, quantified in terms of primary energy and water consumptions using manufacturer's data and scientific principles.

- Transport results are based on a travel regression model that draws on the key land use, location and demographic variables to determine a best estimate for residential vehicle use. Associated greenhouse gas emissions are calculated using representative private and public vehicle emissions data from a range of sources.

- Cost estimates provided in this report are indicative only based on Kinesis's project experience and available data from published economic assessments.

- The Kinesis software tool and results generated by it are not intended to be used as the sole or primary basis for making investment or financial decisions (including carbon credit trading decisions). Accordingly, the results set out in this report should not be relied on as the sole or primary source of information applicable to such decisions.

Key data sources referenced in this analysis include:

1. Bureau of Meteorology local rainfall, temperature and evaporation data
2. Department of Resources, Energy and Tourism, 2010, Energy in Australia – 2010, ABARE, Canberra
3. National Water Commission, 2011, National performance report 2009-2010: urban water utilities, National Water Commission, Canberra
4. Department of Infrastructure and Transport, 2011, Road vehicle kilometres travelled: estimations from state and territory fuel sales, Australian Government, Canberra
5. Australian Greenhouse Office (2010) National GHG Accounts Workbook, July
6. Energy Use in the Australian Residential Sector, 1986 – 2020, Australian Government Department of the Environment, Water, Heritage and the Arts (DEHWA), 2008.
7. Energy Efficient Strategies (2009), Appliance Energy Consumption in Australia: Equations for Appliance Star Ratings
8. Building Code of Australia (2007) Energy Efficiency Requirements in Commercial Buildings
9. Transport Data Centre (2006) The Development of a Sydney VKT Regression Model
10. ABS (2010) 'Household Expenditure Survey, Australia: Summary of Results', catalogue number 65300DO001_200910, Australian Bureau of Statistics, Canberra.
11. SimaPro Life Cycle Analysis - Australian materials data sets where available.
12. Lawson, B (1996) Building Materials Energy and the Environment, Appendix B, Embodied Energy Tables.

13. ABSA (2009) 'ABSA energy efficiency workshops: lowering the cost of 6 star compliance', presentation for Building Australia's Future, Association of Building Sustainability Assessors, Australia.
14. CSIRO (2009) 'Intelligent grid: a value proposition for distributed energy in Australia', Report ET/IR 1152, CSIRO, Australia.
15. Delfin (2006) 'News at Ropes Crossing', issue 01 (August), available at www.delfin.com.au/llweb/ropescrossing/main.nsf/images/pdf_rc_01_august2006_01.pdf/$file/pdf_rc_01_august2006_01.pdf [accessed 1/11/2010].
16. RACQ (2009) 'Private ownership costs', available at www.racq.com.au/motoring/cars/car_economy/vehicle_running_costs [accessed 5/5/2010].
17. Yarra Valley Water (2009) 'Recycled water marks milestone at Aurora', available at www.yvw.com.au/Home/Aboutus/news/Recycledwaternews/Aurorarecycledwater/index.htm [accessed 1/11/2010].
18. Yarra Valley Water (2010) 'Highlands recycled water project', available at www.yvw.com.au/Home/Waterandsewerage/recycledwater/Recycledwaterareas/Highlands/index.htm [accessed 1/11/2010].