FINAL DRAFT

Bankstown City Centre and Campsie Town Centre Sustainability Study Phase 2

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Prepared for:

CITY OF CANTERBURY BANKSTOWN

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Executive Summary

This report is the second phase of a broader sustainability study that will inform the Preferred Masterplan Development Scenario for the Bankstown and Campsie strategic centres. This second phase aims to integrate the findings of the Phase 1 study and the conclusions of other complementary studies undertaken concurrently by other specialists to inform the masterplanning.

Phase 3 of this study will inform the masterplanning through the development of standards for individual developments.

Phase 4 of the study is to peer review the draft masterplan and provide an analysis of benefits.

The assessment of existing conditions has established a 2020 baseline of environmental impacts in each of the study areas and provides supporting analysis on key areas of environmental impact. Key observations are:

- The energy used in buildings accounts for over 75% of all greenhouse gas emissions in both study areas.
- Both study areas show elevated temperatures compared to the broader LGA and Sydney metropolitan region, which is a result of the urban heat island effect.
- There is a higher reliance on private car use and lower patronage of public transport by commuters than the Sydney regional average.
- There is a very low uptake of rooftop solar panels on apartment buildings, and significant capacity exists for more rooftop solar energy generation in the study areas.

The environmental impacts expected when the growth targets are delivered in 2036 has been assessed without the constraints imposed by FSR and height limits in the current LEP. This has been done to allow the full impact of growth to be understood and provide a full-growth environmental benchmark that the benefit of the strategies and principles developed can be measured from.

A survey of external trends and impacts was used to inform the 2036 projections. The two most relevant findings were:

- Climate change will lead to a further 1ºC increase in average maximum daily temperature by 2036. This will impact amenity and also increase electricity demand.
- The expected move away from fossil fuels for electricity generation in NSW will reduce the greenhouse gas emission associated with electricity use by 46%.

The impacts of the targeted growth in 2036 are projected to be:

- Greenhouse gas emissions will increase by 61% in Bankstown City Centre and 40% in Campsie Town Centre
- Water use will increase by 144% in Bankstown City Centre and 64% in Campsie Town Centre
- Waste generation will increase by 95% in Bankstown City Centre and 59% in Campsie Town Centre
- Heat added to the centres from air conditioning and vehicle use will increase by 95% in Bankstown City Centre and 80% in Campsie Town Centre

The study shows that the current controls are not adequate to mitigate significant environmental impacts associated with the growth of the precincts.

A study of the impact of increased building mass was undertaken for the amount of floor space and building heights allowable under the current controls. These allowances are less than what is required to deliver the growth targets but clearly illustrate that denser development will reduce the 'sky view factor' from the streets, contributing to increasing urban heat island effect.

An assessment of the environmental impacts in the study areas with continued application of the floor space bonus scheme for improved sustainability was undertaken. The study showed that the environmental benefits realised from the scheme are expected to be modest due to limitations in the design of the scheme and the relatively low uptake rates expected. It is recommended that the scheme be amended.

The phase 1 study developed an understanding of the most significant environmental impact sources associated with the existing buildings and those buildings that will be developed or redeveloped. This knowledge can be leveraged, together with an understanding of the impact of environmental externalities, to inform controls and strategies for the masterplan that can significantly reduce impact from future development.

Integration workshops were conducted where the phase 1 study's findings were presented alongside the concurrent studies of other specialists, including tall buildings, urban tree canopy and land use, and economics. The integration process showed general alignment in the priorities amongst the studies with the area of urban greening identified as the priority requiring the most coordination between the specialist disciplines. The related principles in this phase 2 report have been expanded to address the gaps identified in the integration process.

The strategies and principles developed must extend beyond the current targets published in the LSPS and embrace all feasible opportunities to reduce environmental impact. The following table summarises the relationship between the strategies and the previously published priorities relevant to the study areas. Key areas where the strategies presented here extend the previously published ambitions include:

- Requiring all new buildings to be all-electric to avoid the lock-in of fossil fuels impacts
- Requiring all new buildings to devote a minimum amount of roof space to solar energy generation
- Making buildings future proof for electric vehicles and alternative water supply
- Transitioning to natural refrigerants
- Requiring passive treatment in buildings including good natural ventilation in apartments and external shading to highly glazed facades

Importantly, the strategies and principles have been developed with consideration of practicality, maximum potential impact and ability to be clearly described and assessed through the planning process. Many strategies also show material ongoing cost savings to building owners, residents and the City of Canterbury Bankstown.

Matrix showing relationship between previous published priorities and the strategies in this report

	Connective City LSPS							Complete Streets				Bankstown CBD Airport Place*					
Strategy	Canopy Cover	50% single dwelling PV	1.7M t CO2e	Exceed BASIX Water	205 kL/yr ave cons.	20% Waste to landfill	200 kg Waste per person	60% Car trips	bike lanes through-out the CBD	+50% canopy street cover	High amenity streets	Higher BASIX	Precinct approach	Green Grid	Investi-gate food waste treatment	Urban Heat Island	Cost of living
All-electric Buildings			■									·	·			·	·
Rooftop PV		■	▪									·	·				▪
EV infrastructure			▪					▪			▪					·	■
Residential Natural ventilation			▪													·	■
Natural refrigerants			▪													·	·
Organic Waste to Energy					·	▪	▪						▪		■		
Water resilience				■	■						·	·	▪				▪
Urban Heat mitigation	▪		·							·	■		▪	·		■	·
Amended Sustainability Bonus Scheme			▪	▪	▪	▪						▪				·	·
Energy and water targets			▪													·	

* Collaboration Area - Bankstown CBD and Bankstown Airport Place Strategy

Legend

Significance to achieving published priority	Symbol
Significant	■
Fair	▪
Minor	·

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Document Control

Project Name	Bankstown and Campsie Sustainability Study
Project Number	125
Document Title	Bankstown City Centre and Campsie Town Centre Sustainability Study Phase 2 report

Revision	Date	Prepared By	Approved By	Changes
Exhibition	15 January 2021	Ché Wall / Mario Neves	Ché Wall	Issued for exhibition

1. Introduction

The City of Canterbury Bankstown has established a vision for growth in the Connective City 2036 Local Strategic Planning Statement (LSPS). Bankstown City Centre and Campsie Town Centre's strategic centres are established as the main priority areas for growth in employment, education, and housing.

A process of masterplanning is being undertaken to determine how the growth targets can be supported by new development that also contributes to the LSPS's targets to reduce the environmental footprint in the local government area. Flux has been commissioned to support the masterplanning process by establishing sustainability strategies for each of the Bankstown and Campsie strategic centres and the controls required to deliver the sustainability strategies in the future private development of the centres.

This report is the second phase of the sustainability strategy. It is required to integrate the findings of the phase 1 study and findings of other complementary studies undertaken concurrently by other specialists to inform the masterplanning.

1.1. Report structure

The report is structured in keeping with the broad themes required to determine the strategies necessary to deliver the environmental ambitions in 2036.

The **existing context** is analysed to determine the environmental sustainability impact of the present buildings and operations within the study areas. This has established a **2020 baseline for environmental outcomes**.

The **future impacts** are analysed with respect to growth targets, current sustainability related planning controls and environmental context. The environmental context includes externalities such as the expected decarbonisation of the electricity grid, changes to the climate and technological change. This has established the projected **baseline for environmental outcomes in 2036**, assuming no constraints to growth from the FSR and building height provisions in the current LEP. The extent of development possible under the FSR and building height provisions within the current LEP is assessed in the context of build form impacts on the **urban heat island** effect.

Intervention opportunities and resulting **Sustainability priorities and strategies** are presented to improve the environmental outcomes in 2036.

1.2. Approach to estimation

The report estimates the existing environment footprint of the study areas using a variety of data sources. The sources of data are disclosed in the relevant section.

Two general approaches have been taken to the estimation of total impacts in the study areas.

A **top-down approach** to estimation has been applied where reliable aggregated data is available for specific environmental impact areas, such as electricity usage. The impacts of individual elements within the study area can then be determined through apportionment using data from other sources.

A **bottom-up approach** to estimation has been used where reliable aggregated data is not available. In this case, the impacts of individual activities and usage types are estimated. The total is established from the aggregation of those impacts.

Where costs or economic value is considered, all amounts are based on 2020 prices. Future price changes through market drivers, inflation or other factors are not considered.

1.3. Limitations of the Report

The report is authored at the earliest stages of planning and without the benefit of resolved technical requirements. The analysis that informs the initiatives recommended has been undertaken at a strategic level and is expected to be developed as the masterplanning progresses.

2. Sustainability Assessment of Existing Conditions

The existing context has been analysed for each of the Bankstown City Centre and Campsie Town Centre study areas to determine sustainability impacts.

2.1. Study areas

2.1.1. Location

The location of the study areas within the boarder Sydney metropolitan area can be seen below.

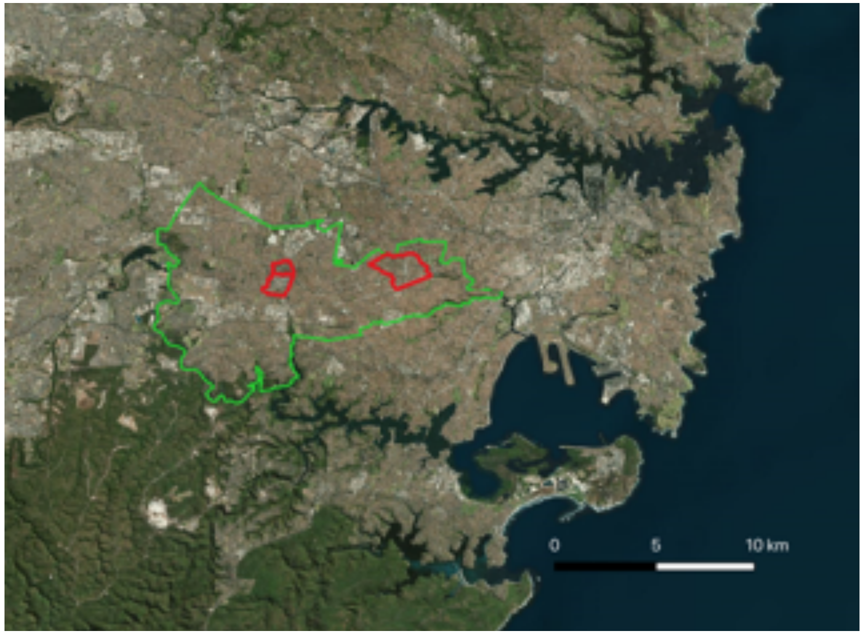


Figure 1 Location of study areas

2.1.2. Bankstown City Centre bounds

The study centre comprises the existing Bankstown CBD and covers a land area of approximately 2.2 km^2 representing just over 2% of the City of Canterbury Bankstown Local Government Area (LGA).

Figure 2 Ariel photograph showing the Bankstown City Centre study area

2.1.3. Campsie Town Centre bounds

The study centre comprises the existing Campsie town centre and covers a land area approximately 3.7 km^2 representing just over 3.3% of the LGA.

Figure 3 Ariel photograph showing the Campsie Town Centre study area

2.2. Building stock

The non-residential building stock floor area was obtained from the audits undertaken by Hill PDA[1,2] in 2019. Residential housing stock has been assessed from ABS 2016 census data with an allowance for growth until 2020 based on SGS Economics forecasts[3]. The ABS data was sourced from SA1 datasets and manually interpreted where data cells were only partially within bounds of the study areas.

Retail was separated into two types, Retail and Retail (H), to reflect the significant difference in environment intensity of different retail operations.

Type	Gross Floor Area (m2)
Office	173,398
Education	86,094
Other	18,634
Retail	78,537
Retail (H)	131,823
Fitness	37,290
Vacant	23,088
Residential	591,750
Total	**1,140,613**

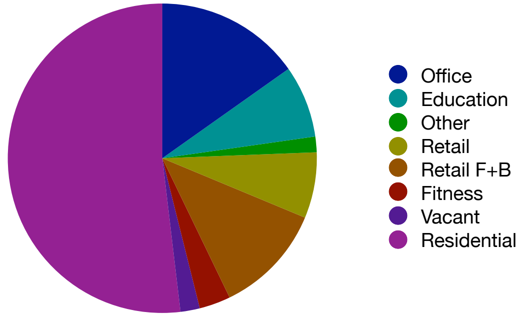


Table 1 Existing building stock in Bankstown City Centre

Type	Gross Floor Area (m2)
Office	31,709
Education	6,592
Other	610
Retail	11,401
Retail (H)	30,198
Fitness	9,421
Vacant	7,079
Residential	1,026,210
Total	**1,123,221**

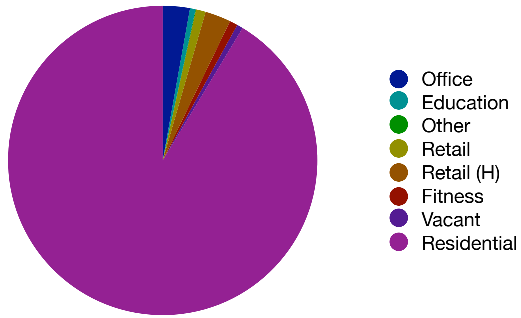


Table 2 Existing building stock in Campsie Town Centre

Retail (H) encompasses restaurants, fresh food, supermarkets, convenience stores, electrical, service retail and the current Bankstown Central shopping centre.

[1] Bankstown floorspace audit March - April 2019, Hill PDA. Bankstown floorspace.xlsx supplied

[2] Campsie floorspace audit March - April 2019, Hill PDA. Campsie floorspace.xlsx supplied

[3] Canterbury-Bankstown – Demographic Study, March 2019. SGS Economics.

Residential floor space is seen to be particularly dominant in Campsie compared to Bankstown which shows almost equal split between residential and non-residential floor space.

The average number of occupants in each dwelling was sourced from the ABS 2016 census data for place of usual residence and showed a higher number of occupants per dwelling than the NSW State average of 2.6, which is used as the benchmark for BASIX Energy and Water targets.

	Bankstown			Campsie		
Dwelling Type	**Number of Dwellings**	**Number of Usual Residents**	**Average density (people/dwelling)**	**Number of Dwellings**	**Number of Usual Residents**	**Average density (people/dwelling)**
House	762	2,806	3.68	2,324	7,855	3.38
Apartment	4,543	12,498	2.75	5,205	13,672	2.63
Total	**5,305**	**15,304**		**7,529**	**21,527**	

Table 3 Density of occupation of residential dwellings

It can be see that the density of occupation per house is significantly above the state average for both study areas. This results in proportionally higher energy consumption per dwelling. Apartments as also seen to be slightly above the state average for density of occupation.

2.3. Transport

To establish the impacts of existing transport uses, the ABS 2016 census data was used together with the Sydney average distance of travel statistics for each transport mode. SA2 statistical areas of Bankstown North and Bankstown South were deemed indicative of the Bankstown City Centre's residential population, and the Belmore-Belfield and Canterbury South statistical areas were taken to represent Campsie Town Centre.

Despite well-serviced train stations, The census data showed private vehicle usage to dominate the commuting mode of transport.

A comparison the modal split for the entire Greater Sydney Region is provided for comparison. It is seen that both Bankstown and Campsie study areas have reduced public transport use and bicycle use. A higher proportion walked to work in Campsie compared to the Greater Sydney average.

	Proportion of travel by mode for daily commute		
Mode	**Bankstown City Centre**	**Campsie Town Centre**	**Greater Sydney Average**
Train	4.5%	6.1%	13.2%
Bus	2.6%	2.8%	6.6%
Ferry	0.0%	0.0%	0.4%
Tram / Light Rail	0.0%	0.1%	0.1%
Taxi	0.2%	0.3%	0.3%
Car (driver)	79.9%	71.4%	61.3%
Car (passenger)	5.9%	6.6%	4.5%
Truck	0.7%	0.8%	0.8%
Motorbike/Scooter	0.3%	0.2%	0.8%
Bicycle	0.2%	0.3%	0.9%
Other	0.4%	0.6%	0.6%
Only Walked	2.9%	7.3%	4.8%
Train + Bus	1.6%	2.5%	3.1%
Train + Ferry	0.0%	0.0%	0.1%
Train + Tram/LR	0.0%	0.1%	0.1%
Train + Car (d)	0.4%	0.3%	1.8%
Train + Car (p)	0.2%	0.2%	0.5%
Train + other	0.1%	0.1%	0.2%

Table 4 Commuting mode of transport split

The number of commuters departing the study area was determined based on average commuters per household in each of the four SA2 areas referenced. The resulting ratios were applied to the dwelling numbers derived from more granular SA1 statistical areas, described in Section 2.2 above. 1.82 commuters per household were determined for Bankstown City Centre compared to 0.64 commuters per household for the Campsie Town Centre.

The statistical variance between the respective areas might be explained by demographic differences, including employment rates, age of occupants and rates of flat and house sharing. The detailed analysis of this aspect is beyond the scope of this report.

The average distance travelled by each mode of transport was taken from the Greater Sydney statistical area adopted in the Climate Active transport calculator and extrapolated to annual distances based on a 260-day working year. The proportion of travel within the boundary of the study areas was also estimated.

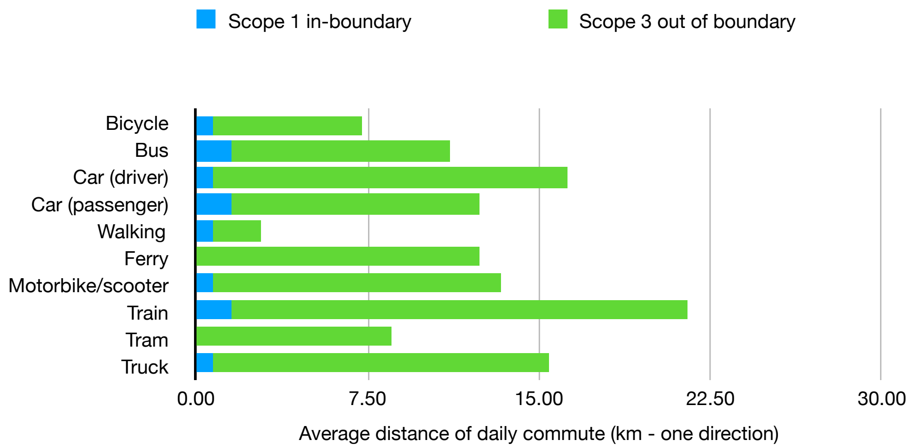


Figure 4 Average daily commute distances for Greater Sydney region by transport mode

For inbound workers, the modal split and average distance of travel by mode were assumed to be the same as for outbound commuters. The number of inbound journeys was determined by the number of jobs provided in each of the study areas, as published in the respective background reports[4,5].

The movement of service vehicles has not been estimated due to lack of available data and expected lack of control and materiality.

2.4. Stationary Energy Use

2.4.1. Electricity

The use of electricity within the town centres was established from recoded distribution zone substation data published by Ausgrid[6].

The Greenacre Park zone substation serves almost the entirety of the Bankstown City Centre site. The Campsie zone substation includes almost all of the Campsie Town Centre study area. Adjustments were made to the proportion of the study area considered attributable to the zone substation loads, with Bankstown City Centre being weighted higher due to the concentration of commercial uses compared to the rest of the area served. The comparative areas of coverage can be seen in the following figure.

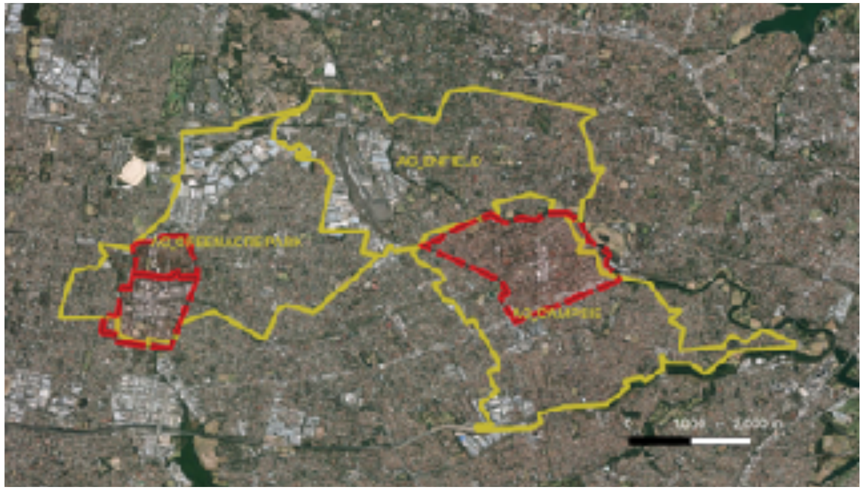


Figure 5 Relative coverage of zone substations supplying study areas

The Ausgrid substation dataset records electricity demands in fifteen-minute intervals over the year. This provides valuable insight into the daily load profiles and total usage of electricity.

[4] Bankstown City Centre Background Report April 2020 City of Canterbury-Bankstown

[5] Campsie Town Centre Background Report April 2020 City of Canterbury-Bankstown

[6] https://www.ausgrid.com.au/Industry/Our-Research/Data-to-share/Distribution-zone-substation-data

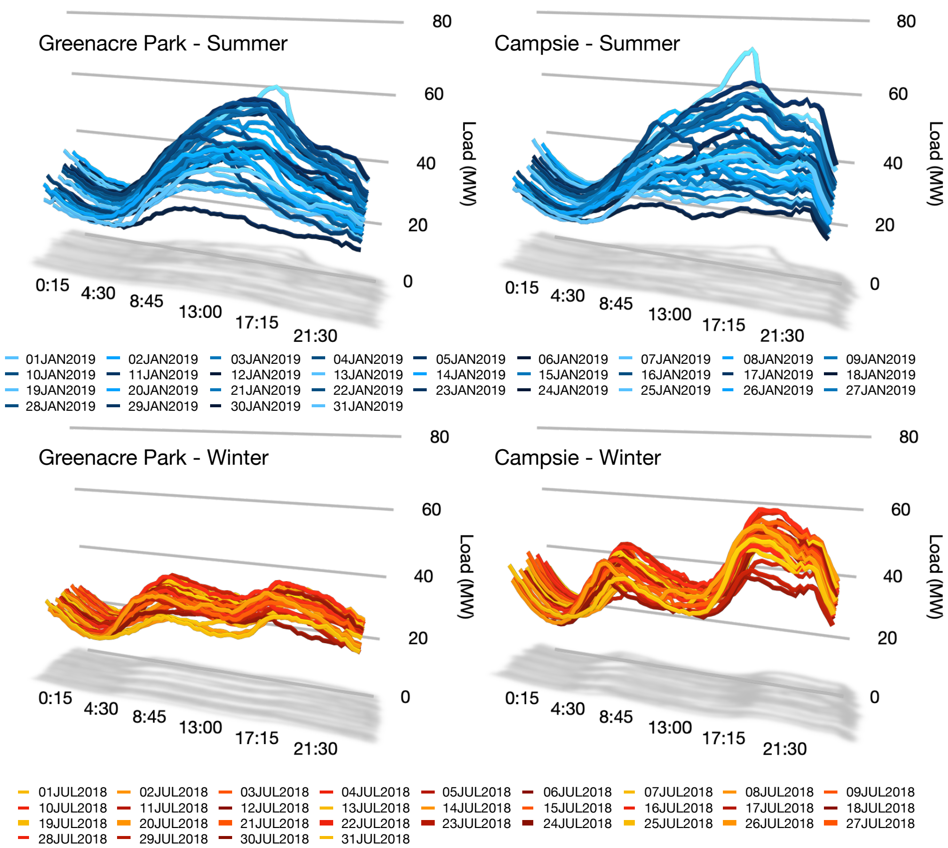


Figure 6 Daily demand profile of electricity in study areas

The Greenacre Park summer daily profiles show a strong peak during the day, typical of commercial building demand. This compares to the Campsie summer daily profile, which shows continued high loads into the evening, typical of residential dominated demand. These differences are more pronounced in winter, when Greenacre Park shows a relatively flat profile, compared to Campsie, which has distinct morning and evening peaks, typical of residential usage. Based on these observations, the substation profiles were considered a good representation of the existing use mixes for the respective precincts they serve.

Analysis of the relationship of daily electricity demand and daily mean temperature provides insight into the proportion of demand related to the cooling and heating of buildings and those not impacted by the climate such as artificial lighting, process loads, ventilation, etc. The illustrations below separate weekends and public holidays from working days to ensure the analysis is not influenced by significant changes in building use and daily behaviour.

The analysis shows a strong correlation between the total daily electricity demand and the mean daily temperature, which can be applied to estimate the future impact of climate change and increased urban heat upon electricity demands.

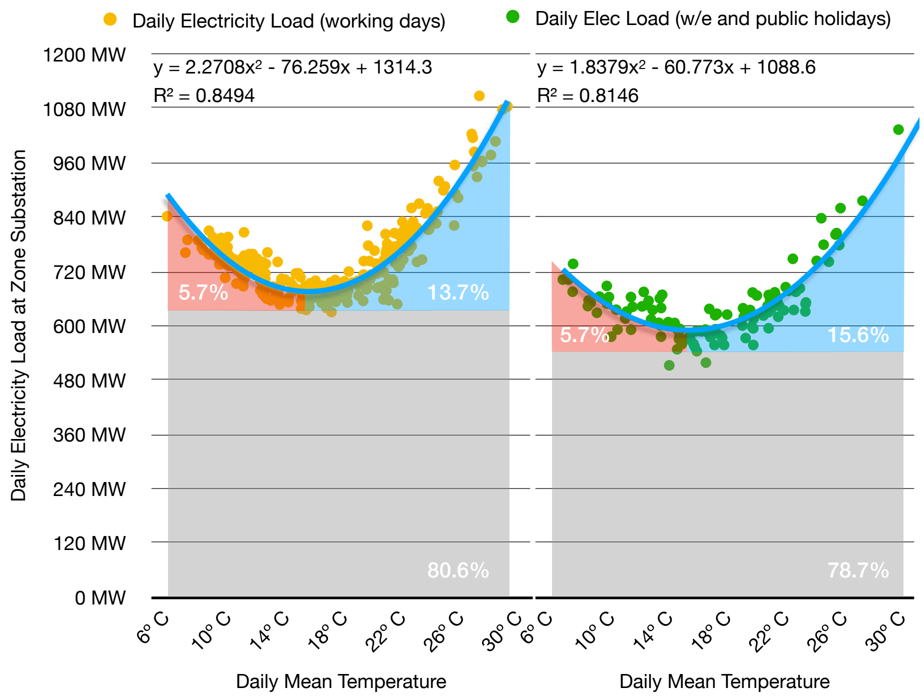


Figure 7 Greenacre Park cooling and heating related electricity consumption

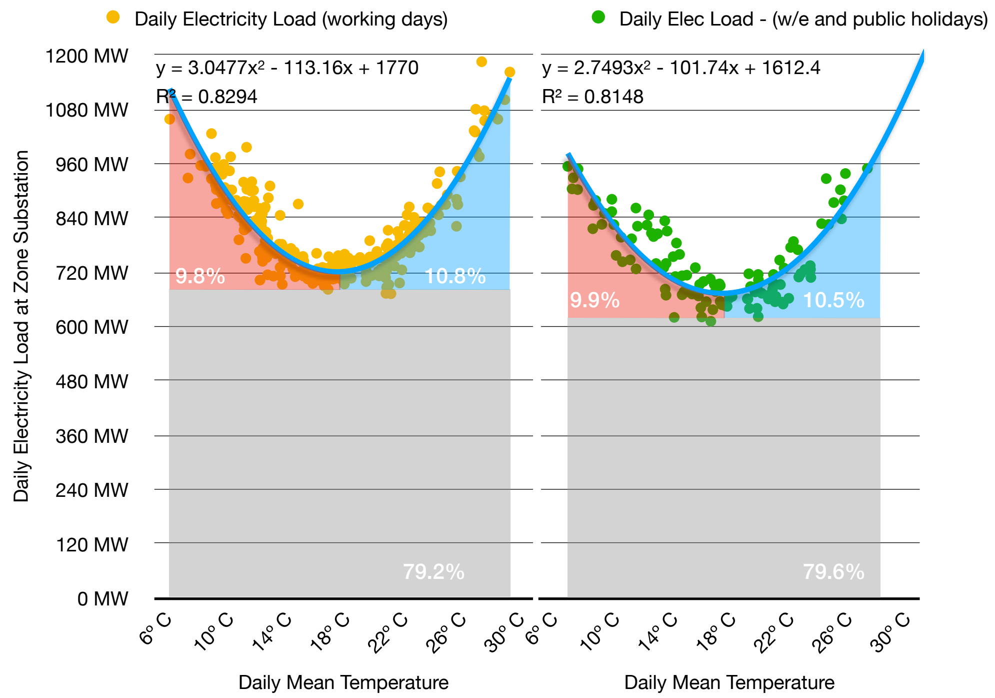


Figure 8 Campsie cooling and heating related electricity consumption

2.4.2. Gas

The demand for natural gas cannot be determined from the distribution network as the gas network is not zoned. Gas use in the study areas has been estimated from bottom-up analysis of estimated building energy demands and typical fuel splits.

There is limited information on fuel split by building types in NSW. The NABERS dataset provides valuable information for the Sydney metropolitan region, but it is limited in the breadth of building use types covered and the exclusion of tenants related impacts in most building types. For retail, this limits the insight into the common areas and excludes any information on the consumption of energy in the retail tenancies, where food retailers will be a big consumer of gas for cooking.

For the basis of the bottom-up analysis for non-residential, we have referenced the latest available US Commercial Building Energy Consumption Survey (CBECS) survey data for Mixed-Humid and Hot-dry/Mixed-dry/Hot-humid climate zones published by the US Energy Information Agency.

Residential rates of gas use were determined for the AEMO published residential energy benchmarking data.

Compared to total energy use within each building type, the proportion of gas use is shown below, together with the resulting annual gas demand for Bankstown City Centre.

Type	Proportions of gas	GJ/Annum
Office	33%	49,786
Education	52%	17,460
Other	35%	1,417
Retail	8%	4,522
Retail (H)	64%	157,922
Fitness	24%	8,532
Vacant	23%	125
Residential	46%	87,275
Total		327,039

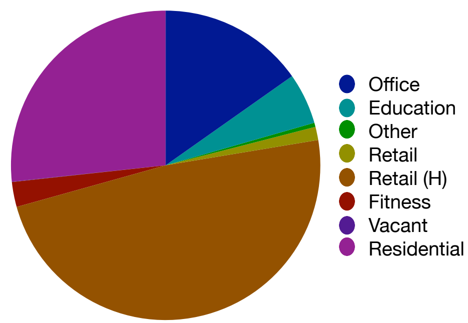


Table 5 Estimate of annual gas demand in the existing Bankstown City Centre

Using the same methodology, 179,089 GJ per annum has been estimated for Campsie Town Centre.

The dominant uses of natural gas in buildings are heating of non-residential buildings, hot water and cooking.

2.5. Renewable Energy

The uptake of rooftop solar photovoltaics (PVs) was benchmarked for each study area using postcode level data supplied by the Clean Energy Regulator. The data is provided for installations smaller than 100kW, which captures all rooftop solar installations except the very largest that might be installed on a shopping centre or industrial shed roof.

The data shows that Bankstown postcode 2200 has the largest capacity per installation in the LGA, with an average capacity of 5.3 kW per installation. Campsie 2194 postcode indicates that average PV capacity is approximately 20% less at 4.4kW per installation.

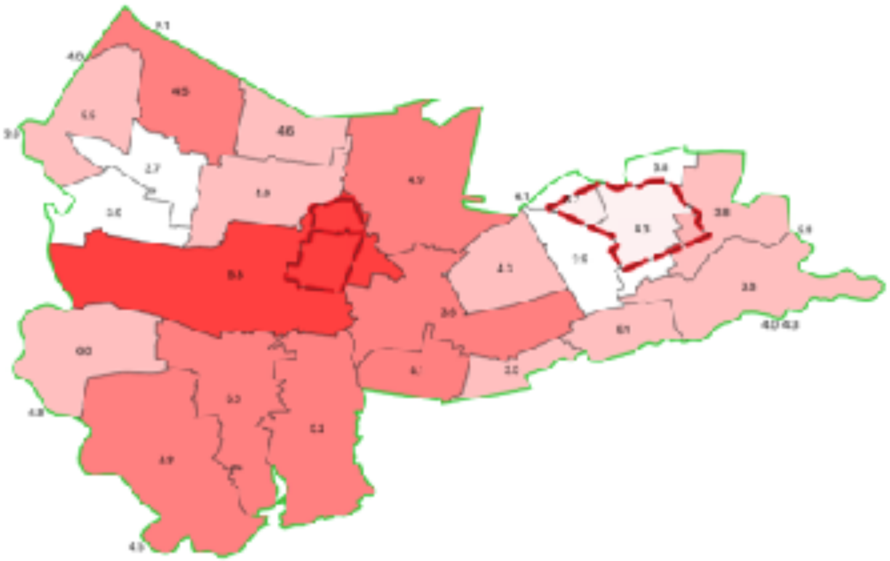


Figure 9 Average installation size of small scale rooftop photovoltaics

The overall capacity of rooftop PVs in both areas is 0.5 watts/m2 of total land area. This compares to a maximum potential capacity of the existing rooftops of 14 watts/m2 of total land area according to a recent study by the Institute of Sustainable Futures. On this basis, only 3% of the notional capacity for PVs on the existing roofs has been utilised.

Analysis of existing roof areas, topologies, and potential solar locations was undertaken and determined a lower potential capacity of 9.8 watts/m2 in the Bankstown City Centre and 9.4w/m2 in the Campsie Town Centre. Our more conservative estimate of potential capacity for rooftop PVs indicates that the current installations have absorbed 5% of the notional capacity.

The data available on the number of rooftop solar installations by postcode does not provide information on whether the systems are installed on houses, apartments or non-residential buildings. It is therefore not possible to confirm the proportion of households that have solar installed on their rooftops.

An analysis of BASIX certificates for apartment buildings in the postcodes overlapping the study areas was undertaken and revealed significant under-provision of PVs in apartment buildings.

In Bankstown postcode 2200 only three apartment buildings included PVs in the BASIX Energy certification. The total installed capacity was given as 192.5 kW. The number of apartments within the three buildings was 685, 11% of the total number of dwellings certified under BASIX in the same period. This equates to an average install size of 280 watts capacity per apartment in a building with PVs on the roof, or just 32 watts per apartment averaged over the total number of apartments certified under BASIX.

In Campsie postcode 2194 just one apartment building included PVs with a 2.4 kW installation serving 24 dwellings, just 0.7% of the total apartment rated under BASIX in the period. The capacity of installed PV on an apartment basis was only 100 watts/apartment in the building and 0.7 watts/apartment when averaged over the total number of apartments certified under BASIX within the postcode.

The analysis confirms that the BASIX Energy regulated minimum requirements for multi-unit residential buildings are not sufficiently stringent to ensure PVs are installed on rooftops.

2.6. Air Conditioning

The capacity of installed air conditioning equipment was estimated for the existing building stock to support an understanding of the environmental impacts of synthetic refrigerant gases and anthropogenic heat. The proportion of single-family houses with air conditioning was taken to be 48%, which was derived from BASIX Certificate Data and 70% of apartments, which assumes all new apartment dwellings are proved with air conditioning. Air conditioning of commercial buildings was taken at 100% with schools at 50%.

Building Usage	Bankstown City Centre Estimate of refrigerant charge (kg)	Campsie Town Centre Estimate of refrigerant charge (kg)
Office	4,467	817
Education	647	50
Other	0	0
Retail	2,023	294
Retail (H)	5,660	1,297
Fitness	1,121	283
Vacant	595	182
House	1,840	5,612
Apartments	8,874	10,167
Total	**25,227**	**18,701**

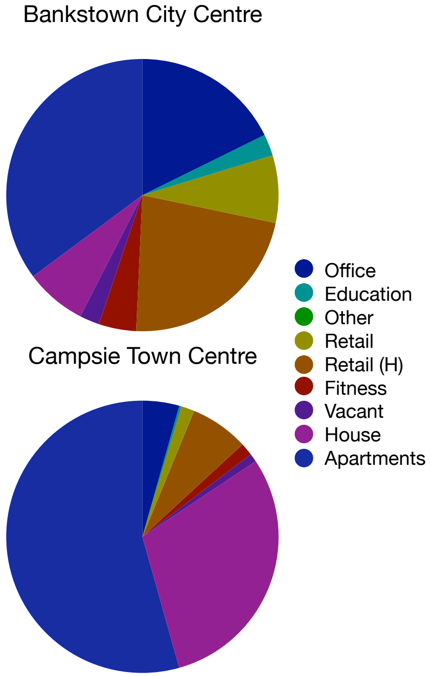


Table 6 Estimate of installed synthetic refrigerants

An estimated 47 MW of total cooling capacity is installed in the Bankstown City Centre with a total refrigerant charge of 25.2 tonnes. A lower refrigerant charge of 18.7 tonnes was estimated for the Campsie study area.

2.7. Water use

Water use has been estimated using bottom-up analysis of the existing building stock and typical use benchmarks from Sydney Water, Hunter Water and other sources.

Building Usage	Bankstown City Centre Estimate of Water use (ML/annum)	Campsie Town Centre Estimate of Water use (ML/annum)
Office	143	20
Education	60	5
Other	7	0
Retail	50	7
Retail (H)	224	51
Fitness	46	9
Vacant	2	1
Residential	1,133	1,616
Public Parks	38	51
Total	**1,705**	**1,761**

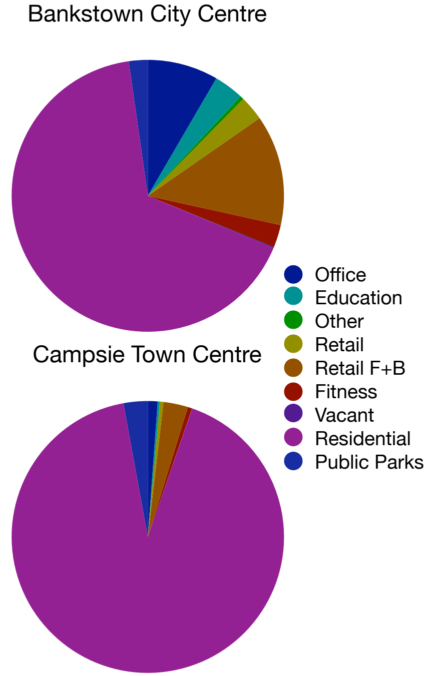


Table 7 Estimate of annual water demand

Residential water demand is seen to be dominant in both study areas. In the Bankstown City Centre study area, average water consumption was taken as 200 kL/year for each apartment and 295 kL/year for each house. The average water consumption in Campsie Town Centre was reduced to 195 kL/year for an apartment and 276 kL/year for a house to reflect the lower density of dwelling occupancy in the area.

The low water use for the non-residential buildings in the Campsie Study Area is attributed to the relatively small size of buildings, which do not suit the application of cooling towers for air conditioning heat rejection.

2.8. Waste generation

Waste generation has been estimated using bottom up analysis of the existing building stock and typical generation benchmarks. The SSROC Canterbury Bankstown 2019 audit[7] was used as the basis for residential waste. The multi-unit dwelling waste generation was cross compared with a similar study by the City of Sydney[8] and found to be consistent.

Building Usage	Bankstown City Centre Estimate of waste generation (t/annum)	Campsie Estimate of waste generation (t/annum)
Office	1,561	285
Education	775	59
Other	168	5
Retail	4,712	684
Retail (H)	7,909	1,812
Fitness	336	85
Vacant	2	1
Residential	2,986	5,195
Public Parks	305	405
Total	**18,754**	**8,531**

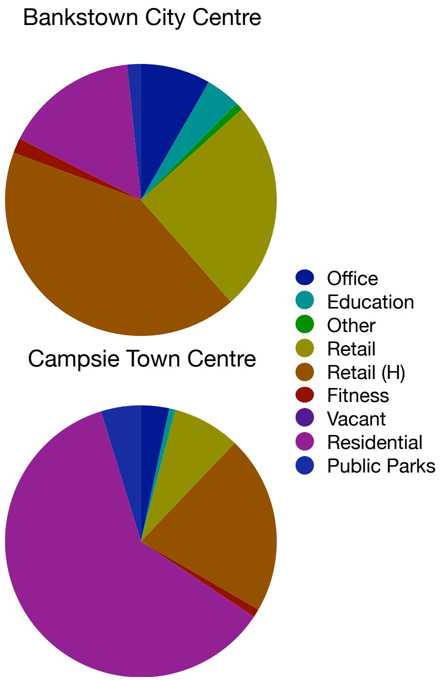


Table 8 Estimate of annual waste generation rates

Retail is seen to be the most significant contributor to waste generation in Bankstown. This is due to the waste from shipped goods, packaging and organic waste.

The impacts of transport and disposal to landfill of the waste has been considered in the greenhouse gas emissions inventory.

2.9. Vegetation

The amount and distribution of urban vegetation were established from the OEH urban heat and green cover datasets[9]. The maps indicating the proportion of coverage with any type of vegetation are shown below.

Figure 10 Coverage of vegetation in the Bankstown and Campsie study areas

[7] SSROC Kerbside Waste Audit City of Canterbury Bankstown Report 2019

[8] SSROC Kerbside Waste Audit City of Sydney Council Report for high-rise multi-unit dwellings 2015

[9] NSW Urban Vegetation Cover to Modified Mesh Block 2016

It can be seen that the commercial core of the Bankstown study area is particularly challenged for vegetation.

The environmental benefits accrued from more urban vegetation are dependant on several characteristics. For trees, the amount a shade provided and cooling effect created through evapotranspiration is a product of the leaves' average surface area, the density of leaves, and the leafed canopy volume. Large canopy trees are therefore significantly more beneficial than small trees.

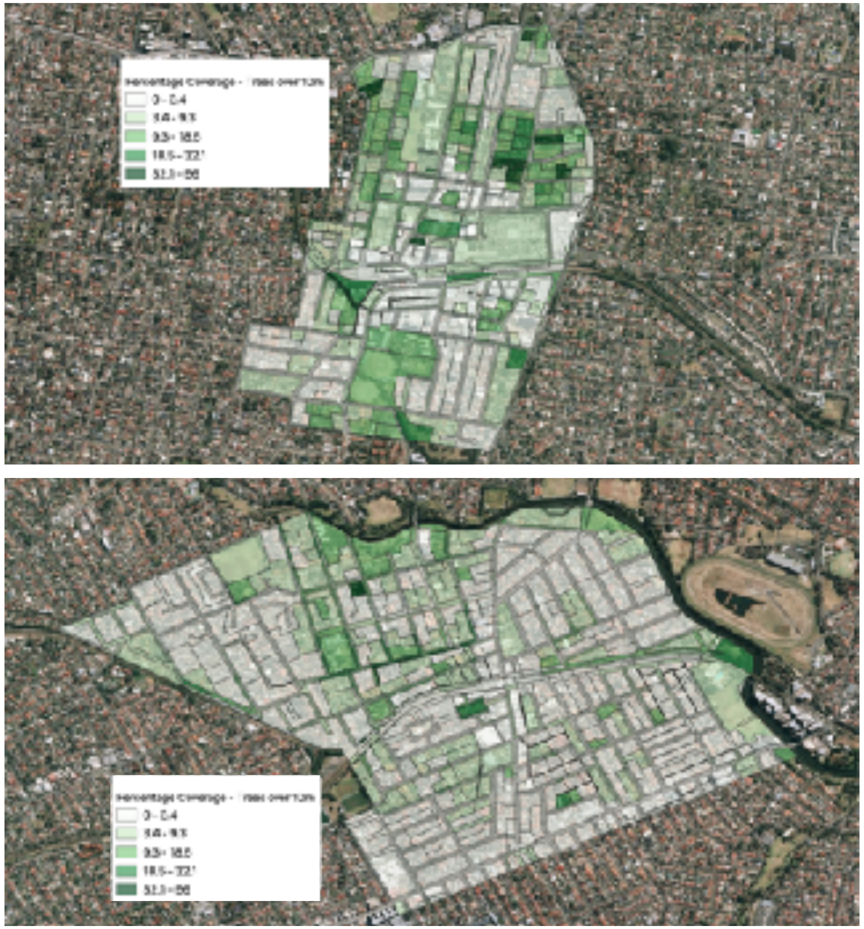


Figure 11 Coverage of tall trees in the Bankstown and Campsie study areas

The data was mapped to show the portion of the study area that benefits from trees of a minimum 10m height, which is the nearest proxy available in the data set to isolate the more beneficial larger canopy trees.

It can be seen that there are limited tall trees in both study areas with the majority of the Campsie study area showing a low percentage of coverage of larger canopy trees.

A benchmarking comparison of the distribution of tree canopy percentage coverage (for any size tree) was undertaken for each study centre compared to the LGA and the Greater Sydney region. It shows that the Bankstown study area is typical of the Greater Sydney Region and Campsie is better than the benchmarks.

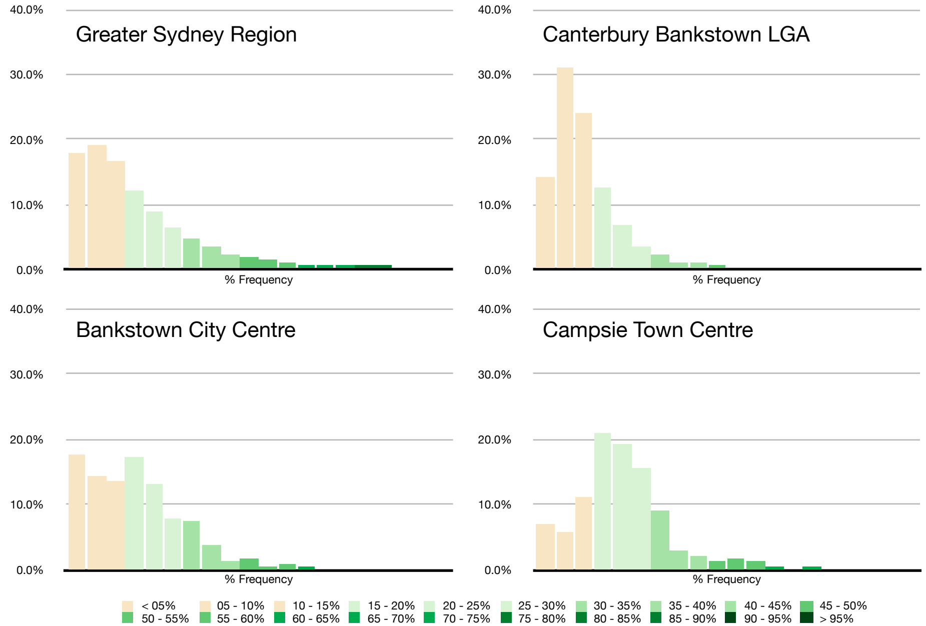


Figure 12 Tree cover (any height) benchmark comparison

Further analysis of average percentage coverage by the height of tree confirms that the Campsie study area has more smaller trees and fewer trees over 10m height, as suggested in the maps above.

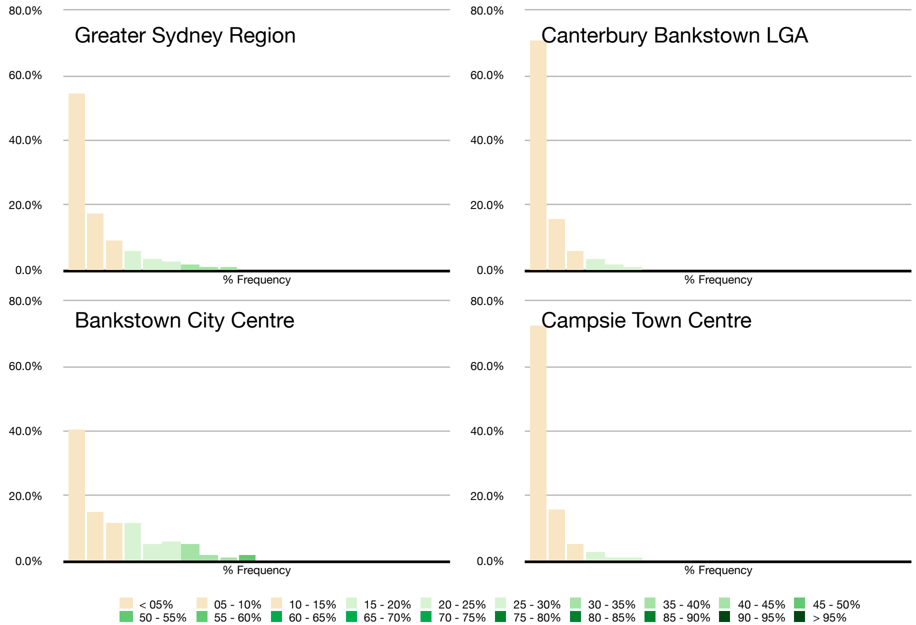


Figure 13 Tall tree cover (10+ m) benchmark comparison

It is noted that the distribution of percentage coverage in the OEH dataset is provided per mesh block unit and is not normalised to a common area basis. This will overweight small mesh blocks and underweight large mesh blocks in the distribution. However, because the area of mesh blocks is not biased towards any particular percentage of tree canopy coverage, it still provides useful insight.

Whilst trees are important to provide shade and evapotranspiration, there is only a weak correlation with land surface temperatures, so tree cover cannot be used as a singular proxy for urban heat impacts.

The analysis above was found to be consistent with the findings of the Bankstown and Campsie Urban Tree Canopy Masterplan Phase 1 report that was prepared concurrently by Oculus.

2.10. Temperatures

2.10.1. Surface Temperatures

Land Surface Temperatures (LST) were benchmarked using the OEH urban heat and green cover datasets[10]. LST deviation measures the difference in surface temperature to a non-urban vegetated reference within the Greater Sydney Region. For example, the reference temperature may be the average temperature of heavily wooded areas of national parks around Sydney. The LSTs in the dataset were observed by satellite in the summer of 2015-2016.

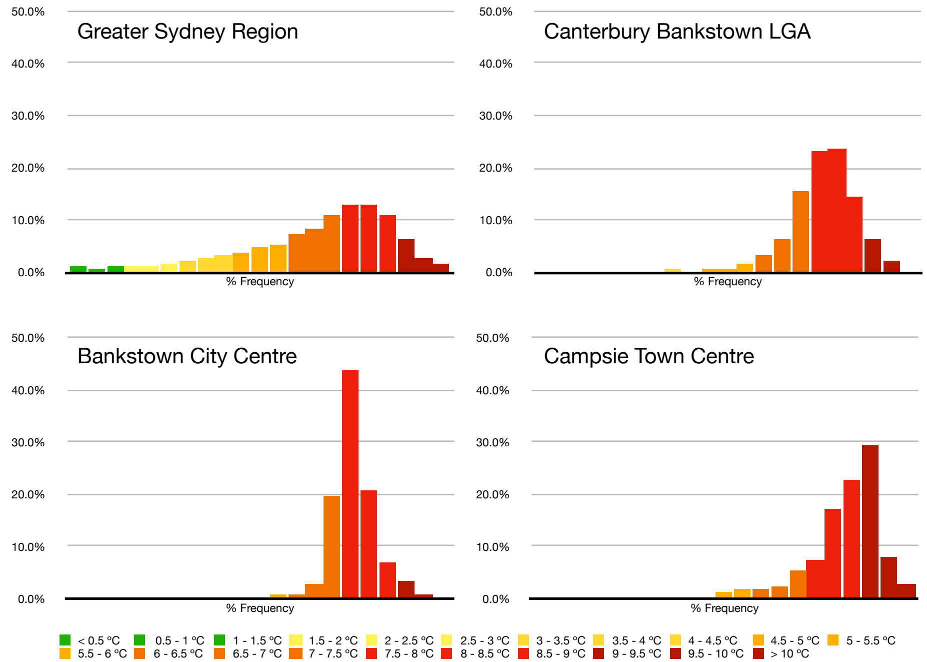


Figure 14 LST benchmark comparison

A benchmarking comparison of the distribution of LST deviations was undertaken for each study centre compared to the LGA and the Greater Sydney region. It shows that both study areas have significantly elevated

[10] NSW Urban Heat Island to Modified Mesh Block 2016

land surface temperature compared to the Greater Sydney region. They are also markedly hotter than the broader LGA.

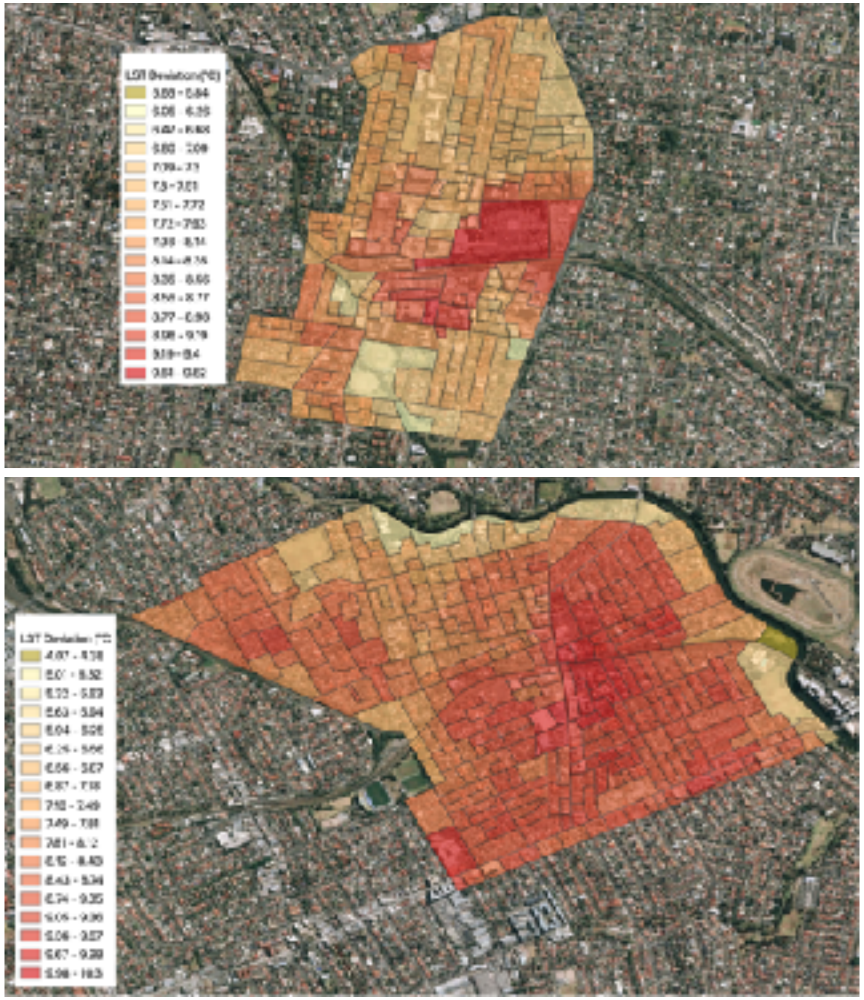


Figure 13 Land Surface Temperature deviation in Bankstown and Campsie stud areas

The mapping data shows the elevation in LST caused by denser development. It also shows the benefit of parks and green public open space in moderating surface temperature elevation.

Elevated LST is caused by the absorption and trapping of heat in the urban environment and is a key indicator of the Urban Heat Island effect.

2.10.2. Air temperature

The mean daily air temperatures were benchmarked at the nearest available weather monitoring station and compared to the Mascot weather AMO weather station, which is often used to inform energy assessments for large parts of the greater Sydney region, including under the NCC 2019 BCA and BASIX. Bankstown Airport is the nearest weather monitoring station to the Bankstown City Centre. Canterbury Racecourse provides monitoring of weather directly adjacent to the Campsie Town Centre.

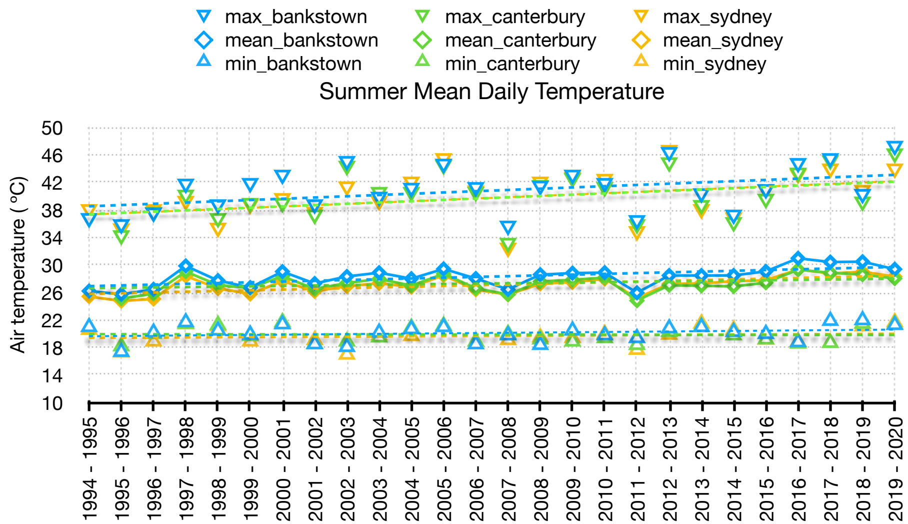


Figure 15 Mean daily air temperature comparison

It can be seen that the mean daily maximum air temperature has risen significantly over the last 25 years in all three locations. Bankstown airport typically records a mean maximum air temperature in summer of 2-3 °C above that recorded at Mascot. Canterbury racecourse is seen to record mean air temperature closer to that observed at Mascot.

The observations for Bankstown confirm that energy predictions undertaken during the design of new buildings are likely to underestimate energy usage when using weather data recorded at Mascot.

2.11. Sky View

The Sky View Factor (SVF) is a key factor affecting urban surface heat balance. It is a simple geometric measure of what portion of the sky can be seen from any point at street level and provides a proxy for net radiation.

An SVF of 0 indicates that the view of the sky is completely obscured and no direct radiation exchange can occur with the sky. As the view of the sky increases, the SVF increases to a maximum of 1, which indicates a completely unobstructed view of the sky.

The SVFs within open space in the Bankstown CBD was benchmarked using a 3D model of the existing buildings supplied by the City. It showed that the current CBD maintains relatively high sky view factors.

Figure 16 Sky view factors in the existing Bankstown CBD

Increased building height, street wall height and urban infill all reduce the view of the sky, which in turn reduces how much heat can be dissipated overnight through radiation exchange with the sky vault. Reduced dissipation of heat in a daily cycle leads to an increase in trapped heat within the urban fabric and SVF is therefore an important indicator to understand the urban heat island effect.

2.12. Rainfall

The study areas' rainfall was benchmarked using the nearest available weather monitoring station and compared to the Mascot AMO weather station, which is commonly used as a proxy for the broader metropolitan region.

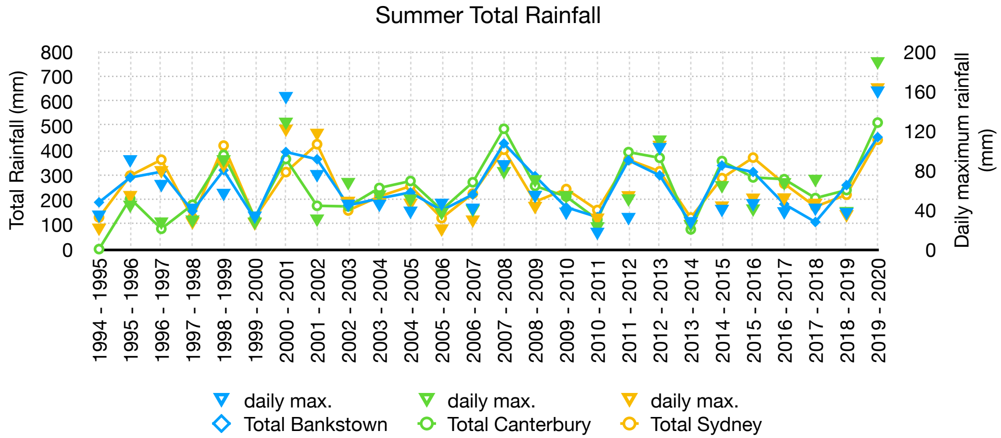


Figure 17 Comparison of historic rainfall

The analysis showed no single year with typical rainfall for either the Bankstown or Campsie study areas. To assess rainfall harvesting capacity, a typical year was constructed using different years for each of the four seasons that best represented rainfall patterns over the 25 years of data analysed. The method applied was a modified version of the process developed by Flux to determine representative weather years for passive performance assessment[11].

[11] Weather Year for Passive Performance Assessment repository

A spatial audit was undertaken to estimate the rainfall available for harvesting from roofs. A breakdown of the proportion of areas for the Bankstown and Campsie study areas and the annual rainfall received by each is shown below.

Typology	Bankstown City Centre annual rainfall (ML)	Campsie Town Centre annual rainfall (ML)
Roofs	582	973
Roads, Pavements + Rail	539	947
Public Open Space	161	213
Private Open Space	1,062	1,761
Total	**2,344**	**3,895**

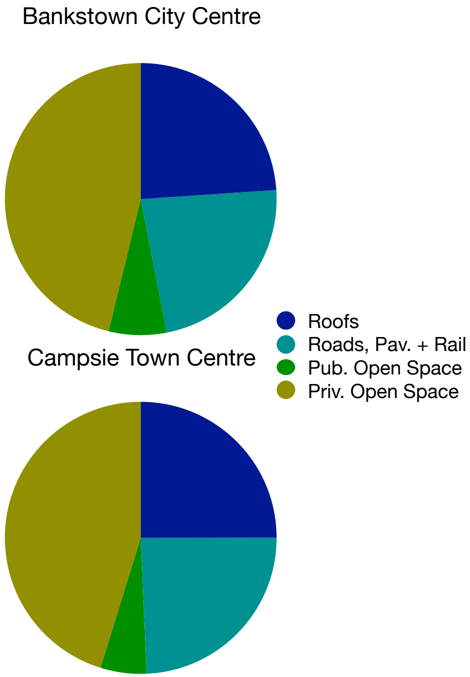


Table 9 Estimate of typical annual rainfall availability

The BASIX dataset was analysed to establish the uptake of rainwater tanks in residential development. It showed that since 2012, 151 dwellings were certified with rainwater tanks in Campsie postcode 2194 and 1,149 dwellings had rainwater tanks in Bankstown postcode 2200. When adjusted based on the number of dwellings in the postcode area and dwellings in the study areas, it is estimated that approximately 11,000 kL per year is reused in the Bankstown study area compared to 10,000 kL per annum reused in houses in the Campsie study area. BASIX does not provide rainwater tank data for multi-unit residential and it is not expected that other non-residential buildings would have significant rainwater reuse given it is not regulated.

2.13. Anthropogenic heat

Heat rejection from building air conditioning and motor vehicles has been estimated as the primary sources of anthropogenic heat in the study areas. Unless effectively dissipated, anthropogenic heat will contribute to urban heating.

Heat rejection from building air conditioning was assessed on a hot summer day as a product of diversified total cooling loads within the buildings and the energy consumed by the compressors that provide the mechanical cooling. The proportion of buildings with cooling towers was estimated and the loads apportioned to latent heat, which has less heating impact on outdoor air temperature than the sensible heat rejection of air-cooled units.

Building Usage	Bankstown City Centre Estimate of total anthropogenic heat (MWh)	Campsie Town Centre Estimate of total anthropogenic heat (MWh)
Office	125	46
Education	29	2
Other	0	0
Retail	136	20
Retail (H)	221	101
Fitness	75	19
Vacant	0	0
Residential	159	238
Motor Vehicles	41	31
Total	**786**	**457**

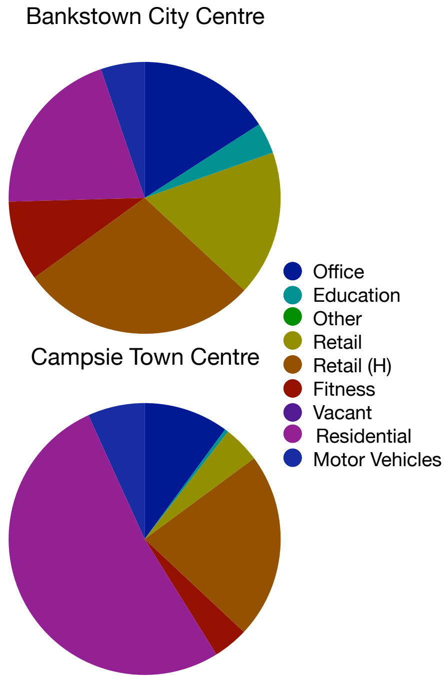


Table 10 Estimate of daily anthropogenic heat on a hot summer day

For travel, vehicle movements within the site boundary were considered with traffic volumes as detailed in section 2.3. An additional allowance was made for visitors to the studies areas.

Heat rejection from air conditioning is shown to be the most significant contributor to anthropogenic heat. The amount of anthropogenic heat rejected is dependent on cooling demands. Anthropogenic heat from motor vehicles is comparatively modest, but is concentrated at peak times and is also rejected within the occupied zone of streets, where it has a more direct impact on microclimate.

2.14. Greenhouse Gas Inventory

A greenhouse gas inventory has been prepared for the two study areas using the principles of relevance and materiality detailed in the federal government's Climate Active standard for Precincts[12].

The estimated annual greenhouse gas emissions associated with the two study areas are shown below in stacked bars, with impact areas stacked in the same order as the adjacent legend.

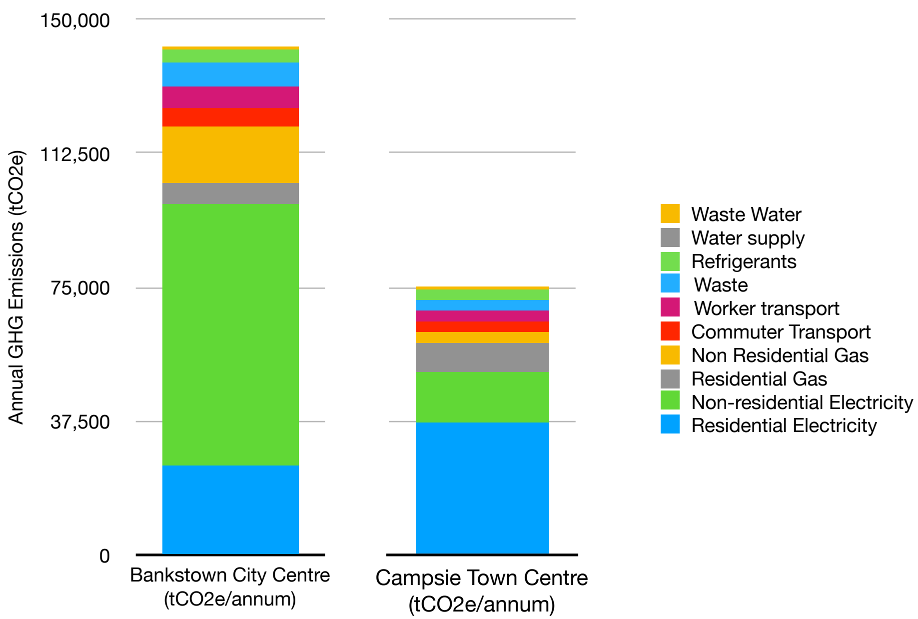


Figure 18 Estimated annual greenhouse gas emissions in the study areas

The emission boundary is established as the geographic boundary of the study areas. The relevance tests and list of excluded sources of emissions can be found in Appendix A.

The allocation of emissions to scope in accordance with the Climate Active standard is shown below.

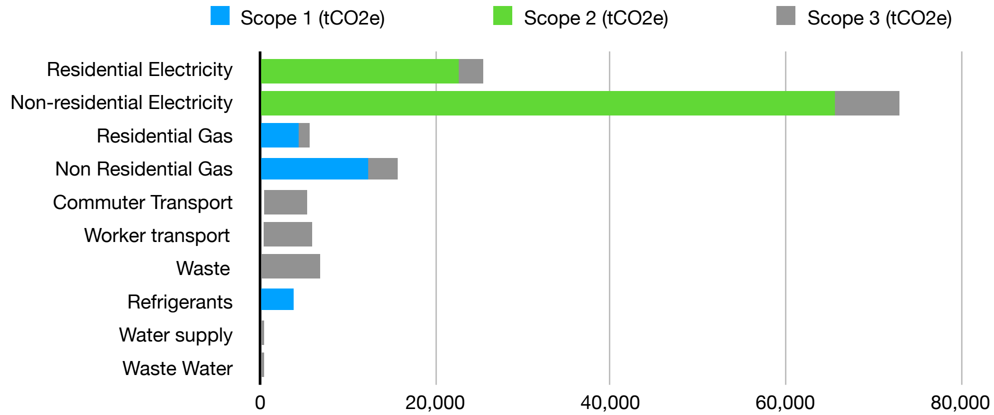


Figure 19 Annual GHG Emissions by scope - Bankstown City Centre

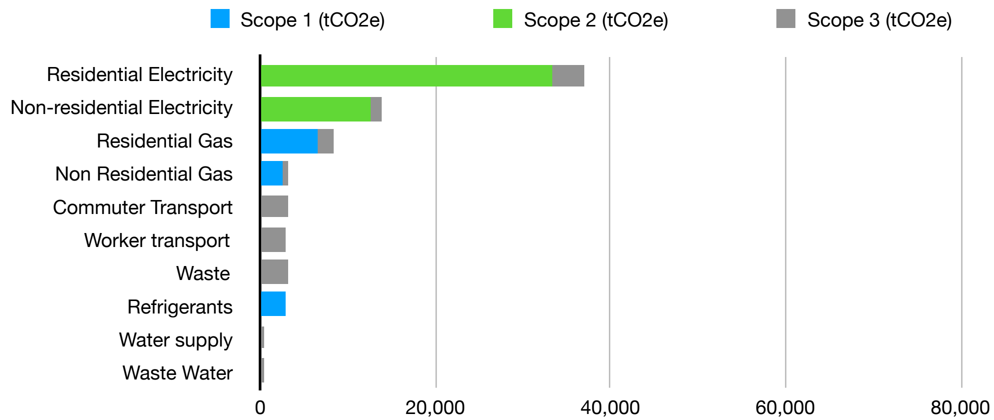


Figure 20 Annual GHG Emissions by scope - Campsie Town Centre

[12] Climate Active Carbon Neutral Standard for Precincts Department of Industry, Science, Energy and Resources 2019

Summary of implications for the masterplan

1

Maximising energy efficiency is the single most important environmental concern for the masterplan.

The greenhouse gas emissions within the study area are dominated by energy use within buildings, which account for approximately 80% of all emissions. Of the energy use within buildings, electricity is shown to be the most significant.

2

Energy efficiency has to consider more than just thermal efficiency.

The analysis showed that 20-30% of the overall electricity demand could be attributed to buildings' heating and cooling. Therefore, it is essential to extend controls as broadly as possible, including energy-efficient appliances and the fitting out of the buildings.

3

Rooftop PV is under-utilised as a source of renewable energy.

The assessment showed that installed rooftop PV is presently only 5% of the existing rooftops' potential capacity. Apartment buildings were shown to have a very poor uptake of PVs indicating current minimum regulated requirements are not stringent enough.

4

Water re-use in priority for reducing the demands on drinking water.

The assessment found that residential water uses dominant in both study areas, which indicates the scope of continued savings through more efficient fixtures and fittings will be limited.

5

The Urban Heat Effect and microclimate are key considerations for the masterplan.

The analysis showed evidence of increased average air temperatures and elevated land surface temperatures in both study areas. The addition of more buildings will introduce more sources of heat and also reduce the dissipation of heat. This will have a direct impact on increased urban heat if not controlled.

6

The sustainability impacts of air conditioning are broader than just the use of energy.

The study has estimated the greenhouse gas emissions associated with the leakage of synthetic refrigeration gases and also the significant amount of anthropogenic heat that air conditioning contributes to heating the urban environment.

7

Both study areas show a high reliance on private car use.

Car use for daily commuting is higher than 70% of trips in both study areas. As employment places outside the study area may not have convenient access to public transport, the reliance on private cars is likely to continue in the medium term.

8

Residential and retail sources of solid waste provide the greatest opportunity to reduce impact from landfill.

The analysis of waste generation has confirmed that retail and residential waste streams provide the most significant opportunities to divert waste from landfill.

3. Assessment of future impacts under current environmental controls

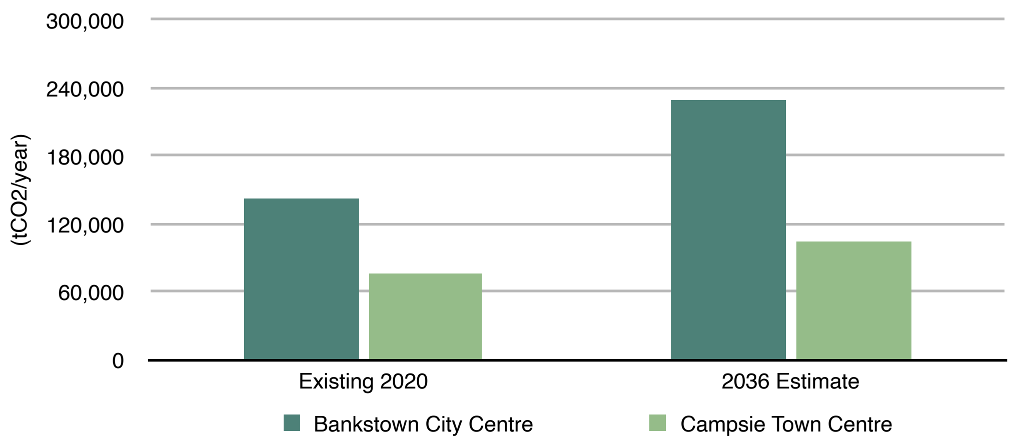
This Section provides quantification of the environmental outcomes associated with the growth targets.

The impacts are presented by environmental impact area for each study area in 2036 and compared to the 2020 estimated impacts benchmark.

The current planning scheme cannot meet the growth targets for housing, education and jobs. To estimate the future environmental impacts under the current DCP and LEP controls, we have assumed that the delivery of the projected additional dwelling and floor space requirements is unconstrained by existing controls limiting floor space ratios and height. This approach allows the full environmental impact of the projected growth requirements to be tested. It also provides a full growth 2036 baseline to test the benefit of sustainability interventions and strategies developed through the masterplanning process.

3.1. Greenhouse Gas Emissions

The LSPL has a target for the reduction of Greenhouse Gas Emissions in 2036. The target equates to a 29% reduction when compared to current Greenhouse Gas Emissions.



The projected annual greenhouse gas emissions in 2036 are summarised below. It can be seen that the LSPL target will not be met.

Figure 21 Greenhouse gas emissions impact of growth targets

Total Greenhouse Gas Emissions		Existing	2036 Estimate
Bankstown City Centre	(tCO^2/year)	142,253	228,767
	% change from Existing		61%
Campsie Town Centre	(tCO^2/year)	75,133	104,998
	% change from Existing		40%

Table 11 Greenhouse gas emissions impact of growth targets

3.1.1. Bankstown City Centre GHG Emissions Breakdown

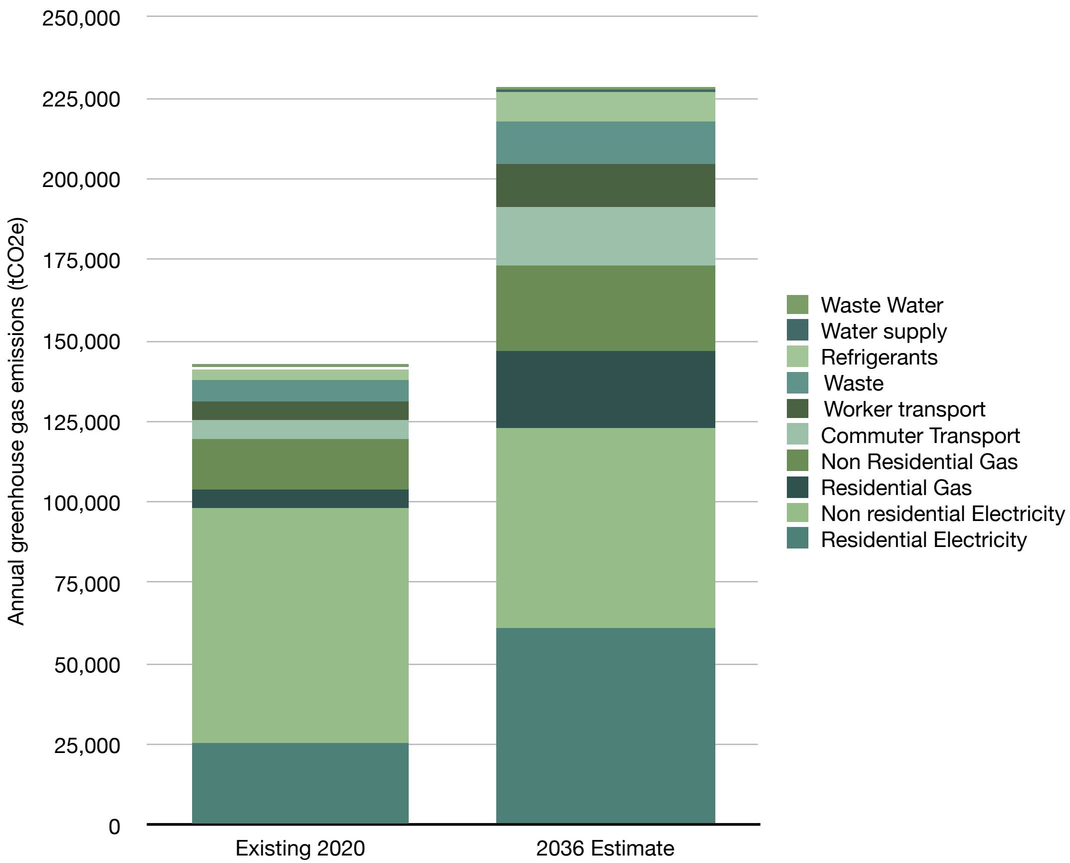


Figure 22 Bankstown City Centre GHG emissions breakdown

3.1.2. Campsie Town Centre GHG Emissions Breakdown

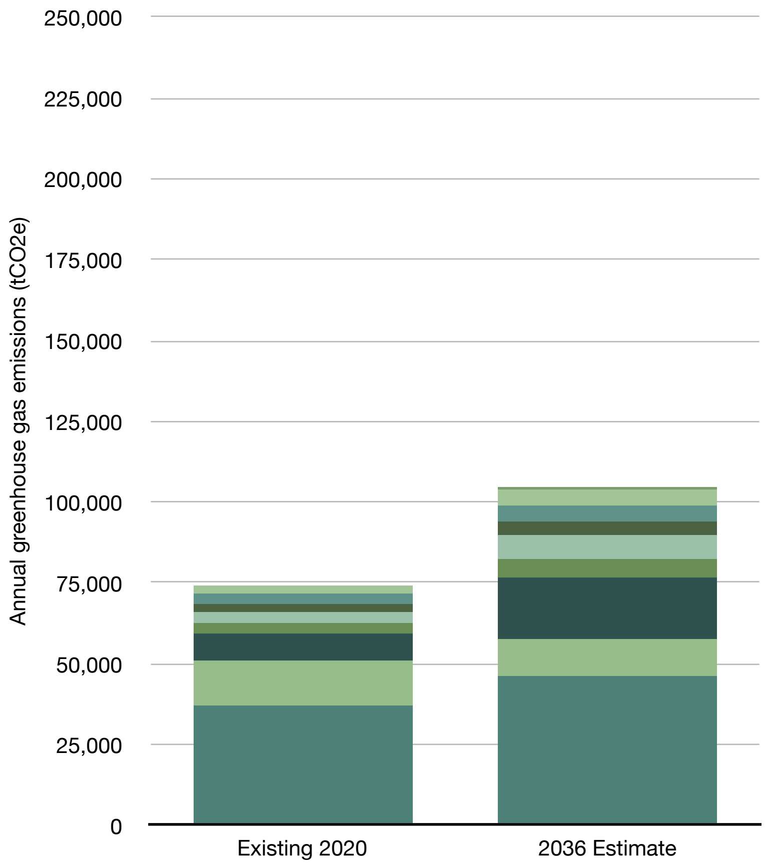


Figure 23 Campsie Town Centre GHG emissions breakdown

3.1.3. Observations

Significant growth in greenhouse gas emissions is projected. Bankstown is projected to have emissions 127% higher in 2036 than the target set by the LSPL. Campsie is projected to have emissions 97% higher than the 2036 target in the LSPL would allow.

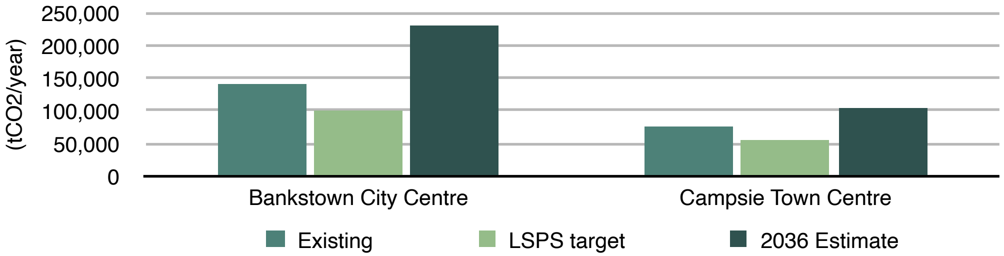


Figure 24 Growth in greenhouse gas emissions compared to LSPL reduction target

An important observation is the difference in the relative growth of greenhouse gas emissions associated with electricity use compared to fossil fuels, which include natural gas and petrol. The following chart illustrates the benefit that the greening of the grid makes in limiting the growth in emissions from electricity use, compared to the large increase in emissions associated with fossil fuels.

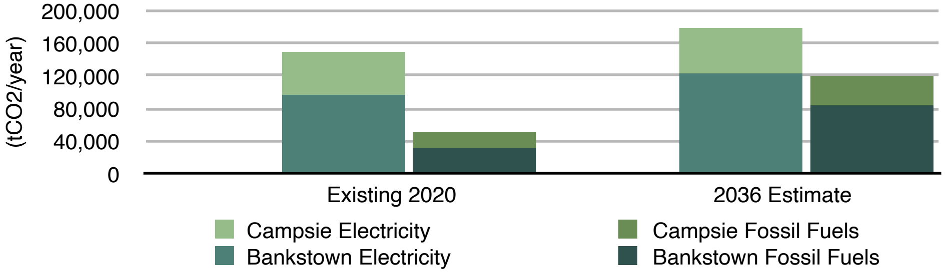


Figure 25 Comparison of electric and non-electric emission growth

The increase in residential emissions is seen to be significant. This is due to the lower BASIX targets applying to buildings over six stories. At the current regulated level of BASIX Energy 25, the target for new apartment buildings under BASIX allows higher emissions per occupant than the existing dwellings in the study area currently achieve. This results in a net increase or predicted emissions per dwelling.

3.2. Water use

The LSPL has two targets, which both relate solely to residential dwellings. A 25% reduction in average water consumption per dwelling is targeted together will all new buildings exceeding BASIX Water efficiency requirements.

The changes in estimated annual water consumption associated with the growth targets are summarised below. Significant growth in water demand is anticipated.

No additional water reuse is accounted for except where required to meet the minimum BASIX water requirements in the new residential developments.

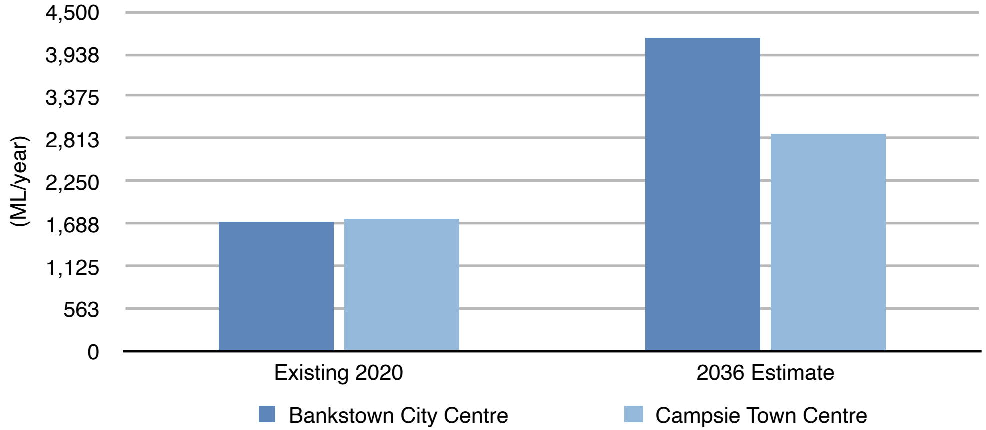


Figure 26 Water use impact of growth targets

Total Water Use		Existing	2036 Estimate
Bankstown City Centre	(ML/year)	1,705	4,165
	% change from Existing		144%
Campsie Town Centre	(ML/year)	1,761	2,896
	% change from Existing		64%

Table 12 Water use impacts of growth targets

3.2.1. Bankstown City Centre Water Use Breakdown

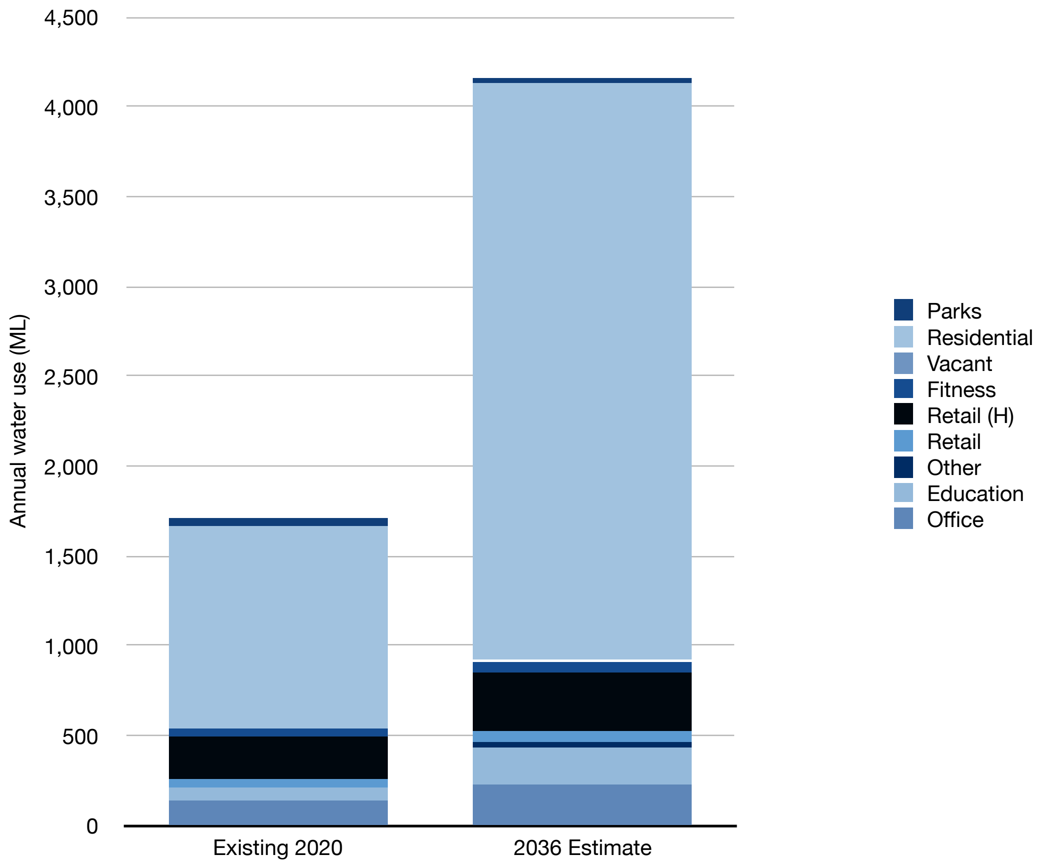


Figure 27 Bankstown City Centre water use breakdown

3.2.2. Campsie Town Centre Water Use Breakdown

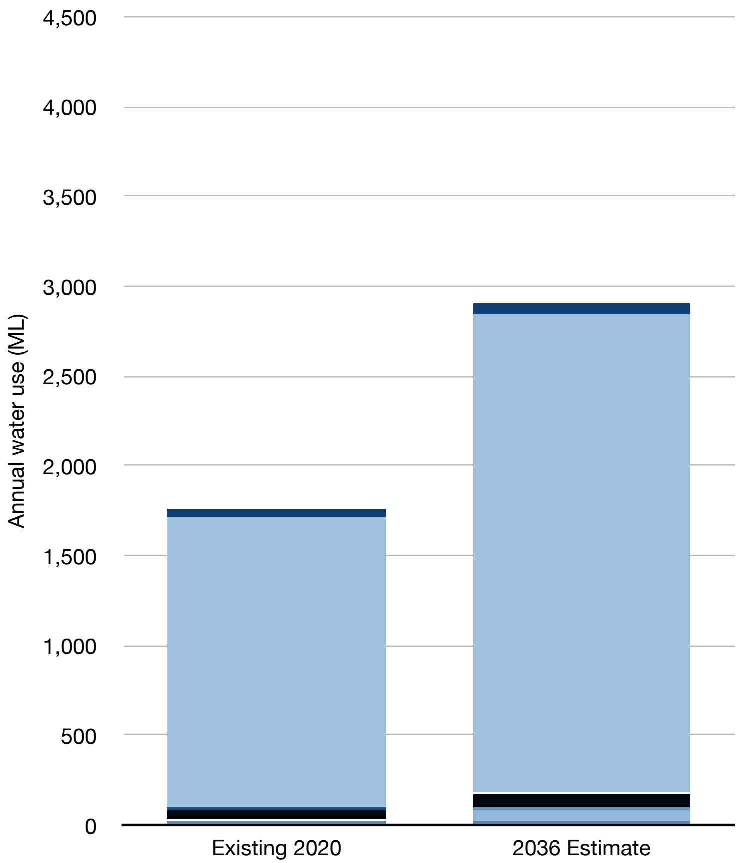


Figure 28 Campsie Town Centre water use breakdown

3.2.3. Observations

The breakdown in water use by building type for each study area clearly shows the dominance of residential dwellings upon the total water demand.

The non-residential sector, particularly the education sector, is shown to increase water demand as larger buildings are delivered. Larger non-residential buildings are expected to increase the use of cooling towers for air conditioning heat rejection.

3.3. Waste generation

The LSPL targets a reduction in waste generation per person per year from 225kg to 200kg, just over 11%. It is assumed that per person means per resident as the 225kg baseline is the same as the residential average reporting in the auditing of residential waste in Bankstown.

The changes in the annual amount of waste generated associated with the growth targets are summarised below.

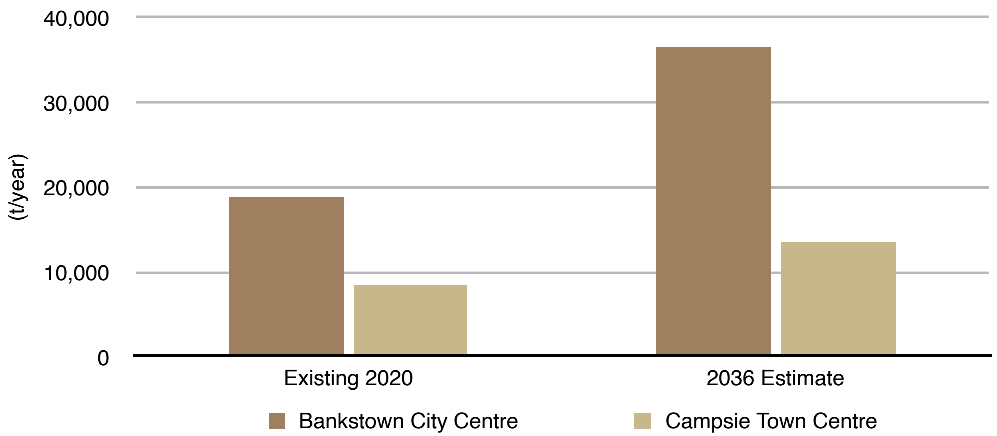


Figure 29 Waste generation impacts of growth targets

Total Waste Generation		Existing	2036 Estimate
Bankstown City Centre	(t/year)	18,754	36,482
	% change from Existing		95%
Campsie Town Centre	(t/year)	8,531	13,587
	% change from Existing		59%

Table 13 Waste generation impacts of growth targets

3.3.1. Bankstown City Centre Waste Generation Breakdown

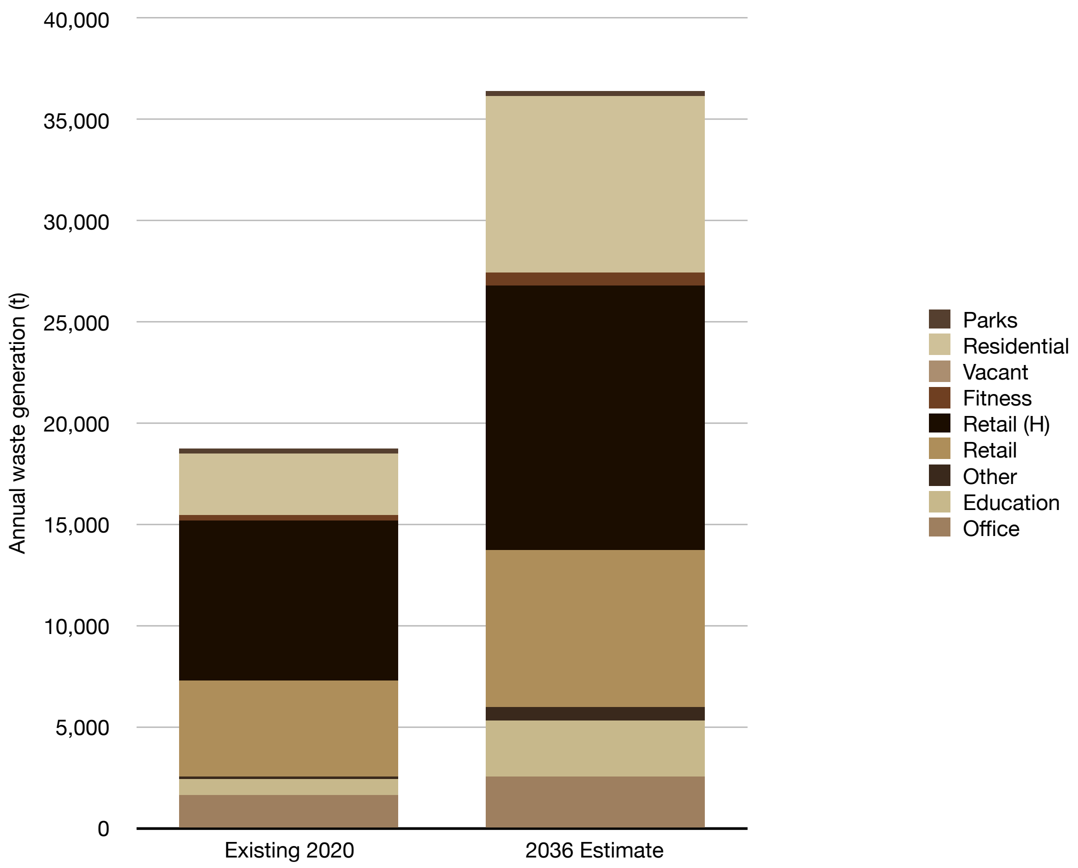


Figure 30 Bankstown City Centre waste generation breakdown

3.3.2. Campsie Town Centre Waste Generation Breakdown

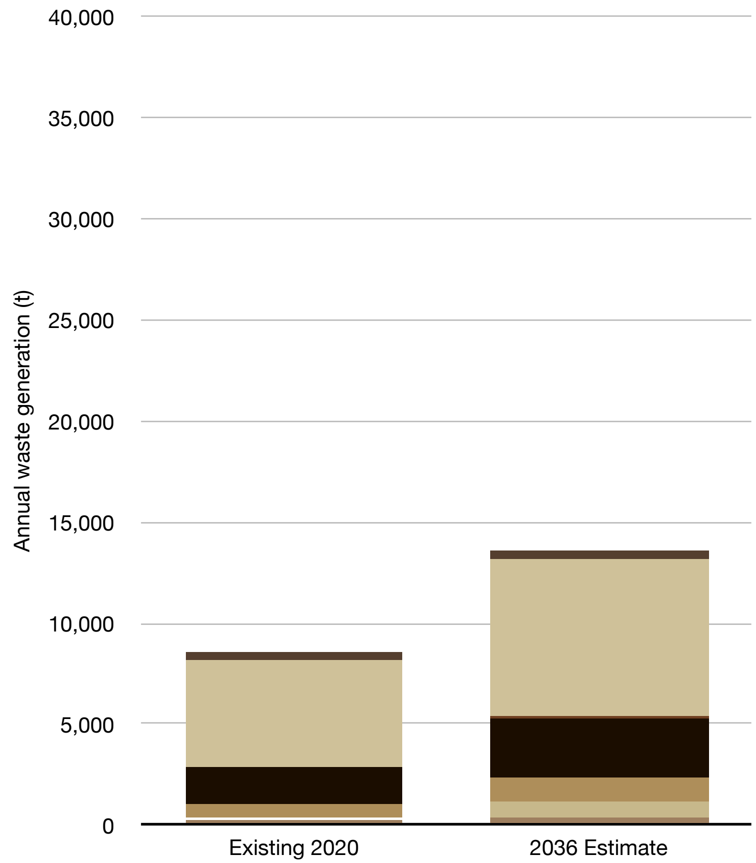


Figure 31 Campsie Town Centre waste generation breakdown

3.3.3. Observations

The breakdown in projected waste generation shows that retail is expected to be the most impactful sector in the Bankstown City Centre. There are no LSPL targets for non-residential waste generation.

In the Campsie Town Centre, residential waste will continue to dominate impacts.

The future development of apartments to meet growth targets is expected to decrease the amount of waste generated per person across the precincts to comfortably exceed the LPSL target without additional intervention. This is due to waste generation within houses being double the amount per occupant compared to apartments. However, it is noted that the LSPL target is LGA wide and any gains made in the study areas through the transition to apartment living may not be sufficient to ensure that the target is met over the entire LGA.

3.4. Anthropogenic Heat

There are no targets for the reduction of anthropogenic heat within the LSPL.

The changes to the anthropogenic heat that will contribute to urban heat are detailed below. Anthropogenic heat is compared on a hot summer day and will vary by season.

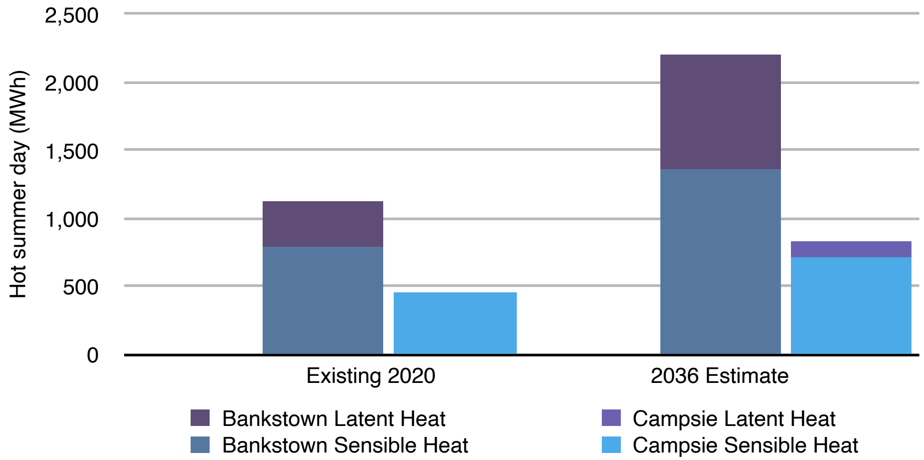


Figure 32 Anthropogenic heat impacts of growth targets

Total Anthropogenic Heat - Hot summer day		Existing	2036 Estimate
Bankstown City Centre Sensible Heat	(MWH/day)	786	1,361
	% change from Existing		73%
Bankstown City Centre Latent Heat	(MWH/day)	346	843
	% change from Existing		144%
Campsie Town Centre Sensible Heat	(MWH/day)	457	715
	% change from Existing		56%
Campsie Town Centre Latent Heat	(MWH/day)	0	110
	% change from Existing		-%

Table 14 Anthropogenic heat impacts of growth targets

3.4.1. Bankstown City Centre Sensible Heat Breakdown

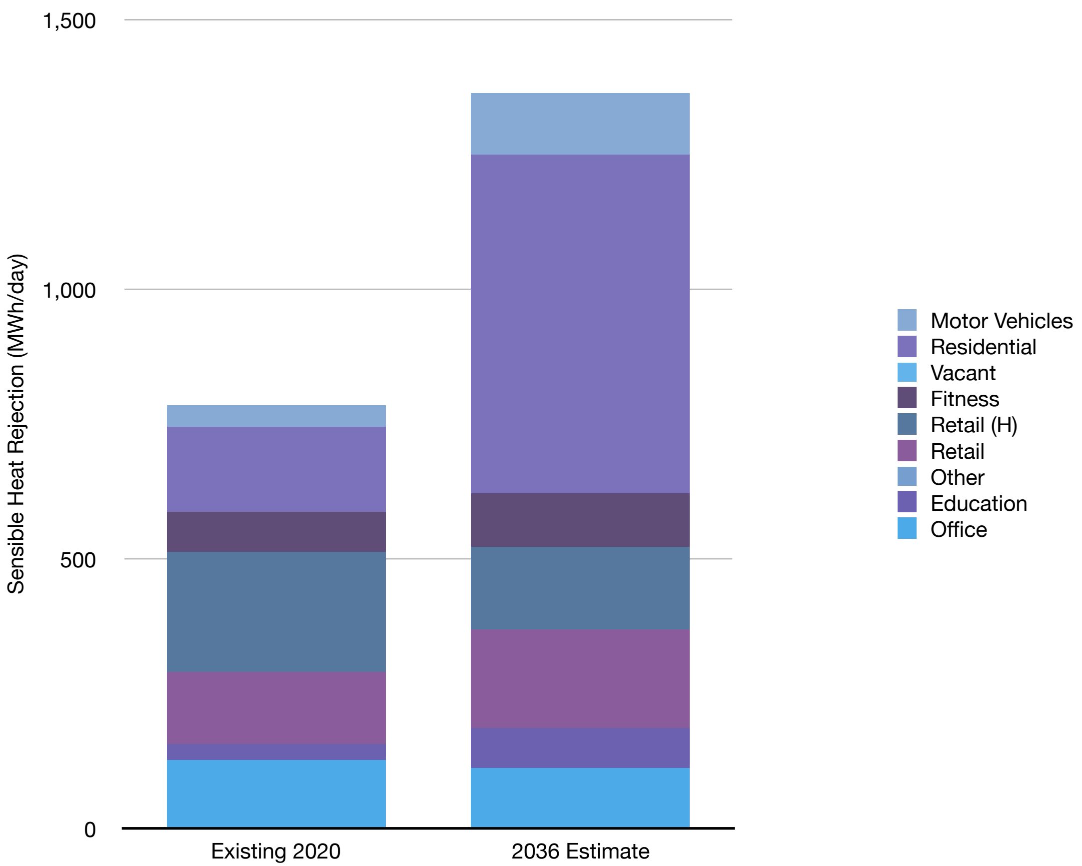


Figure 33 Bankstown City Centre anthropogenic heat breakdown

3.4.2. Campsie Town Centre Sensible Heat Breakdown

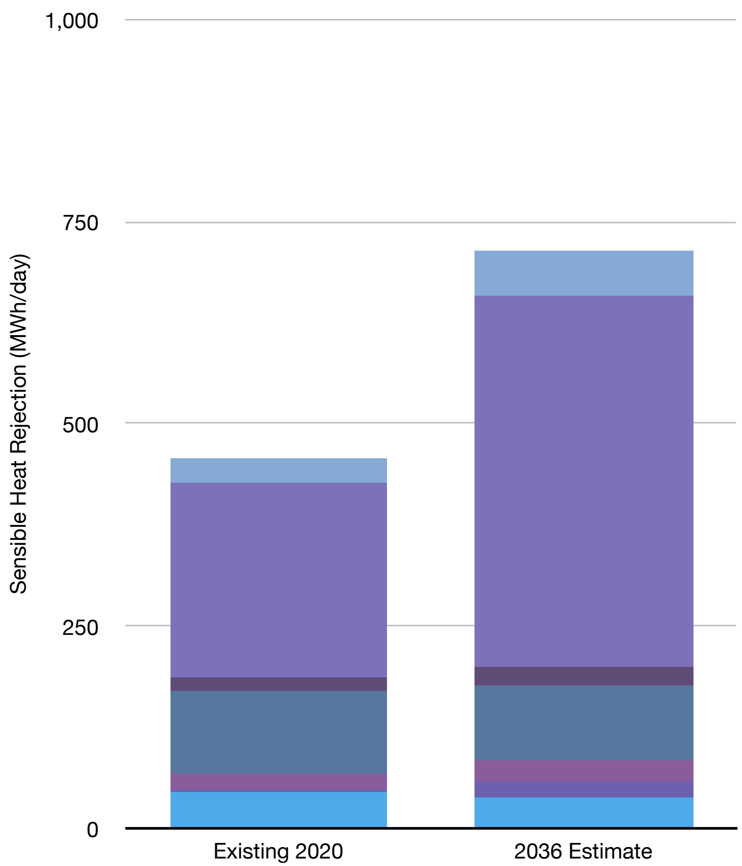


Figure 34 Campsie Town Centre anthropogenic heat breakdown

3.4.3. Observations

The projected reduction in sensible heat for some building use types in 2036 is due to the expectation that a greater proportion of non-residential buildings will be of a size where cooling towers are the preferred choice for heat rejection. When cooling towers are used, heat rejection is achieved though a latent process.

The total anthropogenic on a hot summers day will be equivalent to approximately 1 $kWh/m^2/day$ of land area in the Bankstown City Centre study zone. For the Campsie Town Centre, the figure is significantly lower at 0.24 $kWh/m^2/day$.

The estimated anthropogenic heat added daily to the study centres can be compared to the 8-8.5 kWh/m^2 of solar heat received in the study area on a sunny summers day. Solar heat arrives in the form of radiation, so it does not directly heat the air. Instead, it is reflected and absorbed in the urban environment. A portion of the solar heat absorbed by surfaces within the urban environment will then warm the air through heat transferred by convection.

Summary of implications for the masterplan

1 **The precincts will not deliver the LSPL published targets for Greenhouse Gas emissions reduction without material improvement to controls.**

Bankstown is projected to have emissions 127% higher than the LSPL targets in 2036. Campsie is projected to have emissions 97% higher than the 2036 target in the LSPL would allow.

2 **Increased sustainability performance of new development provides the biggest opportunity to reduce emissions.**

The increase in environmental impacts across all indicators is directly associated with the growths for housing and employment. The process of masterplanning, design and construction to meet those targets also provides and unique opportunity to dramatically improve environmental outcomes through improved efficiency and climate aligned design objectives.

3 **Electricity is the preferred energy source for a low carbon future.**

The greenhouse gas emissions associated with electricity consumption will reduce over time due to the continued greening of the grid. The masterplan's sustainability outcomes in 2036 will benefit from an accelerated transition to all-electric buildings.

4 **Increased water re-use must be a priority to lessen the increase in demand for drinking water.**

Water demand will increase broadly in line with the number of residents, workers and students. As there is limited scope for further efficiency gains from appliances, equipment and restrictions on use, providing reuse water for non-drinking uses is required to reduce demand.

5 **Anthropogenic heat, which contributes to the urban heat island effect, will double.**

The heat released from air conditioning and cars will more than double in Bankstown and nearly double in Campsie. The masterplan needs to consider how any increase of local air temperatures can be minimised by controlling the sources of heat and designing to maximise the movement of breezes through the precincts.

6 **Greenhouse Gas emissions associated with commuting are projected to increase significantly.**

Private car use is expected to remain the dominant mode of transport. Providing infrastructure to accelerate the transition to electric vehicles will provide greenhouse gas reductions independent of any modal shifts or future infrastructure investment by the State.

7 **The leakage of refrigerant gases from air conditioning is projected to contribute nearly 4% of total annual greenhouse gas emissions.**

The leakage of refrigerants can be reduced through planned maintenance, but the masterplan's main opportunity is to transition to refrigerants with a very low global warming potential, which will reduce the impacts of any leakage by over 99.5%.

8 **The relative impacts of different building use types vary for different areas of environmental impact.**

The masterplan should use the understanding of the relevant impact of different uses to prioritise responses. For example, retail is the most significant contributor of waste, and residential apartments should be the primary focus for water conservation.

4. Assessment of future Impacts under current height and FSR controls

The delivery of additional dwellings and floor space to meet growth targets will necessitate a change to the height and massing of buildings. This move to a higher density of urban development changes the relation of open space to the sky, wind movement through the precinct, and ultimately the microclimate. The simplified energetic basis for changes to the microclimate is illustrated below.

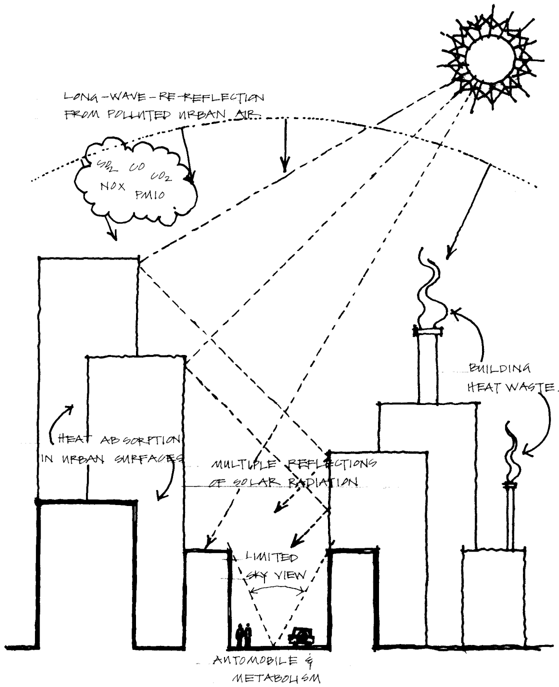


Figure 35 Energetic basis of urban microclimate changes, source: Emmanuel, 2005)

This section quantifies the potential impact of current height and Floor Space Ratio controls on the sky view factor, which is a key factor affecting urban surface heat balance. The sky view factor is determined from a geometric analysis of how the buildings obscure the view of the sky from the ground plane. The City of Canterbury Bankstown supplied the models analysed.

The comparative massing of the existing Bankstown City Centre and the same area built out to the extent permitted under the current LEP control limits on Floor Space Ratio and Height can be seen below.

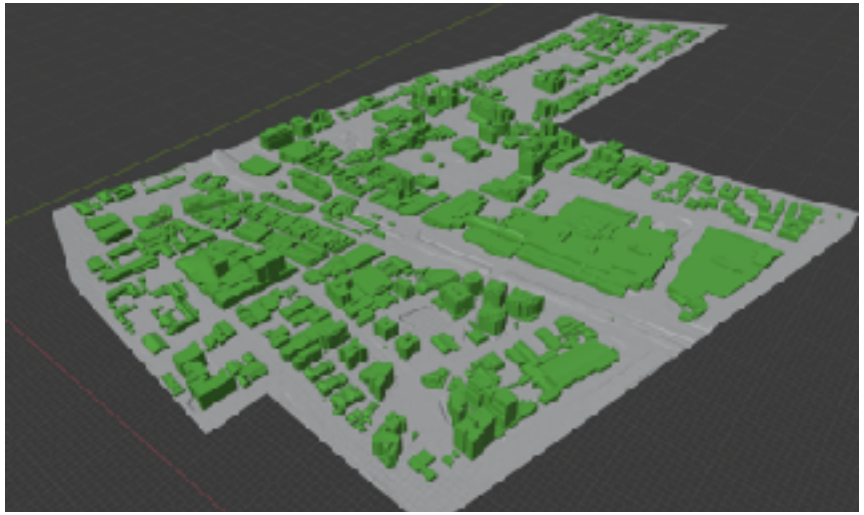


Figure 36 3D model showing massing of existing Bankstown CBD

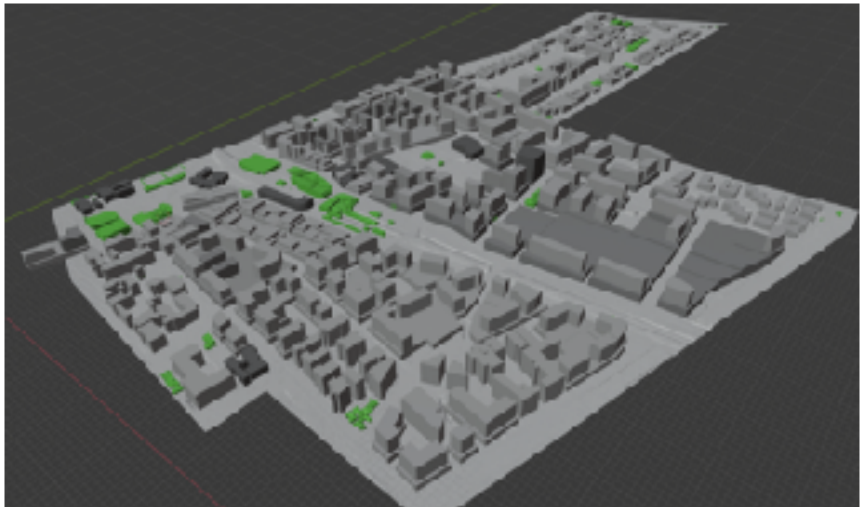


Figure 37 Bankstown CBD developed to the extent of current height and FSR controls

The existing massing was not available for the Campsie business district. The extent of development permissible under the current LEP limits on Floor Space Ratio and height can be seen below.

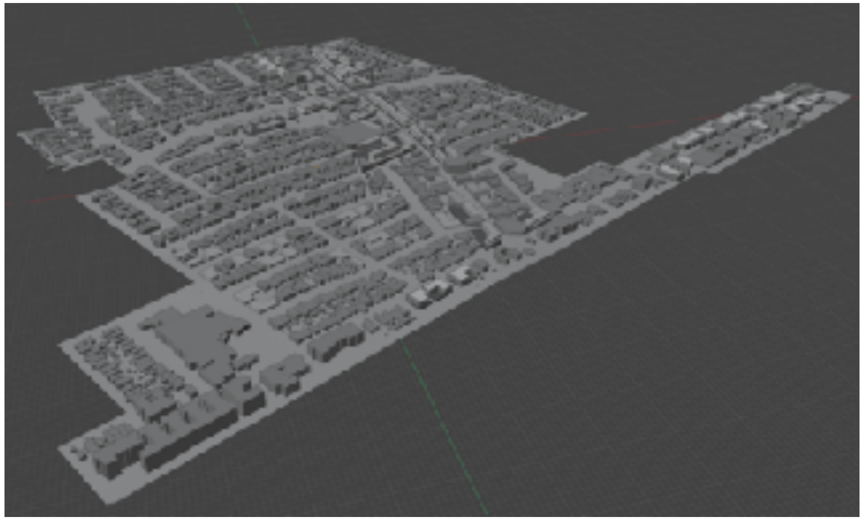


Figure 38 Campsie centre developed to the extent of current height and FSR controls

4.1. Bankstown CBD Sky View Factor

The sky view factor measured at ground level is shown to reduce with increasing building and massing. The reduction in sky view factors will reduce heat dissipation to the night sky through radiation exchange, resulting in more heat being trapped in the urban environment.

The following figure summarises the change in the distribution of the sky view factors, with the gap between the existing and developed scenario representing the loss in sky view factor. Values of zero represent the footprint of the buildings, which is seen to increase with the growth requirements.

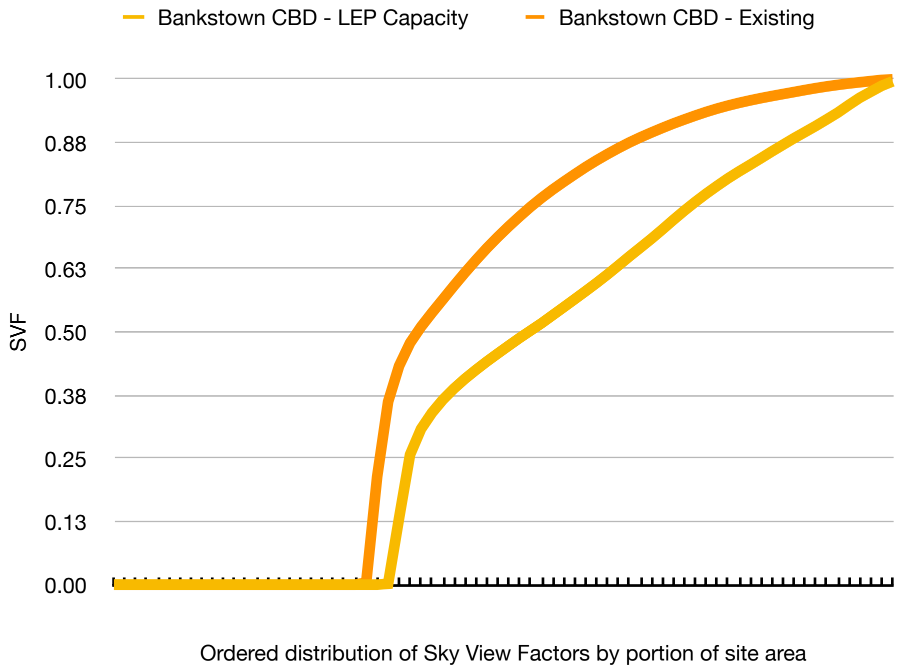


Figure 39 Comparison of sky view factors in Bankstown CBD

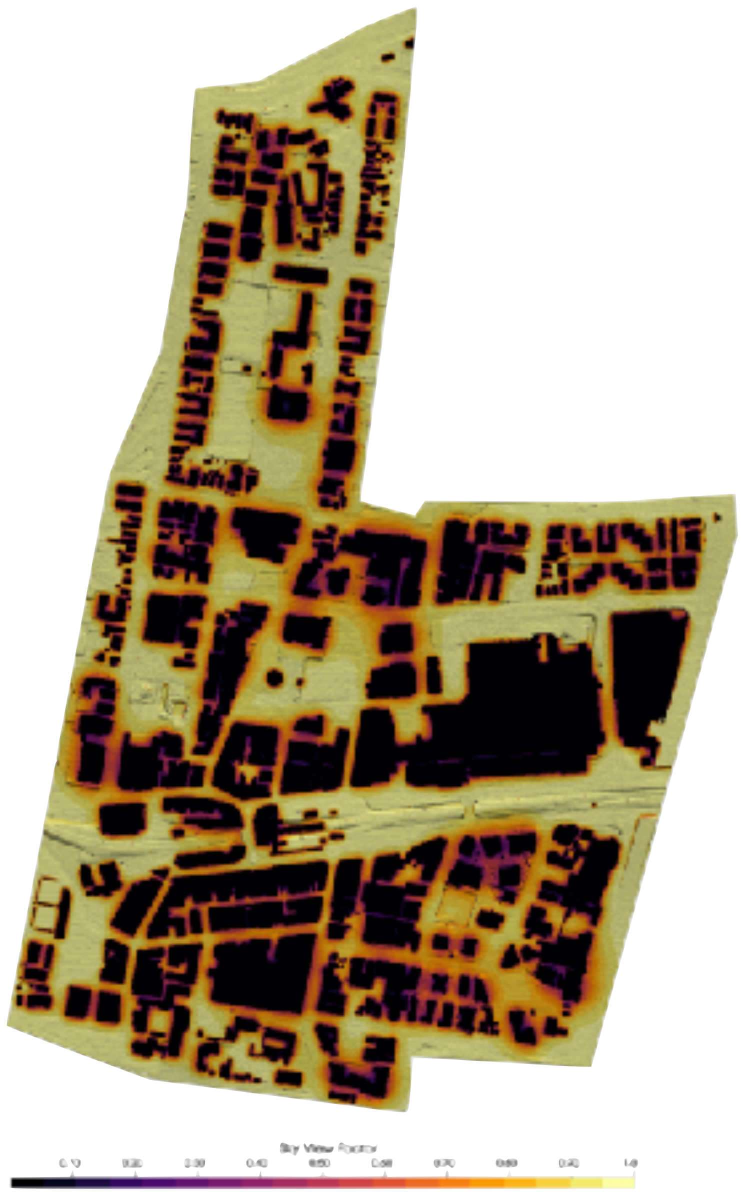


Figure 40 Sky view factors for existing Bankstown CBD

Figure 41 Sky view factors for Bankstown CBD developed to current LEP capacity

4.2. Campsie CBD Sky View Factor

The sky view factor measured for the development capacity given in the current LEP will result in a sky view factor higher than currently exists in the Bankstown CBD. The sky view factor will result in an increase in urban heat island effect and should therefore be balanced were possible with suitable controls.

The following figure summarises the distribution of the sky view factor with the gap between the Campsie LEP capacity and Bankstown CBD. Values of zero represent the footprint of the buildings.

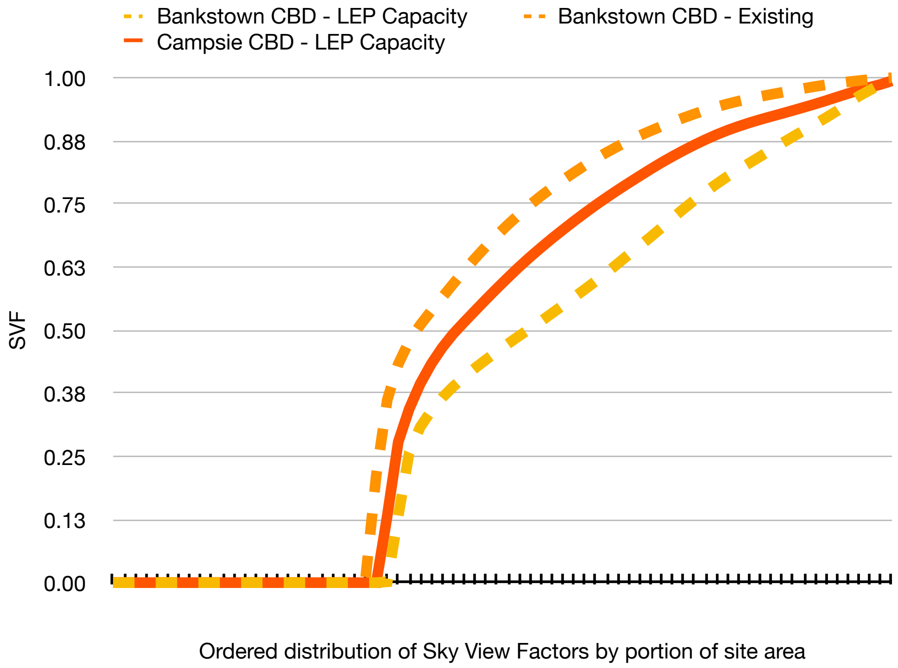


Figure 42 Sky view factor for Campsie CBD compared to Bankstown CBD

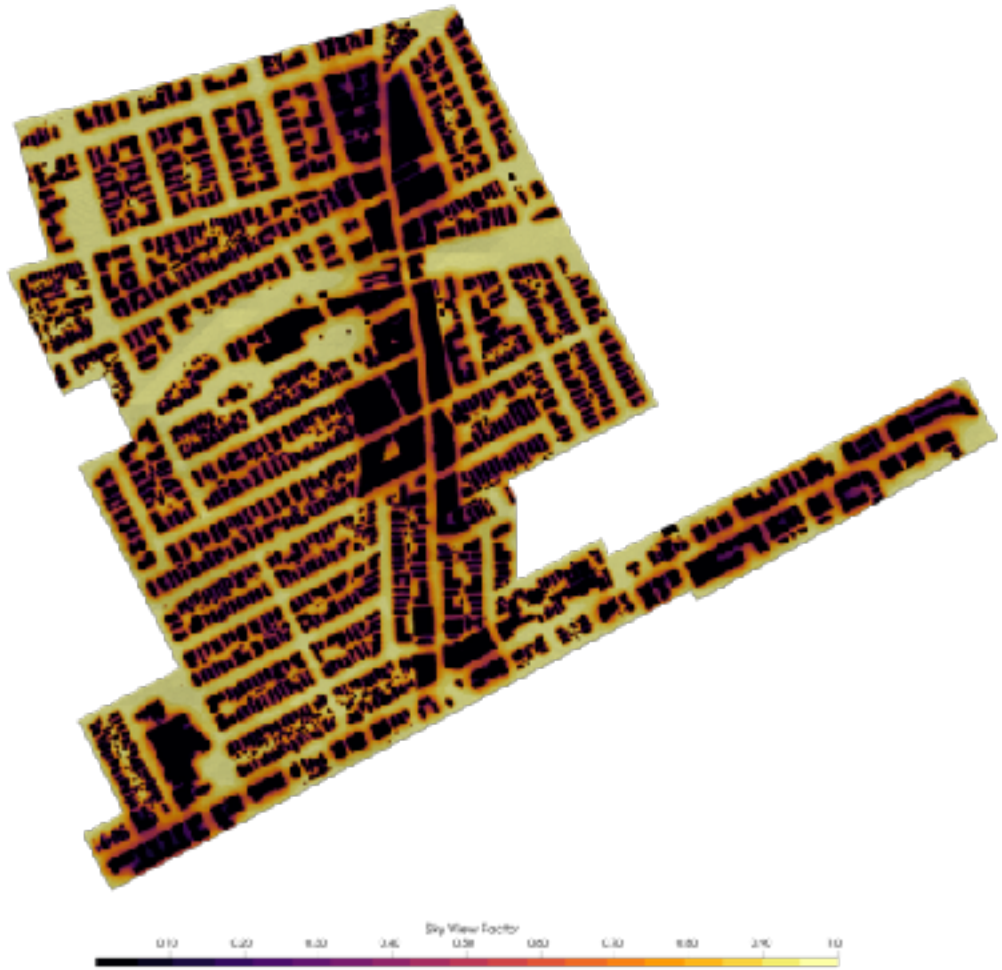


Figure 43 Sky view factors for Campsie CBD developed to current LEP capacity

Summary of implications for the masterplan

1

Any increase in massing will decrease the sky view factor, which will increase the retention of urban heat in the study areas.

The masterplan should prioritise strategies to reduce the sources of heat into the precincts to compensate for the reduction in ability to dissipate heat.

2

The planning envelopes established in the masterplan will have an impact on sky view.

The testing of the sky view factors under the current FSR and height controls in the LEP illustrated the negative impact of delivering more floor area and building mass. Strategies that reduce visual bulk when viewed from the street will increase the view to the sky and promote the movement of breezes through the precincts.

3

The mapping of sky view factors can usefully inform other strategies, such as tree canopy and shade.

Areas with low sky view factors are likely to benefit from slightly cooler temperatures during the day and higher temperatures overnight. These spaces will benefit the least from increased planting to promote evapotranspiration and shade.

5. Environmental outcomes with bonus FSR for sustainability

This Section provides quantification of the environmental outcomes associated with the growth targets in Bankstown if the current sustainability bonus scheme within the LEP is maintained and utilised.

The sustainability bonus scheme provides targets for energy and water consumption for both residential and non-residential building usage.

For non-residential buildings, it is not clearly defined whether the LEP targets only apply to those items the developer is responsible for, or whether the targets include the energy that will be consumed by the tenants and the users of the buildings. The LEP clause 4.4A (4) (d) requires verification that the development will comply with the energy and water targets if all the commitments relating to the building design (namely the built form and layout) listed in the report are fulfilled. This appears to confirm only building design-related loads are to be included.

Our review of the efficacy of the sustainability bonus scheme is included in Appendix B. Based on the findings of our review; there are some benefits expected to residential building outcomes.

Our review could not confirm any benefits will be delivered for non-residential buildings and noted significant risk in delivering improved BASIX commitments for residential buildings.

The projected savings in 2036 are presented below based on an estimated uptake rate of 30% of new residential dwellings. Outcomes are compared to the projected 2036 impacts without the bonus scheme. The total floor area is assumed to be consistent in both cases.

The residential LEP bonus is shown to have potential continued benefit in water efficiency. Otherwise, the scheme is considered ineffective in materially reducing the environmental impacts associated with new development.

5.1. Review of requirements

5.1.1. Non-residential

The non-residential targets are quoted as;

- Energy target is a maximum 135 kg/m^2 per year,
- Water target is maximum 0.47 kL/m^2 per year for business premises and office premises and a maximum of 1.68 kL/m^2 per year for shops, restaurants and function centres.

Both energy and water targets are poorly defined concerning the scope of energy use and the basis of measuring floor area. It is normal when regulating building energy and water to isolate the load components that the developer is directly responsible for, commonly referred to as base building loads, and exclude those components of the building where the impacts are dictated by a tenant's future fitting out and operations. However, the reference to restaurants in the LEP suggests an end-users impact is required to be included.

This ambiguity can be exploited as seen in the 190 Stacy Street development application, where the energy associated with the car parking within the building was arbitrarily excluded when assessing compliance with the maximum energy target.

We have considered stringency of the energy target relevant to business as usual delivery. The energy requirements of the Building Code of Australia dictates the minimum regulated requirements in Australia. The requirements themselves cannot be directly translated into greenhouse gas emissions targets but there is a pathway within the BCA to demonstrate compliance using NABERS Energy and achieving 5.5 stars.

The diagram below illustrates the operational greenhouse gas emissions measured for office buildings at different star ratings within the Sydney metropolitan area.

The worst performing 5.5 star NABERS Energy office building in Sydney is shown to have a greenhouse intensity of 64 kg/m^2 per year. The LEP bonus requirement for offices of 135 kg/m^2 per year is therefore twice the minimum regulated requirements if applied to base building, which would be the normal interpretation. On a whole of building basis, it would still be less stringent than the regulated minimum. The target is also made easier to achieve when an applicant arbitrarily excludes normal base-building inclusions.

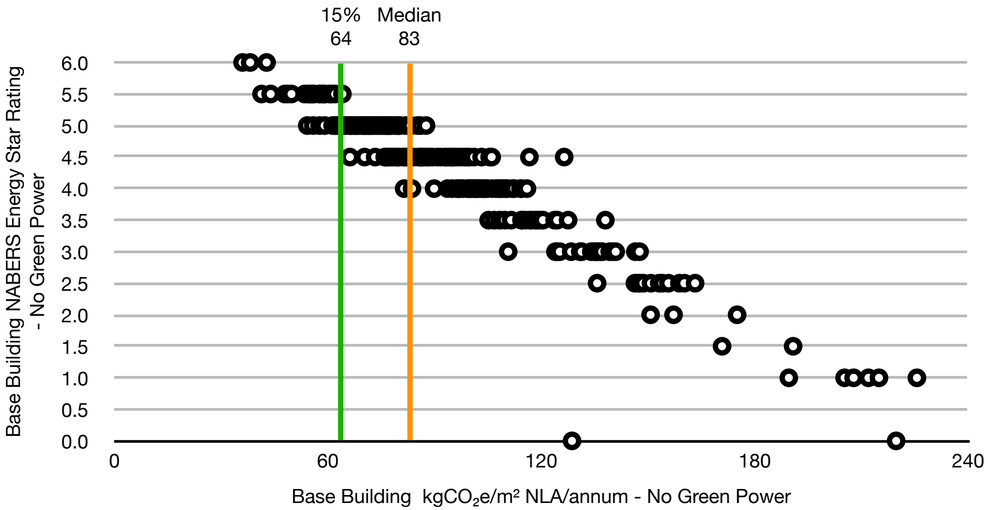


Figure 44 Greenhouse gas emissions of offices in Sydney metropolitan area

For non-office building energy, the target is very difficult to judge because of the lack of specificity of how much of the tenant's load is included. For retail, if tenant loads are excluded, the target is significantly higher than the regulated minimum requirements. If the restaurant or shop tenant's energy use is included, the target is impractically low for most food service types, where an emissions intensity of 200-300 kg/m² per year might be expected. Regardless, fit out related loads for shops and restaurants wouldn't be known at the time of a development application for the building. Retail is often delivered as 'cold shell', meaning the air conditioning is supplied by the tenant, as part of future fitting out works.

The spread of greenhouse gas emissions from landlord loads in shopping centres shown in the NABERS dataset is provided below for context.

It can be seen that the energy efficiency target is poorly defined and calibrated and cannot be relied upon to deliver energy efficiency improvement for non-residential building stock.

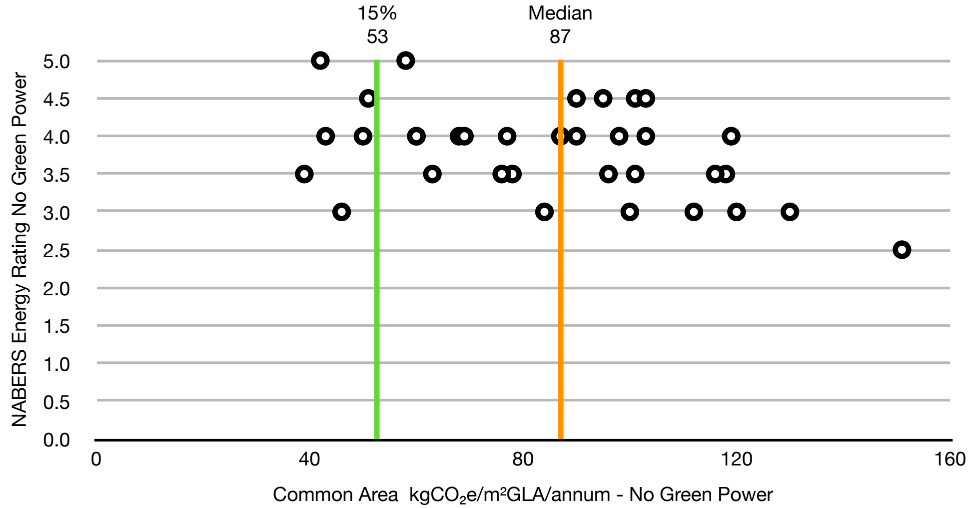


Figure 45 Greenhouse gas emissions of shopping centres in Sydney metropolitan area

For water, the same uncertainty exists concerning which uses are included in the target. However, it appears better calibrated. When compared to NABERS Water ratings, which are a measure for the whole building, the target of 0.47 kL/m² per year for business premises can be seen to represent best practice.

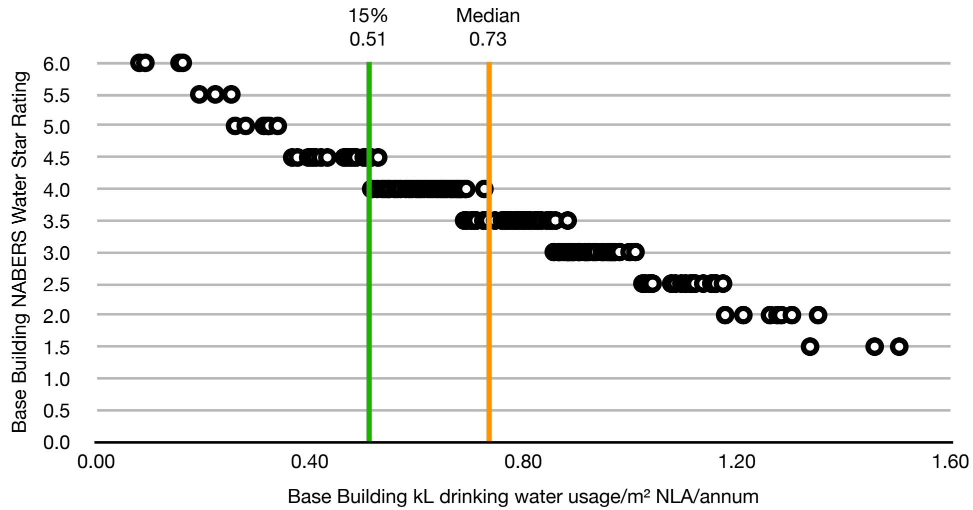


Figure 46 Water use of offices in Sydney metropolitan area

For shops, restaurants, and function centres, the water target is difficult to apply without detailed knowledge of the building's future tenants. A comparison against common area water demands for shopping centres shows that the target of 1.68 kL/m² per annum will not improve upon business as usual. It is also noted that the NABERS data is presented on a Gross Leasable Area basis and the LEP water intensity target would be some 20-30% lower still if recalibrated to GFA.

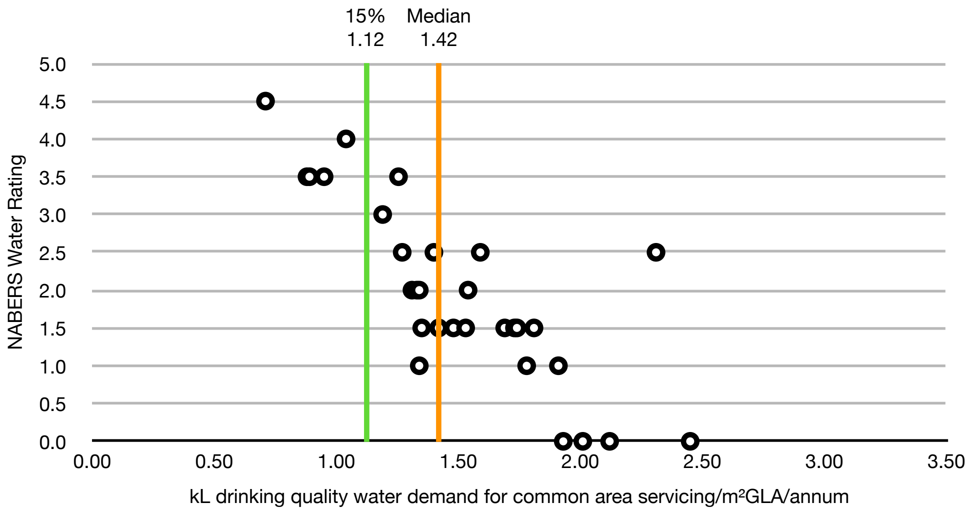


Figure 47 Water use of shopping centres in Sydney metropolitan area

5.1.2. Residential

The residential targets are quoted as;

- Energy target is a minimum of 10-point increase in BASIX score compared to the current requirements.
- Water target is a minimum BASIX 60.

For energy, most new residential will be six storeys or higher, which requires BASIX 25 under the current requirements. With the LEP bonus, this would increase to BASIX 35, representing an additional 10% reduction per occupant from the NSW State average.

For water, the BASIX minimum requirement is BASIX 40. The BASIX 60 requirement of the sustainability bonus translates to an additional 20% reduction in water usage per occupant from the NSW State average.

The setting of targets using BASIX scores has the inherent advantage that BASIX has a very clearly laid out set of rules for what must be included, how it is to be measured and what must be documented to support the commitment at the development application stage. These published requirements provide certainty to an application and support effective assessment as to whether the sustainability bonus requirements have been satisfied in an application.

The description of BASIX energy target being a minimum +10 point increase over the current (regulated) requirement has the additional advantage of maintaining a continuous improvement as minimum regulated requirements change over time.

5.2. Energy Efficiency

The residential greenhouse gas emissions are shown to decrease by 2,500 tonnes of CO2e, representing a 3% improvement, compared to 2036 projections without the sustainability bonus control.

The reduction in energy and resulting greenhouse gas emissions is proportional to the scheme's uptake rate. Therefore at 100% uptake, the scheme would deliver the maximum benefit of 10% reduction in the residential emissions attributable to gas and electricity use.

No emissions reduction has been attributed to the non-residential proportions due to the uncertainty in the maximum targets' relevance and the lack of clarity in requirements.

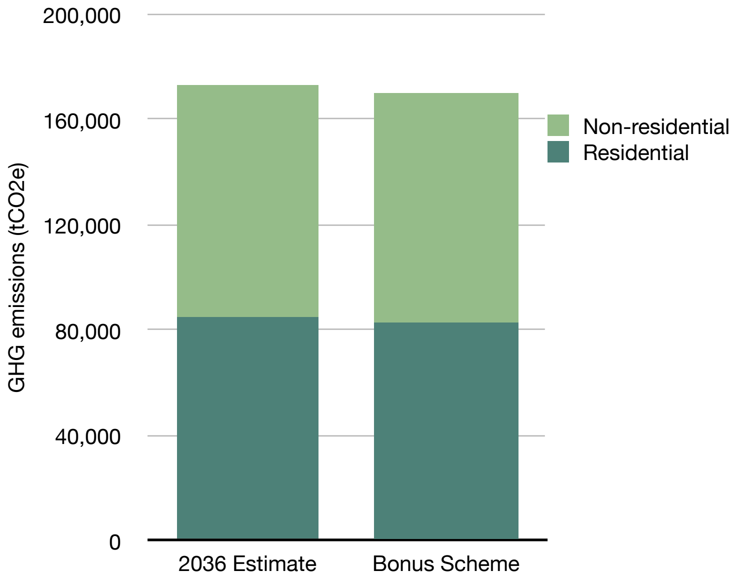


Figure 48 GHG emissions benefit of LEP sustainability bonus in Bankstown City Centre

5.3. Water Efficiency

The predicted residential total water use is shown to decrease by 210 ML per year, representing a 6.8% improvement, compared to 2036 projections without the control.

The reduction in water use is proportional to the scheme's uptake rate. Therefore at 100% uptake, the scheme would deliver the maximum benefit of 20% reduction in the residential water use.

No water efficiency savings have been attributed to the non-residential proportions due to the uncertainty in the maximum targets' relevance and the lack of clarity in requirements.

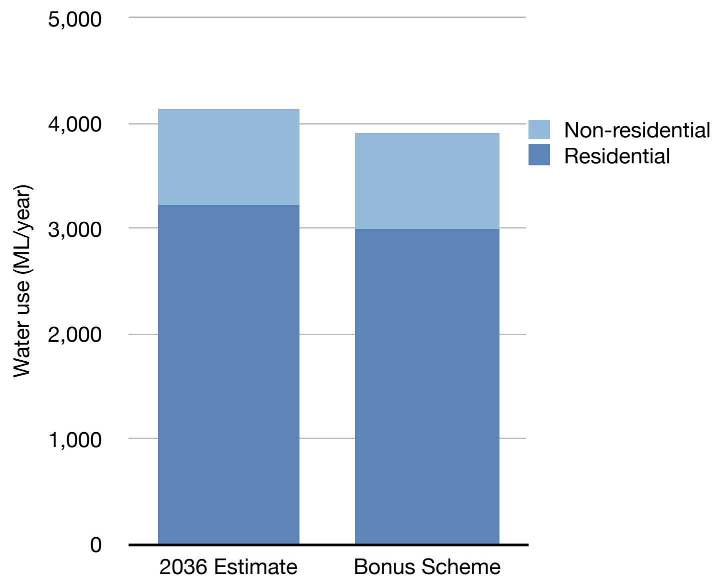


Figure 49 Water saving benefit of LEP sustainability bonus in Bankstown City Centre

Summary of implications for the masterplan

1

The Sustainability Bonus Scheme should not continue in its current form.

A lack of clarity in the scheme's design undermines its effectiveness and may contribute to low uptake in new developments. The targets within the scheme are also poorly calibrated.

2

A redesigned Sustainability Bonus Scheme could deliver better outcomes.

Achieving better sustainability outcomes through the provision of bonus floor space or similar incentive is an important mechanism. The scheme should be redesigned not abandoned.

3

The residential sector will benefit most from a redesigned scheme.

New residential floor space will be the largest component of new construction to meet the growth targets. The BASIX SEPP limits the effectiveness of any development controls that seek to reduced greenhouse gas emissions, water consumption or improve the thermal performance of residential dwellings. Therefore, a redesigned sustainability bonus scheme is most important to deliver better outcomes in these areas.

6. Strategies and Principles

This Section provides intervention opportunities, strategies and principles that are recommended to be actioned to improve sustainability outcomes.

The strategies are developed based on expected environmental impact and their ability to be implemented in the masterplan and accompanying controls in a manner that can be; clearly communicated to the applicant; objectively assessed before granting development consent; can demonstrate economic benefit; and are complementary to other state planning policies that overlap with sustainability, including the BASIX SEPP and SEPP 65.

Each strategy and principle's benefits are summarised for either resilience, future-proofing or amenity.

The cumulative effect of the controls on greenhouse gas emissions is illustrated below in stacked bars, with impact areas stacked in the same order as the adjacent legend.

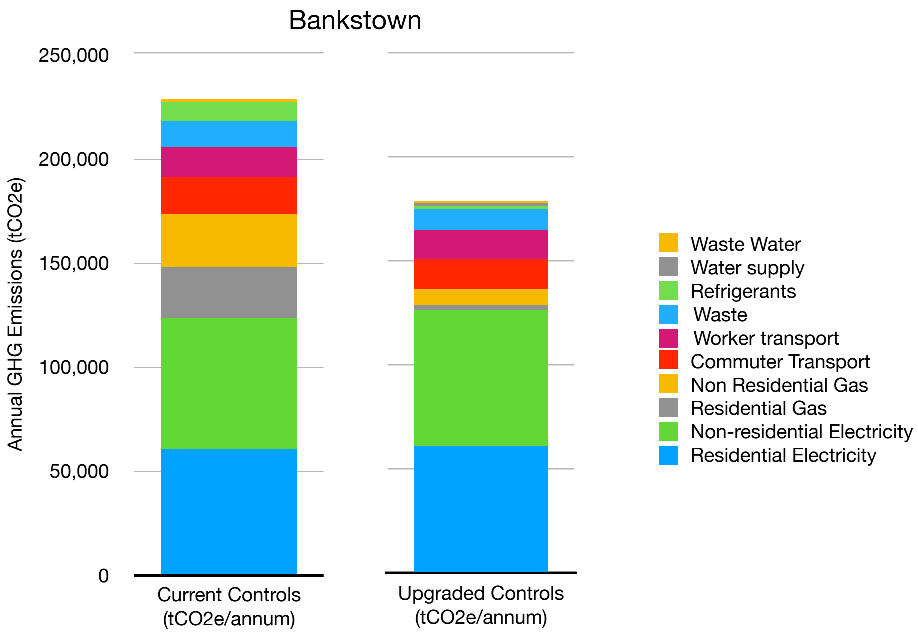


Figure 50 Reduction in 2036 GHG emissions from improved controls in Bankstown City Centre

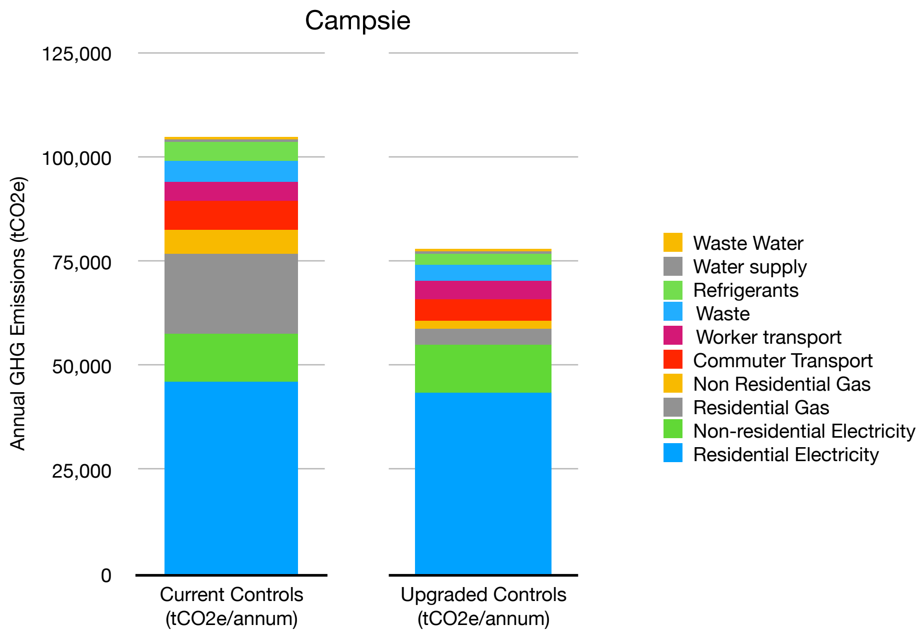


Figure 51 Reduction in 2036 GHG emissions from improved controls in Campsie Town Centre

All-electric buildings

The most significant observation from the 2036 projections is that the environmental impact of fossil fuel combustion scales directly with the increase in the number of dwellings or floor area. This contrasts with electricity-related loads, where the impact is significantly reduced over time due to the grid's progressive greening.

A principle that all new buildings are to be all-electric will provide the single biggest reduction in emissions in 2036. It is also essential to place new development on a net-zero emissions trajectory for 2050 that is not reliant on the ongoing expense of purchasing carbon offsets from forestry and similar sources. In addition to the importance of future-proofing for net-zero carbon emissions, there are also ongoing economic and amenity benefits.

For residential development, there is a first cost saving of not installing a gas service to each apartment. A recurrent cost saving is achieved for each residential homeowner by avoiding the distribution charges associated with having a gas service, estimated by IPART to be 55% of a typical bill[13]. The avoided standing charge alone is estimated at $240/year/dwelling, which equates to over $3.5m a year saved across the projected newly developed dwellings in Bankstown City Centre and $2.2m a year Campsie Town Centre.

A further benefit in requiring an all-electric apartment building is that the BASIX Energy Score for apartments is harder to achieve. This makes it complimentary to BASIX and requires more energy efficiency measures to be adopted elsewhere in order to meet the minimum regulated requirement of BASIX.

The avoidance of gas for cooking hobs will also remove a significant source of indoor air pollution from new dwellings. Both nitrogen dioxide and carbon monoxide are byproducts from the combustion of gas. A 2018 study by the University of Queensland found that around 12 per cent of childhood asthma around the country can be attributed to gas cooking[14]. Whilst adoption of induction cooktops in contemporary residential apartment developments is uncommon; they are increasingly the preferred cooktop in professional kitchens.[15]

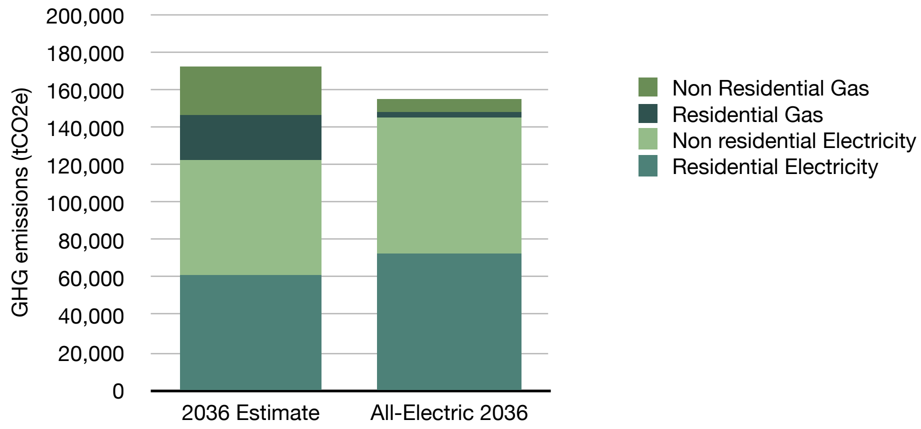


Figure 52 Reduction in GHG emissions from all-electric buildings in Bankstown City Centre

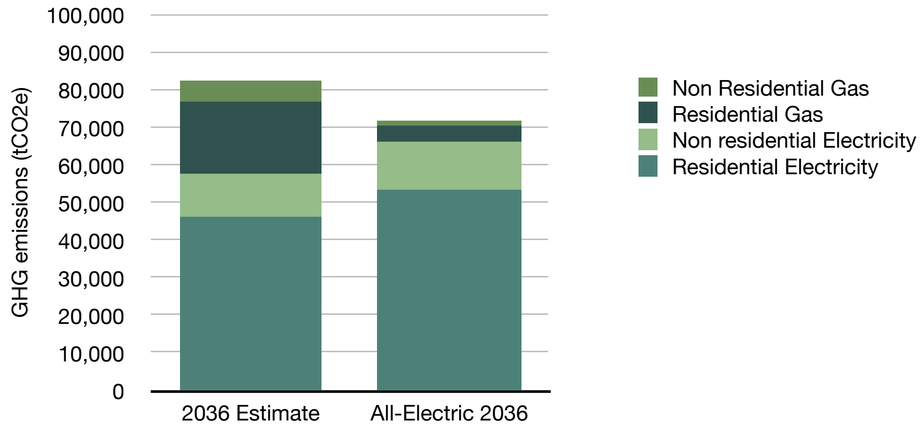


Figure 53 Reduction in GHG emissions from all-electric buildings in Campsie Town Centre

13 Why gas costs what it does IPART

14 Cooking with Gas: bad for the planet, and bad for your health 21 May 2020 The Fifth Estate

15 Gas v induction cooktops, what is your pick? 3 May 2017 Good Food

The positive impact of the all-electric building strategy will further improve over time with continued greening of the power generation serving the NSW electricity grid. This report's GHG benefit estimates are based on a reasonable conservative prediction for decarbonising the grid by 2036. The basis for this assumption is detailed in Appendix D.

To assess the further benefits in the future, the emissions are projected through to 2050 for conservative and optimistic continued rates of decarbonisation of the electricity grid using the same methodology detailed in Appendix D. The optimistic decarbonisation projection results in a 45% contribution from renewable energy generation in the NSW grid in 2050. The optimistic projection achieves 80% contribution from renewable energy generation by 2050.

Figure 54 compares the GHG impacts from delivery of the Bankstown City Centre growth targets in 2036 through to 2050 under the conservative and optimistic grid decarbonisation scenarios. It confirms that the relative benefit of an all-electric strategy compared to conventional development that remains dependant on fossil fuels improves into the future. The relative improvement grows to 26% under the conservative scenario and 39% under the optimistic decarbonisation.

The total saving GHG savings for the Bankstown City Centre study are 2036 through to 2050 is estimated as 347,000 tonnes under conservative decarbonisation scenario and 383,000 tonnes under the optimistic scenario. The relative difference in performance between the scenarios is similar for Campsie with a total saving in GHG from 2036 to 2050 estimated to be 195,000 tonnes under conservative decarbonisation scenario and 209,000 tonnes under the optimistic scenario.

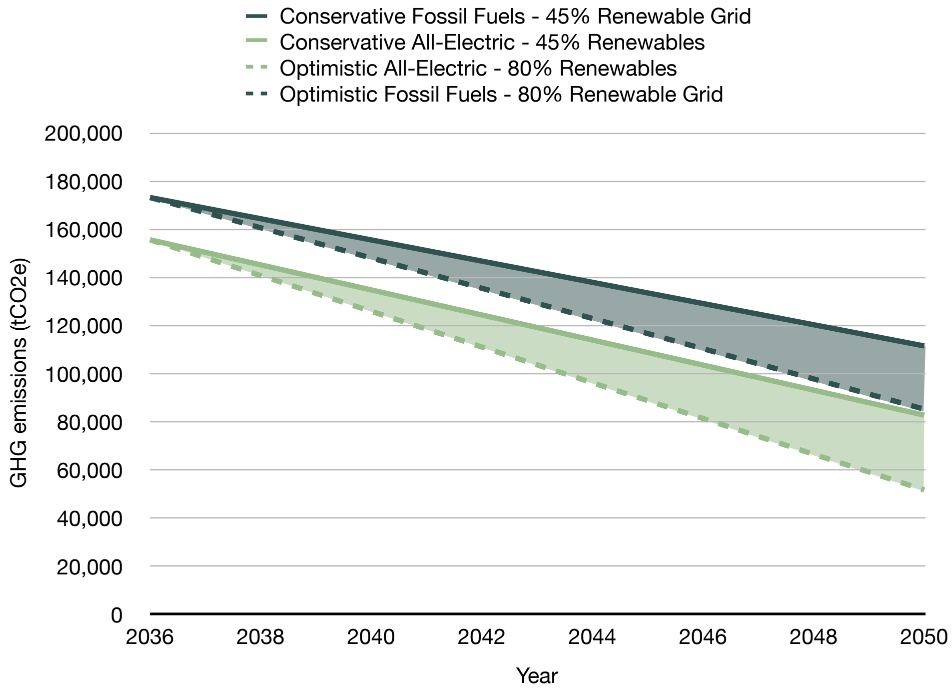


Figure 54 Reduction in GHG emissions from all-electric buildings in Campsie Town Centre

Maximised Rooftop PV

Maximising rooftop PV will have an immediate impact on reducing the carbon emissions associated with grid-supplied electricity. The benefit in emissions savings will reduce over time as the electricity grid decarbonises.

As discussed in Section 7.5.2, the economics are strongly in favour of rooftop PVs but market-led new developments split the capital costs and ongoing benefits associated with PVs to the extent that there is no return on investment for a developer. This results in an under-investment in PVs for all buildings types other than single-family housing.

In Campsie Town Centre approximately 13,185 MWh, or 16.6% of projected 2036 residential electricity demand is estimated to be met by PVs covering 40% of the newly developed roof area. This is reduced to 1,175MWh or 10.8% for non-residential demand.

In Bankstown City Centre, approximately 6,045 MWh, or 5.1% of the residential load is expected to be met by PVs due to the buildings' increased height. The yield for commercial buildings is reduced to 3,605 MWh, which is approximate 3.8%, of 2036 projected electricity demand for the non-residential buildings.

The economic benefit for future residents is Bankstown City Centre is estimated at $1.5m in aggregate or approximately $99 per year per dwelling. For Campsie Town Centre residents, the economic benefit is $2.2m in aggregate and $248 per year per dwelling.

An issue arising from the integration workshops was the competition for roof space between rooftop PVs, greening and urban canopy. PVs must be located in areas with good exposure to the sun, restricting the opportunity to roofs. This limitation does not apply to greening and urban canopy, where objectives can be met on the facade, or more effectively on the ground plane. PVs are therefore considered the highest and best use for roof space.

A requirement that mandates a minimum proportion of roof area, or site area, be provided with PVs will ensure the potential for collection is maximised and will be straightforward to assess at DA stage. This requirement would exceed the LSPS target for rooftops PVs, which is based on a simple count of installations.

For residential development, there is an overlap with the BASIX Energy requirements. However, the requirements for PVs, nominated on a minimum amount of roof area will also reduce maximum electrical demand in the study centres. This is an important outcome that is complementary to BASIX. There is also and need to ensure that the control to maximise rooftop solar does not conflict with the use of the roof for communal open space as may be required by the ADG.

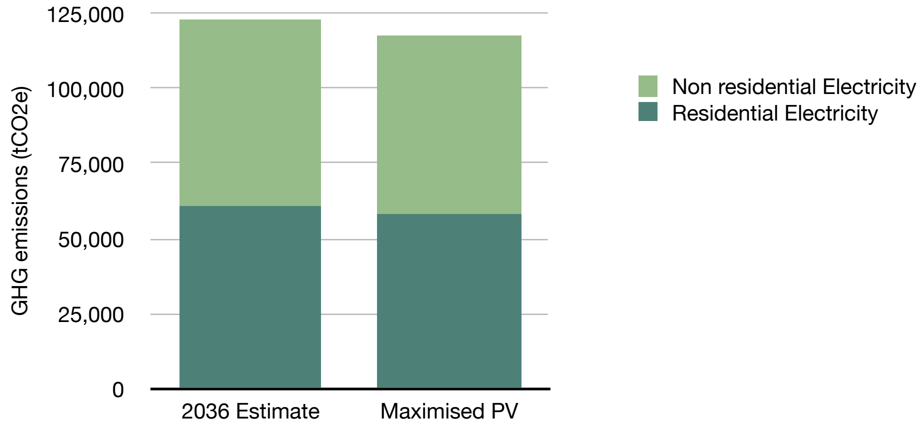


Figure 55 Benefit of maximised rooftop PV in Bankstown City Centre

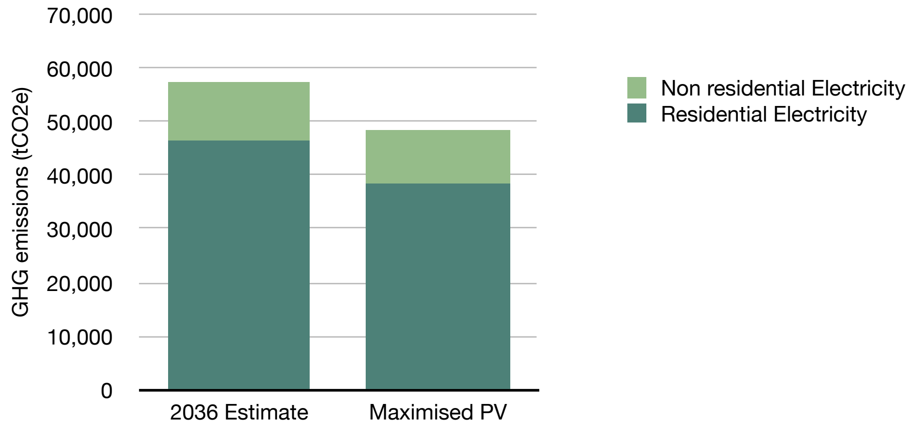


Figure 56 Benefit of maximised rooftop PV in Campsie Town Centre

EV infrastructure

The provision for vehicle charging infrastructure in all new residential development will help future proof the buildings and remove a key barrier that is likely to slow the uptake rate of electric vehicles, which is the inability to charge a vehicle at home base.

To minimise capital cost and maximise the future-proofing benefits, the infrastructure delivered in the development should be limited to a dedicated switchboard, cable trays and charging load management hardware suitably sized to support 100% of car parking spaces. This removes the cost of cabling and charging device to each car space from the development costs. The final connection to individual parking bays can then be undertaken at a later date at minimal cost by the apartment owner.

The use of charging load management hardware will ensure that the overnight electric vehicle charging can be staged. This is essential to avoid a significant impact on the maximum electrical demand and avoid the need to upgrade electrical feeders and substations to the building.

There is a significant cost saving per kilometre travelled for users of electric vehicles. An average petrol vehicle will cost about 12.5 c/km at a price for petrol of $1.20 per litre. The comparative cost to travel a kilometre in an electric vehicle is 2.5 c/km at an overnight tariff of 15 c/kWh. This equates to a saving to a typical commute by car of $870 per year.

Greenhouse gas savings are shown below on a like-for-like basis, accounting for 50% of commuter travel, representing either an inbound or outbound journey. This is the convention imposed by the Climate Active precinct standard. However, in practice, the entire commute is likely to be powered by charging the car at home base so the additional electricity-related emissions in the study centres will be double those shown.

The movement from fossil fuel to electricity will also see the emissions reduce further with the continued decarbonisation of the electricity grid, making this an important strategy for delivery net-zero emissions in 2050.

In addition to cost-benefit and greenhouse gas emissions savings, there are considerable amenity benefits, including reduced road noise at low speeds and eliminating noxious air emissions.

EV charging is not currently considered under BASIX, so this initiative is complementary.

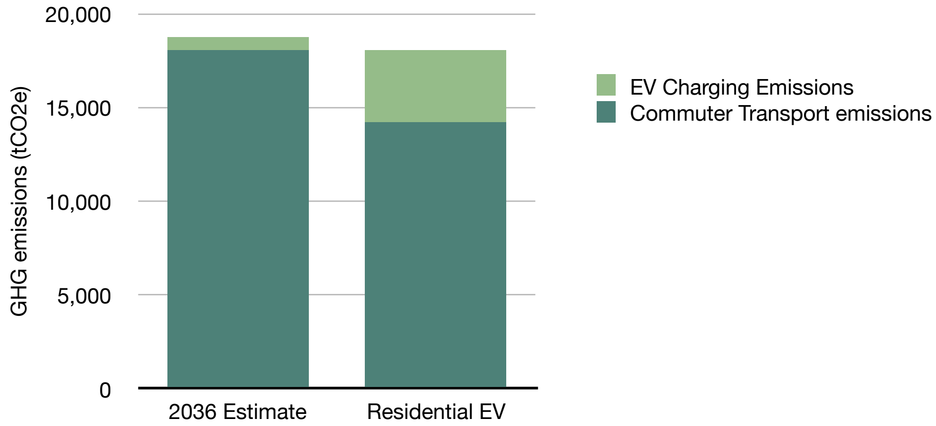


Figure 57 Benefit of Accelerated EV uptake for residents in Bankstown City Centre

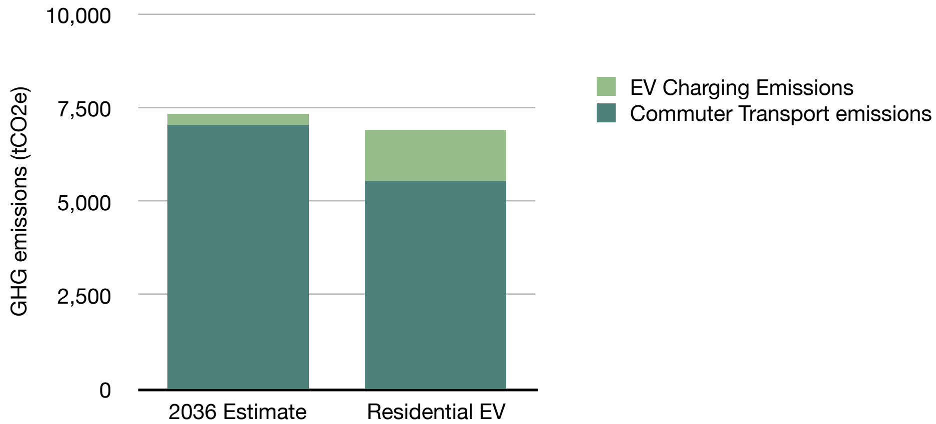


Figure 58 Benefit of Accelerated EV uptake for residents in Campsie Town Centre

Improved natural ventilation of apartments

Natural ventilation is an effective means to cool a home for much of the year in Sydney's temperate climate. Good natural ventilation is a core objective of the Apartment Design Guide (ADG) referenced by SEPP 65. However, several issues contribute to suboptimal natural ventilation in new apartments.

The introduction of fall prevention requirements into the NCC BCA has meant that achieving the required effective open areas for natural ventilation is impossible with standard awning windows. At the expense of effective natural ventilation, the BCA resolved this conflict by changing the definition of an openable window. However, the ADG definition, which remains robust, takes precedent over the BCA in NSW.

NatHERS, the thermal modelling component of BASIX, provided no transparency for modelling natural ventilation. NatHERS Assessors could exploit this oversight to improve apartment ratings. New NatHERS certificates that corrected the omission became mandatory at the end of July 2020.

The increasing preference for winter gardens, or enclosed balconies, in high rise apartment development often results in poorer thermal and natural ventilation outcomes, due to breezes being restricted and trapping of heat.

Effective natural ventilation is also an important resilience strategy to ensure a dwellings' habitability during power interruptions or mechanical failure of air conditioning.

To protect against worse than minimum natural ventilation standards and improve upon minimum regulated outcomes, the following strategies are proposed;

- Compliance checking of openable window sizes for natural ventilation,
- Compliance checking of NatHERS certificates, and
- Introduce controls to ensure winter gardens are designed as outdoor spaces requiring an adequately sized permanent opening to outside.

The cost of this strategy on a developer should be nil as it is simply ensuring minimum standards are being delivered. There will be a cost to the council in compliance checking.

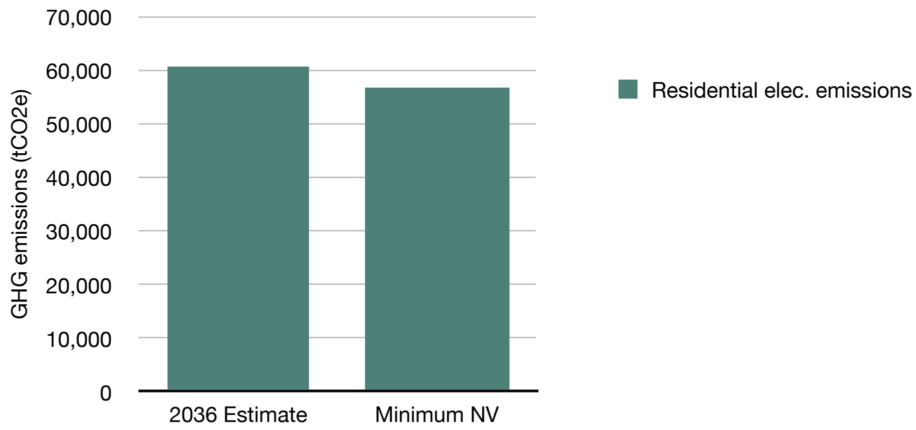


Figure 59 Impact of effective residential natural ventilation in Bankstown City Centre

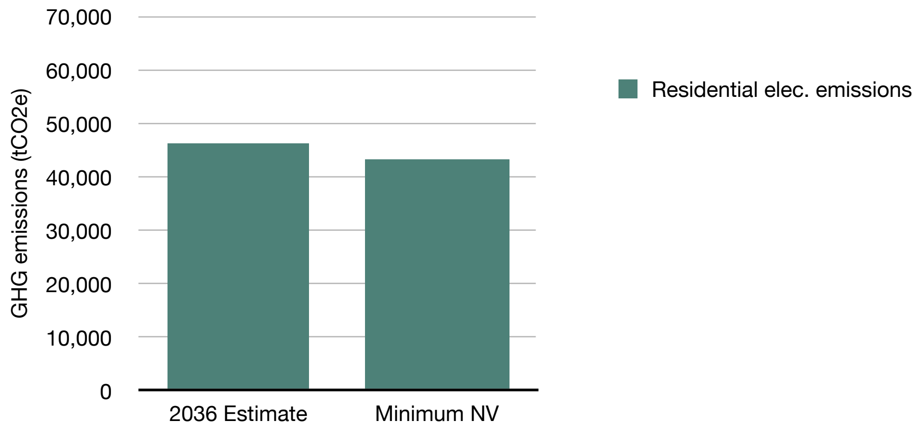


Figure 60 Impact of effective residential natural ventilation in Campsie Town Centre

Organic waste to energy

Organic waste to energy treatment does not have a material impact on building design but is a strategy that will have the combined impact of reducing fugitive emissions from landfill and reducing emissions associated with electricity use.

This strategy would require a dedicated facility comprising a biodigester and biogas powered cogeneration engine. The facility's location should be selected to allow easy access from the road for waste delivery and be adjacent to an end-use for the generator's waste heat.

The amount of energy generated is a product of the calorific value of the organic waste stream, dilution of total dissolved solids in the digester and the proportion of the organics that can be recovered.

It is estimated that 2,100 MWh of electricity can be generated from organic waste in Bankstown City Centre. This represents approximately 0.9% of the total electricity demand. This would also divert 9,300 tonnes of waste from landfill each year.

In the Campsie Town Centre, 750 MWh of electricity generation is possible, representing approximately 0.7% of the total electricity demand. The diversion of waste from landfill would be 3,400 tonnes per year.

Cost estimation and sizing are beyond the scope of this study but a broad sense of scale has been determined based on past experience is as follows.

A facility processing all the recoverable organic water in Bankstown City Centre is expected to cost in the order of $17m and require a building footprint 950 m2. If it were downsized to treat only the residential organic waste stream, the cost would reduce to approximately $4m, and the building footprint would be reduced to about 350 m2.

The area required for organic waste treatment would be doubled if composting was required to be installed in individual buildings. This would also exclude the ability to utilise biogas.

The facility would also consume water, with a full capacity system requiring 70 ML per annum to achieve the highest dilution of solids. A system designed for less dilution would reduce the water demand and reduce plant sizes, at the expenses of more material handling. We have assumed the worst case for these broad estimates.

Savings of $1.86m per year would be achieved in Bankstown through the diversion on 9,300 tonnes of organic waste from landfill at the current cost rate of more than $200/tonne to cover the NSW State government levy and gate fees for landfill. This saving would be partially offset by the cost of water use, wages and routine maintenance. The value of electricity generated from biogas in Bankstown is estimated to be $500,000 per year.

The value of avoided costs and savings for Campsie is estimated to be 35% of those estimated for Bankstown.

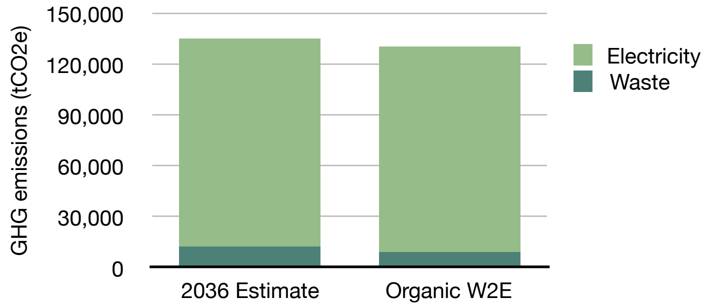


Figure 61 Benefit of organic waste to energy treatment in Bankstown City Centre

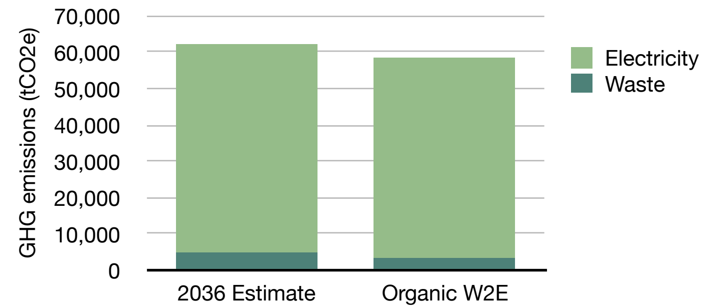


Figure 62 Benefit of organic waste to energy treatment in Campsie Town Centre

Natural refrigerants

The requirement to specify natural refrigerants in air conditioning systems would reduce fugitive emissions from the leakage of synthetic refrigerant gases with very high Global Warming Potential (GWP). There is also an associated benefit of improved energy efficiency for air conditioning compressors due to natural refrigerants' lower operating pressures. Improved energy efficiency also reduces anthropogenic heat loads.

The market barrier to natural refrigerants is market readiness rather than cost. There is currently only two suppliers of natural refrigerant residential air conditioning in Australia but the market is expected to open up to more competition in the near future. Recent installations at Meriton developments in Parramatta and Zetland demonstrate the cost-effectiveness.

The improvement in compressor efficiency will provide ongoing energy cost savings for homeowners and business operators.

The requirement for natural refrigerants will also reduce the future end-of-life costs incurred by the City of Canterbury Bankstown for safe disposal of synthetic refrigerants, which is currently $150/item. This liability for safe disposal could be as high as $2.7m across the study areas.

As air conditioning efficiency is included in BASIX Energy, specification of natural refrigerants may lead to a commensurate reduction in energy efficiency elsewhere to meet the regulated minimum BASIX requirements.

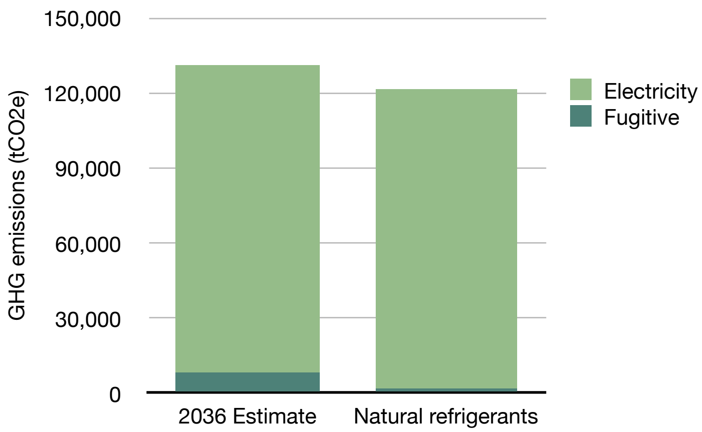


Figure 63 Benefit of natural refrigerants in Bankstown City Centre

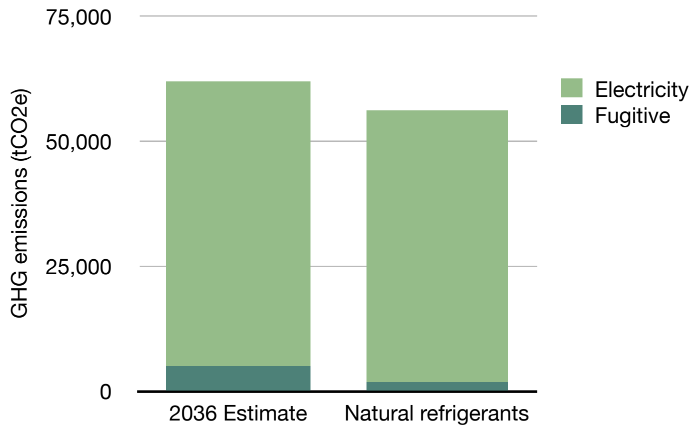


Figure 64 Benefit of natural refrigerants in Campsie Town Centre

Water resilience

The priority for water resilience should be to capture and reuse as much water as possible in each building and dual-plumb the buildings to supplement the rainwater by future connection to a district alternative water scheme. Connection to a district scheme, such as the Rosehill service, and dual plumbing through the building will allow all non-drinking water requirements to be met from alternative water sources.

For Bankstown City Centre, maximised rainwater collection can meet approximately 8% of the projected total water demand. The remaining non-drinking water demand is approximately 1,350 ML/annum, which would provide a revenue stream of $2.5m per year for an alternative water provider.

The value of avoided water use charges from the rainwater collection in Bankstown is estimated at $0.75m per year.

In Campsie Town Centre, the proportion of total water demand that rainwater collection can satisfy is 17%. The remaining non-drinking water demand is approximately 830 ML/annum, which would provide a revenue stream of $1.5m per annum for an alternative water provider.

The value of avoided water use charges from the rainwater collection in Campsie is estimated at $1m per year.

There is an overlap with BASIX water for residential rainwater collection, which means any benefits may be eroded unless the BASIX water target is lifted.

The dual plumbing requirement will remove one of the main barriers causing underutilisation of rainwater, which is the limited end uses served.

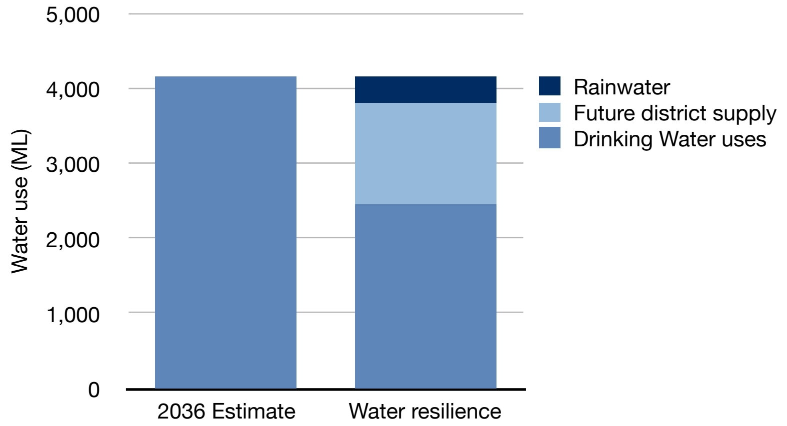


Figure 65 Benefit of water resilience in Bankstown City Centre

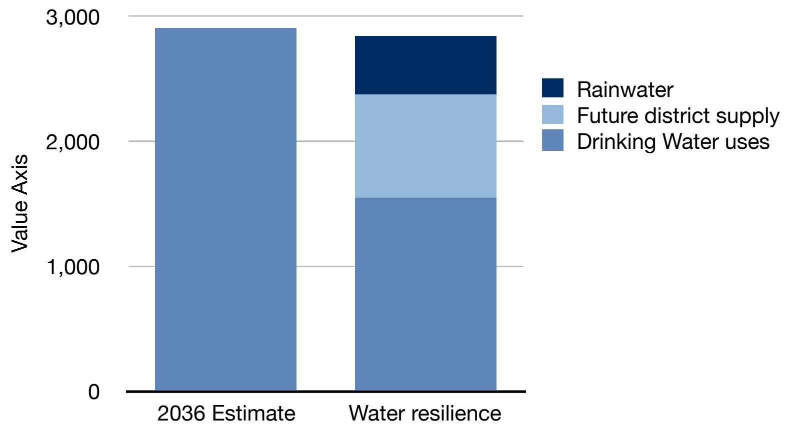


Figure 66 Benefit of water resilience in Campsie Town Centre

Redesigned Sustainability Bonus Scheme

Bonus provisions and other opportunities to agree improved sustainability outcomes with applicants are recommended to improve outcomes beyond the minimum standards established by the preceding priorities. In Bankstown they would replace the current LEP bonus scheme.

The additional benefit of any amended sustainability bonus scheme would depend on the uptake and incremental improvement. Uptake will be maximised if the increased targets are technically and commercially feasible and are described in sufficient detail to provide high levels of certainty on how the target is to be measured.

If the amended sustainability bonus scheme were applied with a 20% improvement to energy efficiency outcomes in non-residential buildings, +10 BASIX Energy target in residential buildings and 50% of the delivered GFA took advantage of the bonus available, a further 6% reduction in Greenhouse gas emissions would be possible for both Bankstown and Campsie study areas.

It is recommended that the redesign of the Sustainability Bonus Scheme consider the following:

- Providing the option of a height bonus or FSR bonus to maximise potential benefit to a project.
- Providing targets of not less than 20% improvement above the relevant planning controls for energy and water conservation.
- Relate targets to industry standard measurement tools to provide certainty for applicant and assessment.
- Provide specific targets relevant to building usage types.
- Avoid the use of 'broad-spectrum' rating tools that might allow better ratings but not deliver outcomes aligned to the city's priorities.
- Be integrated into a broader design excellence process to allow site-specific briefs.

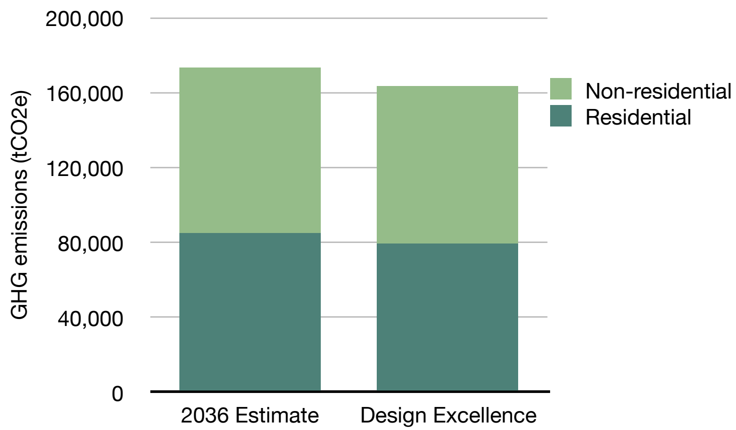


Figure 67 Benefit of design excellence in Bankstown City Centre

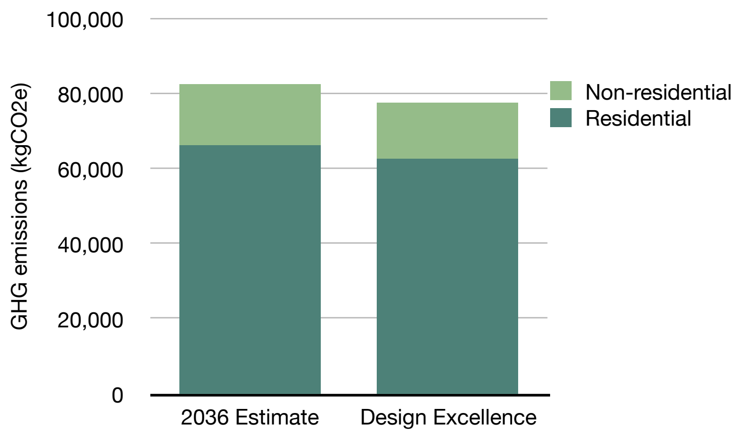


Figure 68 Benefit of design excellence in Campsie Town Centre

Urban Heat

The specific priorities for reducing urban heat include;

- Moderating the solar reflectivity of building facades
- Controlling the placement of heat rejection
- Strategic access to sky and breezes
- Integrated greening
- Increased tree canopy
- Increased surface permeability

Facade solar reflectivity controls

The reflection of solar heat into the lower parts of street canyons contributes to the elevation of surface and air temperatures at street level. Reducing the amount of solar heat that can reach the street is an important strategy to reduce the heat imbalance that is the cause of the urban heat island effect.

Facade solar reflectivity controls are particularly important in the context of the increasing energy efficiency stringency of the building code. These energy efficiency requirements are met with increasingly sophisticated glass performance coatings, which rely on the ability to reflect large amounts of solar heat from the glass. This is beneficial for energy efficiency but leads to more solar heat in public open space. By restricting the amount of reflected heat permitted, the energy efficiency objectives will need to be met through alternate strategies, such as external shading or reduction in the ratio of glass to opaque wall. This ensures a balanced design outcome.

The objectives of the facade reflectivity controls proposed are consistent with the recommendations of the Tall Building Study Phase 1 report that was undertaken concurrently by Bates Smart.

The strategy recommended is to replicate the draft development controls being implemented by the City of Parramatta. This brings the benefit of extensive testing, including peer review.

Heat rejection

Heat rejection from air conditioning is the most significant contributor to anthropologic heat in the study areas. The impact the rejected heat has on the elevation of local air temperatures and the urban heat island effect depends on how quickly it dissipates outside the urban canopy.

Generally, the nearer the heat rejection source is to the average roof height, the less impact it will have.

For heat rejection, the priority is to prohibit heat rejection at or below podium height or on residential balconies. Preference should be given to locating heat rejection as high as possible, with the roof location being mandated for all building other than residential above 10 stories. Locating heat rejection plant on the roof does limit the area available for other uses but does not need to conflict with the target to maximise roof area available for PV installations.

There are also benefits in encouraging cooling towers over air coolers. They use latent heat rejection, which increases the outdoor air temperature less than air cooled heat rejection. Consideration should be given to mandating the use of cooling towers and or evaporative pads or air coolers for heat rejection plant above a threshold capacity.

Access to sky view and breezes

Sky view and wind movement are the two mechanisms relied upon to dissipate heat collected in the study areas each day. It is important that both mechanisms are enhanced as far as practically possible in the masterplanning.

The masterplan should seek to limit maximum street wall lengths and increase the separation between towers above podium height to promote wind movement through the precincts. These strategies will maintain airflow above podium height, dissipate heat, and limit downdraft, which can negatively impact pedestrian comfort and safety.

The requirements are complementary to the recommendations of the Tall Building Study Phase 1 report.

Greening

Integrated planting on structures will help reduce heat reflection into the street canyon and provide a source of evapotranspiration. As there is careful consideration required to ensure adequate maintenance and growth conditions, we recommend controls permit and encourage rather than mandate. Complimentary bird-friendly building controls should also be developed to mitigate any increased risk of bird collisions where planting is adjacent to highly glazed areas. Similarly, consideration should be given to the potential adverse impact to airport operations from increased habitat in the Bankstown City Centre.

Tree canopy

Increased tree canopy will provide shade and evapotranspiration, both positive to reducing the heat island effect, but can reduce sky view factors and trap more heat overnight.

Tree canopy targets are contained in the Bankstown and Campsie Urban Tree Canopy Masterplan by Oculus.

We recommend that tree canopy controls prioritise trees in deep soil and avoid reliance of pits or planters to maximise the size of trees possible and minimise irrigation requirements.

Surface Permeability

A surface permeability target should be established together with meaningful deep soil requirements for new developments to increase groundwater recharge, increase evapotranspiration, and reduce the demand for supplemental watering of trees.

Deep soil was discussed in the integration process and considered an important complement to the tree canopy and urban heat objectives.

The masterplan should prioritise rain gardens to increase permeability in the public streets.

Other Opportunities

Car parking

A key recommendation of the Bankstown Complete Streets report is the relocation of council owned car parking facilities.

This strategy should be extended to replace the need for new below ground car parking to new non-residential dwellings. This would have a double environmental benefit of avoiding the cost of excavating basements and eliminating the ongoing impact of mechanical ventilation that is necessary for below ground car parking.

The above-ground parking structures could also provide a platform for installing large solar PV arrays on the roof and incorporating electric vehicle charging infrastructure.

As the mode of transport shifts away from private vehicles, above-ground structures will be easier to repurpose and, if demolished, allow redevelopment with minimal loss of embodied energy in the structure.

This is a significant change to normal provisions and should be tested further.

Enhanced energy and water efficiency controls

Any environment targets established in the LEP or DCP controlling the growth of the study areas must keep pace with evolving best practice in sustainable design. Inevitably, if a water or energy target is hardcoded into an LEP or DCP, that target will become out of date and ineffectual during the life of the planning instrument.

Dynamic controls could be achieved with a best-in-market benchmarked target. The relevant best-in-market target to be met for each new development can be scheduled each year based on a pre-published method of determination.

Energy and water efficiency targets should be tailored to suit a range of building usage types and where possible leverage existing rules sets for how to calculate outcomes, such as those provided by the NABERS tools or Section J of the NCC BCA.

Tenancy and fit-out energy and water efficiency controls

The tenants and users of non-residential buildings will significantly impact sustainability outcomes in the study centres, so there is an inherent limit to efficiency gains that can be achieved when regulating only the elements delivered by a developer. Tenant impacts are likely to comprise 50% of an office's total impact and can be 70% of impacts in retail.

Controls should be introduced to ensure all fit out works are subject to sustainability targets. For small tenancies, this could be a schedule of prescriptive requirements to reflect best practice at the time. For major fit outs, such as large office and education facilities, performance targets may be more appropriate.

Positive covenants

Environmental initiatives delivered as part of a development that require central services or common ownership face an additional risk that the benefits may not be realised over time, due to poor maintenance or non-essential equipment being turned off to avoid recurrent ownership costs.

To ensure necessary maintenance is provided to deliver the sustainability targets required by the planning instruments, it is recommended that positive covenants be required to govern the maintenance and operation of items including:

- Central water reuse systems
- Central energy systems
- Green walls and roofs

Sustainable materials

The materials used to construct a building have a significant impact, as noted in the Tall Building Study Phase 1 report.

Whilst the impacts of construction materials do not directly relate to the scope of this study, best practice controls to limit the impact of materials are complimentary and should be adopted. It is noted that compliance cannot be demonstrated during development assessment. Therefore, controls will need to focus on conditions of consent that can be assessed by a private certifier before the issue of a construction certificate.

7. External influences impacting the assessment of 2036 environmental outcomes

The estimation of the environmental footprint in 2036 required an understanding of the direct impacts of future growth and the impact of externalities, such as climate change and the decarbonisation of the NSW electricity grid.

This section presents those influences and trends that cannot be directly influenced by an amendment to the planning controls but will have a material impact on the environmental outcomes within the study areas in 2036.

7.1. Growth requirements

The project demand for new dwellings and new floor space are taken from the Bankstown[16] and Campsie[17] background reports and are summarised below.

Additional residential dwelling required by zone type	Bankstown City Centre Additional dwellings required (n)	Campsie Town Centre Addition al dwellings required (n)
R2	89	
R3	76	170
R4 (apartments)	1,405	2,731
B (shop top housing)	10,930	2,699
Total	12,500	5,600

Table 15 Additional residential dwellings required to meet 2036 Estimates

Additional non-residential floor space required by service category	Bankstown City Centre Additional GFA required (m^2)	Campsie Town Centre Additional GFA required (m^2)
Population Serving	161,475	31,025
Knowledge Intensive	100,117	13,344
Health and Education	225,727	76,728
Industrial	63,354	
Other		3,022
Total	550,673	124,119

Table 16 Additional floor space required to meet 2036 jobs and education targets

As the projected demand for additional dwellings and non-residential floor space is to be delivered on existing building lots, some demolition of existing buildings will be required. The likely extent and location of the existing buildings to be redeveloped will be better understood after the masterplanning is completed.

To estimate the environmental footprint in 2036, we have assumed that 50% of the existing stock will need to be redeveloped, with uniform distribution across building types. The 50% is based on a simple visual assessment of the sites and is expected to change when the intent for zoning is resolved in the masterplanning process.

The dwellings and floor space lost to redevelopment are assumed to be replaced with additional new development.

[16] Bankstown City Centre Background Report, City of Canterbury Bankstown April 2020

[17] Campsie Town Centre Background Report Issue A, City of Canterbury Bankstown April 2020

7.2. Decarbonisation of the grid

Electricity use is the biggest source of greenhouse gas emissions from a building or a precinct's operations. When estimating greenhouse gas emissions in the future and establishing strategies to reduce those emissions, consideration must be given to the current and expected future greenhouse gas intensity of electricity generation in NSW.

The NSW Government has committed to an objective of achieving net-zero emissions by 2050 with a commitment of a minimum of 15% renewable energy target by 2020. The amount of electricity generated from renewable sources has been increasing in recent years resulting in the decarbonisation of the grid as shown below.

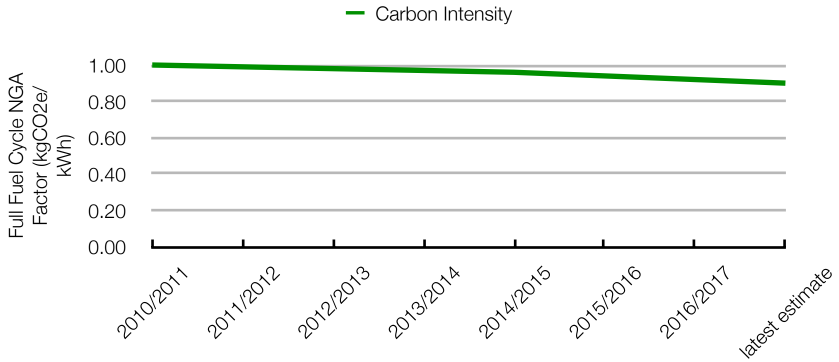


Figure 69 Decarbonisation of NSW electricity grid 2010 - present[18]

Whilst decarbonisation of the grid has been primarily driven in the past through the operation of the federal Renewable Energy Target legislation, it is anticipated that the future decarbonisation of the grid will be determined by the planned retirement of old coal-fired generation plants. Flux has assessed these plant's scheduled retirements and has determined a full fuel cycle emission factor of 0.485 t.CO2e/MWh for the basis of assessment in 2036. This represents a reduction of 46.1% in greenhouse gas emissions per unit of electricity consumed compared to the latest estimate of current emissions in NSW and is therefore very significant in underpinning the development of strategies and actions. Appendix D provides more detail on how the 2036 emissions factor for electricity was derived.

7.3. Climate Change

Changes to the climate currently occurring include rising temperatures, changing rainfall patterns, sea-level rise and ocean acidification.

Further climate change is expected due to increases in greenhouse gas emissions, so it is important to consider this when planning for new buildings or infrastructure. The broad impact of predicted changes to climate as schedule below.

Predicted Change in 2036	Consequences
Increase in temperature and more hot days	- Heat stress - Higher cooling needs - Increased electricity consumption - Reduced amenity of public and private open space - Reduced amenity within homes
Higher evapotranspiration	- Greater irrigation needs for plants in landscaped areas
Increased intensity of extreme rainfall events	- Increased Stormwater runoff - Top soil erosion

Table 17 Impacts of Climate Change on the study centres

7.3.1. Climate Change Prediction for the East Coast of Australia for 2040

The Australian Department of Environment and Energy in collaboration with the CSIRO predict that the future climate in the East coast region[19] of Australia will have:

- An increase in average temperatures (very high confidence)
- More hot days and warm spells (high confidence) and fewer frosts (high confidence)

[18] source: National Greenhouse Accounts Factors August 2019, Department of the Environment and Energy

[19] https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/clusters/?current=ECC&tooltip=true&popup=true

- Decreased winter rainfall (medium confidence)
- Increased intensity of extreme rainfall events (high confidence)
- Increased time spent in drought (medium confidence)
- Increased heights of extreme sea-level events (very high confidence)
- A harsher fire-weather climate (high confidence)
- Increase in potential evapotranspiration in all seasons (high confidence)
- A decrease in humidity later in the century (medium confidence)

The confidence in the projected deviation of summer mean maximum daily air and surface temperatures in 2035 is shown below.

		December - February (DJF) Mean Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
December - February (DJF) Maximum Daily Temperature (C)	Much Hotter > 3.00				
	Hotter 1.50 to 3.00		+ 5 of 45 (11%)	+ 9 of 45 (20%)	
	Warmer 0.50 to 1.50		+ 29 of 45 (64%)		
	Slightly Warmer < 0.50	+ 1 of 45 (2%)	+ 1 of 45 (2%)		

Figure 70 Mean daily air and surface temperature changes projections for 2035

The projected increase in daily maximum temperatures is the dominant consideration for the study areas. This puts extra load on any cooling systems and subjects the residents to heat stress.

7.3.1. NSW and ACT Regional Climate Modelling (NARCliM) project

NARCliM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW, and the Department of Primary Industries.

NARCliM takes global climate model outputs and downscales these to provide finer, higher resolution climate projections for a range of meteorological variables. This allows a more localised set of projections for the Bankstown and Campsie study areas. The NARCliM project provides results at a 10 km square resolution and provides more local data than the CSIRO future climate dataset.

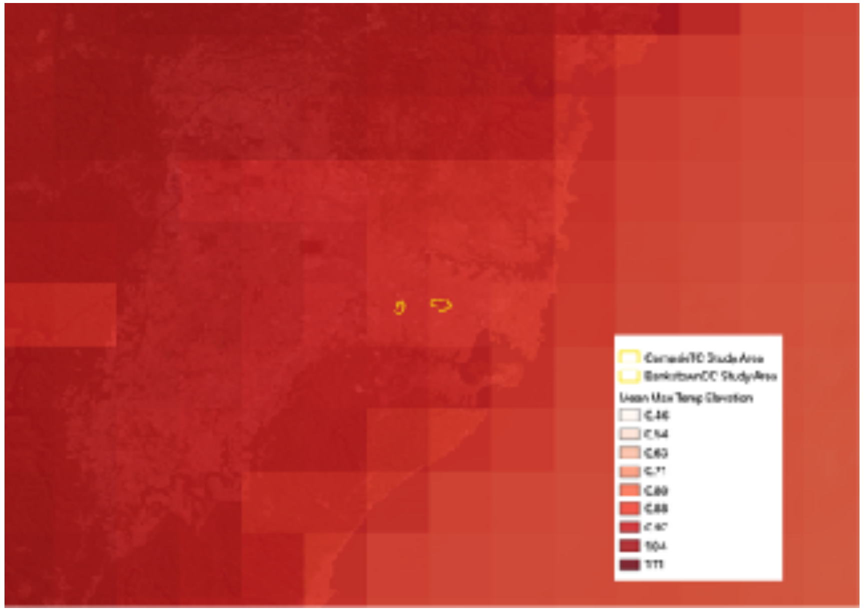


Figure 71 NARCliM projected mean maximum temperatures, summer 2039

The two study areas are located in different data regions of the NARCliM dataset. The projected seasonal climate variance for each is shown below.

Bankstown City Centre	Mean daily min. temp. (ºC)	Mean daily temp. (ºC)	Mean daily max. temp. (ºC)	No days with temp. above 35ºC (n)	Mean precip-itin accumu-lation (%)
Summer	0.46	0.85	0.94	2.57	0.42
Winter	0.83	0.47	0.46	0.00	1.51
Autumn	0.65	0.61	0.55	0.08	9.04
Spring	0.64	0.65	0.70	0.47	-1.98

Table 18 NARCliM 2039 projection for Bankstown City Centre

Campsie Town Centre	Mean daily min. temp. (ºC)	Mean daily temp. (ºC)	Mean daily max. temp. (ºC)	No days with temp. above 35ºC (n)	Mean precip-itin accumu-lation (%)
Summer	0.46	0.83	0.93	2.16	0.81
Winter	0.81	0.46	0.47	0.00	1.60
Autumn	0.65	0.61	0.56	0.05	6.68
Spring	0.64	0.65	0.69	0.39	-0.26

Table 19 NARCliM 2039 projection for Campsie Town Centre

The tables show that both study centres are expected to be similarly impacted by future climate change. Daily minimum, average and maximum temperature are all projected to increase in the future with the highest increase being in average summer maximum daily temperatures which are forecast to rise by almost 1 ºC. The average number of days above 35 ºC is also predicted to increase. Rainfall is expected to increase mainly in autumn with a marginal decrease expected in winter.

The impacts of the projected temperature rise on greenhouse emissions will be to increase cooling related electricity demand in summer and reduce gas and electricity-related heating demands in winter.

7.4. Urban Heat Island effect

Urban Heat Island (UHI) is the phenomenon whereby an imbalance in the heat received in an urban environment is greater than the urban environment's capacity to dissipate it. The science of the Urban Heat Island effect is well understood.

Factors that impact UHI include urban built form, radiative trapping and anthropogenic heat production.

The urban built form refers to the shape, dimension and spacing of buildings, which together effect the amount of radiation received, reflected and emitted within an urban environment. Radiative trapping is also linked to urban geometry. For a highly prospective urban form, the solar rays undergo reflections and heat the surfaces that compose the street before partially emerging towards the atmosphere. Radiative trapping will therefore increase the mean daily temperature inside the street canyon. A higher density of human activities increases the anthropogenic heat releases associated with heating, air conditioning, transport and industrial activities.

All three of these components will change with the Bankstown and Campsie study areas' redevelopment and increase the Urban Heat Island effect. Whilst this can be attributed simply to the increase in density, it is important to understand how considered planning can mitigate the impacts.

Indicators such as sky view factors can characterise the impact of the built form on urban heat. The moderate correlation between urban heat and sky view factor was approximated by Unger and is shown below.

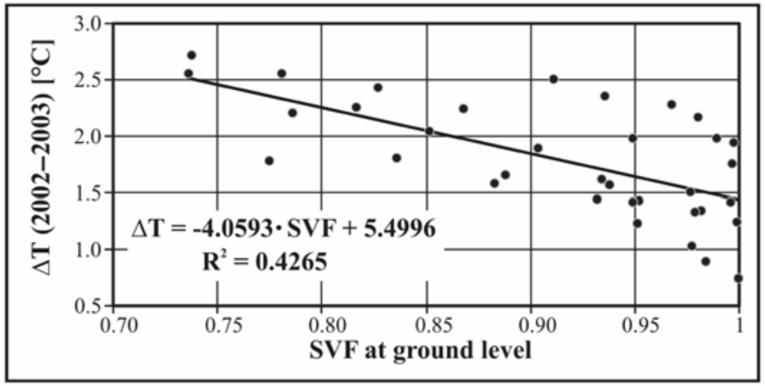


Figure 72 Relationship between sky view factor and increased temperature source: Unger

A study of the effects of Sky View Factor in Montreal[20] revealed similar trends but pointed to slightly cooler street canyons with during the day with a decrease in sky view factor and warmer conditions overnight. The paper also highlights the role of the tree canopy in further reducing sky view factors.

UHI in the Sydney metropolitan area is expected to increase with continued growth and the absence of broad controls to mitigate buildings' impacts. Increases in UHI in surrounding areas will impact the study centres by warming air, as is seen already in the difference in air temperature between Bankstown and Sydney airport. Local changes to the massing of buildings to meet the 2036 objectives will also impact UHI through changes to the microclimate caused by increases in anthropologic heat, redistribution of solar heat, and reduction in heat dissipation through the increased obstruction to the wind and reduced sky view factor.

An increase in local mean daily maximum air temperature, due to decreased sky view factors and increased anthropogenic heat, of approximately 0.7 °C has been allowed for the 2036 development yields. This is expected to be conservative.

7.5. Technical improvement

7.5.1. Appliances

Technical improvement to the efficiency of appliances will help reduce energy requirements into the future. The extent of benefit is dependent on the magnitude of continued technical improvement, the rate of replacement of the technology and the drivers for consumption.

The drivers for consumption are particularly relevant to the consumer market, where energy efficiency is not a significant driver in purchasing decisions in households. For example, this results in energy savings from more efficient television technology being lost to an increase in the size of the television and incorporation of smart functionality. For technical improvement in appliance efficiency, it is reasonable to assume that savings realised will result from continued regulation of efficiency.

The drivers are different for the commercial sector, particularly when the benefits can realise operating costs savings or increased rental values.

The office sector has been the most successful example. The energy efficiency of buildings has improved significantly in the last twenty years. Much of the gains in efficiency can be attributed to the improvement in the efficiency of office lighting and the transformation of computing, which has seen the energy required to read an email reduced from 300 watts for a desktop computer with CRT monitor down to 1-2 watts on an iPhone or tablet and 8-12 watts on a modern laptop. Any saving in the energy for lighting or computer power also has a corresponding saving in air conditioning energy. The figure below illustrates the changes in main equipment loads within an office over the last 30 years.

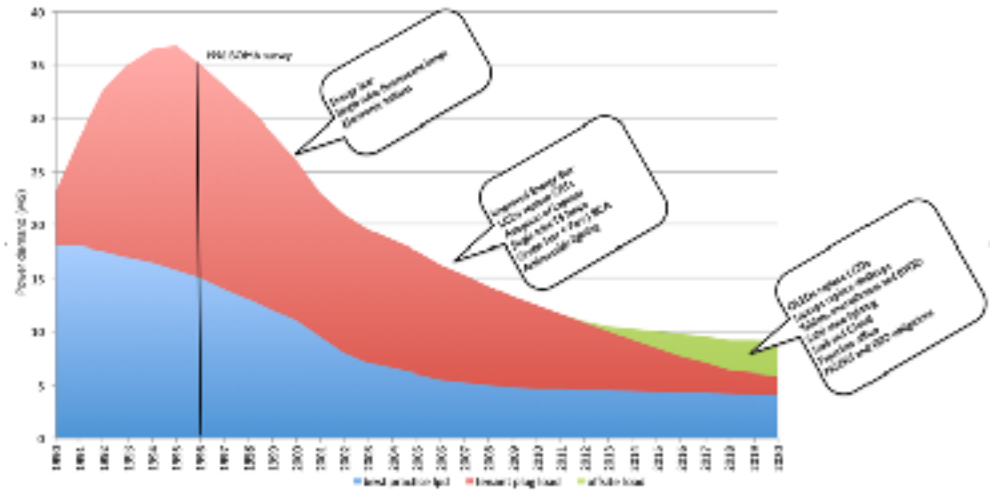


Figure 73 Impact of lights and computers on office power demand 1990-2020

7.5.2. Renewable Energy

Renewable energy has undergone rapid growth, which has seen the dominant technologies decrease dramatically in price to a point where they can be more cost-effective than fossil fuels for electricity generation.

[20] Effect of Sky View Factor on Outdoor Temperature and Comfort in Montreal, Wang and Akbari 2104

Solar photovoltaics (PVs) are considered the prevailing technology for on-site electricity generation. Solar PVs both reduce the peak load on the system (or how big the power plant, wires and transformers are) and the total annual draw from the grid. They can also enable independence from the grid when combined with batteries to enhance resilience. It is generally best practice to size solar installations to minimise export whilst maximising peak load reduction.

The average cost of an installed PV system of 5 kW in Sydney in June 2020 was $872/kW[21]. This has reduced from approximately $1,600/kW in June 2015. This corresponds to a 45% reduction in installed cost in just 5 years.

At current prices, PVs achieve a simple payback in less than 3 years. With a typical operational life of 20 years, this provides 17 years of direct operational cost savings.

The economics of PVs are such that their value is no longer questioned. The extent of PV provided is now often dictated by the physical limitation of available space to locate the PV panels. In this context, conventional PV panels have to compete with other important uses for rooftop space, including common open space for the residents, rooftop greening and plant and equipment. Building Integrated Photovoltaics (BIPVs) offer a solution to this problem through integration into building facades. The attractiveness of BIPVs in terms of increasing available collection area is somewhat offset by reduced efficiency, increased capital cost and more complex routine maintenance requirements.

Importantly, whilst the economics are very strong, regulation will still have an important role in the uptake of PVs in the delivery of new buildings. This is due to the split incentive, where the developer is required to contribute the capital to pay for the installation, but the owner realises the savings. The value of the savings is not currently recognised in the sales price of new apartments, so the developer receives no return for their investment. Commercial buildings have the additional challenge that building owners often pass through outgoings to the building's tenants, further distancing the recurrent benefit from the initial investment.

7.5.3. Electric Vehicles

Electric Vehicles are not new, predating internal combustion vehicles. Availability, price and most importantly, transportability however ensured oil was the dominant energy source for transport. Recent advances in battery technology combined with greater environmental awareness, including consideration of greenhouse gas emissions and air quality in cities, has seen electric vehicles re-emerge. As battery cost, size and weight reduce, and emissions regulations increase, the number of available electric vehicles on the market continues to grow.

Unlike oil-fuelled transport that relies solely on re-fuelling stations, electric vehicles will typically source most of their energy from "home base" charging stations located in homes or workplaces. A premium exists for longer-range electric vehicles (300km+ per charge) however transitional plugin hybrids with a 40 km range (sufficient for typical daily use) are increasingly cost-competitive. Battery technology is also driving significant growth in alternative transport options, specifically eBikes. Plugin hybrids and eBikes are expected to benefit from facilities providing destination charging.

Current long-range electric vehicles have generally targeted the luxury market. These vehicles have a $20,000 premium compared to the conventionally powered model. At current battery prices, half this premium is attributable to the battery cost. The remainder is a factor of availability and little competition.

Electric vehicles provide running cost savings but not to the extent that the investment is recoverable at current pricing. For comparison, a conventional light commercial vehicle travelling 15,000 km per annum will use $1,100 worth of fuel per year compared to $250 worth of electricity (overnight charge), saving about $850 per year. At current prices, the payback would exceed the economic life of the vehicle (23 years).

Electric vehicles constituted 0.7% of new car sales in 2019[22] and, according to BloombergNEF, will rise to 4.6% of new car sales by 2025, 18% of new car sales by 2030 and to 64% of new sales by 2040, by which time electric vehicles will make up 23% of total cars on the road. Using these expected growth rates, we have assumed a BAU scenario of 30% new sales and 10% of all cars on the road will be electric vehicles by 2036.

[21] solarchoice.net.au

[22] Australia to lag in vehicles sales until 2030s. Australian Financial Review May 22 2020

A challenge that is seen as a significant barrier to Electric Vehicles' adoption is the necessary provision of overnight charging in residential apartment developments. The infrastructure to facilitate charging is not currently provided and cannot be easily retrofitted by a single apartment owner. The cost of retrofitting is also 2.75 - 4 times more expensive and the technical challenges may be insurmountable.

7.5.4. Battery Storage

On-site generation in the form of Solar PV is now so cost-effective it is relatively easy to generate more electricity than can be consumed at the time of generation in a single-family house. The impact of this is that rather than avoiding the purchase of electricity, it is sold to the grid at a discounted price. The reduced cost of battery storage driven by global electric vehicle demand has created an associated benefit of reducing stationary battery storage costs within buildings and facilities. Rather than being exported, batteries can be charged during peak generation periods and drawn on when generation falls. Batteries can also be used to enable off grid operation with appropriate control equipment.

Currently, batteries cost $220/kWh. If the battery is cycled 200 times per year, it will provide a financial benefit of approximately $65 per annum (assuming 30c/kWh peak electricity cost, 15c/kWh export, 85% round-trip efficiency). This equates approximately to an eight year payback (or 1600 cycles). This would exceed the current expected battery life of 1500 cycles expected from a Lithium-ion battery. By 2022 this is projected to fall to six years and be within the batteries' economic life.

Alternative technologies, such a zinc-bromide flow batteries, offer much longer life but carry other disadvantages such as increased spatial requirements, increased round-trip losses, and the need to fully discharge on a weekly basis.

Whilst batteries offer an attractive opportunity to maximise the economic benefits of rooftop solar in single-family housing; they will result in an overall reduction in environmental benefit due to round-trip system losses. We have not assumed any material shift in the uptake of batteries in 2036.

7.6. NSW Government Plans and Policies

7.6.1. NSW Climate Change Policy Framework

The NSW Climate Change Policy Framework outlines the government's long-term objectives to achieve net-zero emissions by 2050 and make New South Wales more resilient to a changing climate.

The framework is supported by The NSW Climate Change Fund and the climate change draft Strategic Plan 2017 to 2022. The strategic plan is not formally adopted but identifies the priorities for funding and notes the following policy areas, which are relevant to determining the sustainability strategies:

- Build capacity of local communities to deliver and own renewable energy
- Reduce emissions in NSW to support achievement of Commonwealth objectives
- Identify cost-effective pathways to achieve net-zero emissions
- Improve energy productivity for households and businesses
- Reduce peak demand through battery storage and other demand management measures
- Support vulnerable households to reduce their energy bills
- Increase canopy coverage in heat exposed suburbs and regional towns

7.6.2. South District Plan

The size of the proposed study area requires that it meaningfully address the relevant Objectives and Actions of the South Sydney District Plan to give effect to the Greater Sydney Regional Plans published in 'A Metropolis of Three Cities'. Specifically, the project should consider those parts of the plan noted as the responsibility of Planning Authorities, State Agencies and/or State Corporations:

Planning Priority S19 Reducing Carbon Emissions and Managing Energy, Water and Waste Efficiently

Objective 33 - A low-carbon city contributes to net-zero emissions by 2050 and mitigates climate change.

Objective 34 - Energy and water flows are captured, used and re-used.

Objective 35 - More waste is re-used and recycled to support the development of a circular economy.

Action 72 - Support initiatives that contribute to the aspirational objective of achieving net-zero emissions by 2050, especially through the establishment of low-carbon precincts in Growth Areas, Planned Precincts, Collaboration Areas, State Significant Precincts and Urban Transformation projects.

Action 73 - Support precinct-based initiatives to increase renewable energy generation and energy and water efficiency, especially in Growth Areas, Planned Precincts, Collaboration Areas, State Significant Precincts and Urban Transformation projects.

Action 74 - Protect existing and identify new locations for waste recycling and management.

Action 75 - Support innovative solutions to reduce the volume of waste and reduce waste transport requirements.

Action 76 - Encourage the preparation of low-carbon, high efficiency strategies to reduce emissions, optimise the use of water, reduce waste and optimise car parking provision where an increase in total floor area greater than 100,000 square metres is proposed in any contiguous area of 10 or more hectares.

Planning Priority S18 Adapting to the impacts of urban and natural hazards and climate change is also very relevant to the scale of the proposed redevelopment. This will give effect to the following directions and actions.

Objective 36 - People and places adapt to climate change and future shocks and stresses.

Objective 37 - Exposure to natural and urban hazards is reduced

Objective 38 - Heatwaves and extreme heat are managed.

Action 78 - Support initiatives that respond to the impacts of climate change.

Action 80 - Mitigate the urban heat island effect and reduce vulnerability to extreme heat.

7.6.3. Metropolitan Water Plan and WICA

The NSW Metropolitan Water Plan 2017 does not have targets for recycled water use but notes its importance to contributing to a water supply system that is resilient to stresses and shocks. The plan deferred a strategy for recycled water until the next drought (which has since occurred).

The Metropolitan Water Plan seeks an outcome where water supply is secure and affordable.

8. Summary

The sustainability study has confirmed that growth in residential accommodation, employment and education opportunities will significantly increase environmental impacts.

Investigation of the existing environmental impacts in the precincts has noted several characteristics of the study areas that should inform the future masterplanning. These include;

- Energy use in buildings is the most significant contributor to greenhouse gas emissions
- Both study areas show elevated temperature compared to the broader LGA and Sydney metropolitan region, which are the result of the urban heat island effect
- There is significant capacity for more rooftop solar energy generation
- There is a higher reliance of private car use and lower patronage of public transport that the Sydney region average

It is shown that the current planning controls to limit environmental impact through improved energy and water efficiency will not be effective in mitigating the environmental impacts associated with growth. Without additional controls, the following increases are projected compared to the existing impact;

- Greenhouse gas emissions will increase by 61% in Bankstown City Centre and 40% in Campsie Town Centre
- Water use will increase by 144% in Bankstown City Centre and 64% in Campsie Town Centre
- Waste generation will increase by 95% in Bankstown City Centre and 59% in Campsie Town Centre
- Heat added to the centres from air conditioning and vehicle use will increase by 95% in Bankstown City Centre and 80% in Campsie Town Centre

A study of the impact of increased building massing was undertaken for the floor space and building heights allowable under the current controls. These allowances are less than what is required to deliver the growth targets but clearly illustrate that denser development will reduce the ‘sky view factor’ from the streets, contributing to increasing urban heat island effect.

A survey of external trends and impacts confirmed that expected influences upon the outcomes in 2036 include;

- Climate change will lead to a 1ºC increase in average maximum daily temperature by 2036
- The move away from fossil fuels for the generation of electricity in NSW will reduced the greenhouse gas emission associated with electricity use by 46%
- Electric vehicle adoption rates in Australia are forecast to increase but at a slow rate
- Local battery storage is expected to become commercially attractive but will not necessarily deliver environmental benefits due to system losses.
- Regulation will deliver continued benefits through improved efficiency requirements for appliances.

The study has developed an understanding of the most significant environmental impact sources associated with the existing buildings and those buildings that will be developed or redeveloped. This knowledge can be leveraged together with an understanding of the impact of environmental externalities to inform controls and strategies to the masterplan that can significantly reduce impact from future development.

The strategies and principles needed are required to extend beyond the current targets published in the LSPS and embrace all feasible opportunities to reduce environmental impact.

The strategies and principles recommended for the masterplanning are summarised as;

All new buildings to be all-electric

Moving immediately away from fossil fuels in buildings will ensure the buildings are best positioned to achieve the LSPL priority to achieve net-zero emissions by 2050. It will also generate immediate cost of living savings and improved amenity for residents.

Maximum use of rooftop solar energy

Rooftop solar energy is cheap and will generate significant ongoing savings for building owners. A requirement to maximise solar delivery on each new roof will ensure that the misalignment of financial benefit is overcome.

Electric Vehicle ready buildings

Providing essential infrastructure for overnight vehicle charging will future proof the buildings and ensure residents can easily transition to electric vehicles. Without essential infrastructure, the future installation of charging facilities by an apartment owner can be much more expensive and in some case technically impossible.

Good access to natural ventilation

Access to fresh air through well designed natural ventilation is important to reduce the reliance on air conditioning to provide comfort. More fresh air will also improve amenity for building occupants.

Natural refrigerants in air conditioning

Moving to natural refrigerants in air conditioning will eliminate a significant source of greenhouse gas emissions. It will all provide ongoing saving to users through increased energy efficiency and a cost saving to Council by not paying for safe disposal of synthetic refrigerants.

All new buildings to be water resilient

Maximising rainwater collection and reuse in new buildings could save the study centre residents a total of $1.75m per year. Requiring every building to be dual plumbed and have suitable for connection to a future alternative recycled water supply will future proof the buildings for additional savings.

A redesigned sustainability bonus scheme

Providing an incentive to developers to innovate and materially exceed the minimum energy efficiency and water conservation requirements of the planning scheme will be valuable to maximise each site's potential.

Measures to reduce urban heat island

A suite of strategies will help reduce heating of the urban environment and the associated impact on amenity and energy demands. Measures include;

- limiting the heat reflecting into the streets from tall highly glazed buildings
- Masterplanning to maximise the view of the sky from the street and to promote breezes to help prevent heat build-up
- Reducing the amount of heat rejected into the urban environment from air condoning
- Increasing the permeability of streets and open space
- Increasing urban greening and tree canopy

Energy from organic waste

A centralised facility for treating organic waste to provide biogas that can be converted to energy would provide greenhouse gas savings and reduce the cost of landfill by over $2m per year. Detailed feasibility should be undertaken to confirm viability.

Enhanced energy and water efficiency controls

The planning controls applied to all new developments are to be upgraded to ensure they provide energy and water efficiency outcomes in new buildings that represent genuine best practice. Where possible these are to extend to the fitting out of commercial buildings too.

Reconsider non-residential car parking

Consideration should be given for replacing underground car parking in non-residential buildings with shared above ground parking structures. This will avoid the need for mechanical ventilation and allow for future adaptive reuse or redevelopment.

Appendix A: Greenhouse Gas Inventory

Emissions Source	Scope	In - boundary	Can be influ-enced in planning scheme	Materiality Order of Magnitude (% Total Emissions)	Rele-vance Test	Relevant and/or Material	Included?	Justification for Exclusion
Electricity use in build-ings	2	Yes	Yes	>70%	Deemed relevant	Yes	Yes	
Electricity use in public domain	2	Yes	No	<1%	Deemed relevant	No	No	Emissions are not considered material and not directly influ-enced by plan-ning controls
Gas use in Buildings	1	Yes	Yes	>15%	Deemed relevant	Yes	Yes	
Commuter transport	3	No	Yes	~5%	Deemed relevant	Yes	Yes	
Worker transport	3	No	Yes	~5%	Deemed relevant	Yes	Yes	
Visitor trans-port	3	No	Yes	~2%	Deemed relevant	No	No	Emissions are not considered material and difficult to esti-mate
Solid Waste transport and disposal	3	No	Yes	~5%	Deemed relevant	Yes	Yes	
Refrigerant fugitive emissions	1	Yes	Yes	~1-3%	Deemed relevant	Yes	Yes	
Switchgear fugitive emissions	1	Yes	Yes	<0.1%	Deemed relevant	No	No	Emissions are not considered material and difficult to esti-mate
Water supply	3	No	Yes	~1%	Deemed relevant	Yes	Yes	
Waste water treatment	3	No	Yes	~1%	Deemed relevant	Yes	Yes	

Appendix B: Sustainability Bonus Scheme Audit

Four development applications have been awarded consent with additional floor space awarded under the sustainability bonus scheme in the Bankstown LEP. A desktop review has been undertaken on each to establish an opinion on how successful the sustainability bonus has been.

The review finds that the BASIX water target is sufficiently stringent to require a centrally serviced solution, which is a clear improvement on the minimum requirements of BASIX.

The +10 BASIX energy target was met without any significant initiatives required for those projects approved before the revision of the minimum BASIX Energy target in 2017. The one application to use the scheme after the minimum BASIX Energy target was revised also misinterpreted the bonus scheme requirements. This misinterpretation resulted in the bonus scheme requirements for energy being substantially exceeded, and a 90kW PV array added to the development.

All BASIX submissions reviewed had issues with the adequacy of documentation, which introduced risk to the required initiatives' delivery.

The non-residential targets were delivered with little material improvement to the efficiency of systems. This is attributed to the lack of definition in what water and energy uses must be included and how the applicant should calculate the proposal's performance. The result is that the calculation assumptions have more bearing on the outcome than the proposed initiatives.

A post-occupancy inspection was undertaken of one of the projects to assess whether the commitments made at the time of development approval and the award of bonus floor space were successfully delivered. The inspection revealed that many initiatives material to the sustainability bonus scheme award were not delivered. It also highlighted the significant risk of further erosion of commitments through the process of private certification at construction and occupancy certificate stages.

DA 741/2014 & DA 1152/2015 190 Stacy Street

The residential development comprises 131 units with 128 car parking spaces in two towers over 10 levels. There are two small commercial suites with a combined gross floor area of 140m2.

Residential Energy

There were no significant initiatives recorded on the BASIX certificate for energy efficiency. There was no renewable energy provided and the +10 rating benefits from significant unconditioned areas (lobby + breezeway), efficient lifts and air conditioning and under-accounting of central services.

A review of the BASIX certificate energy requirements found that the car park ventilation system was underspecified as an exhaust only system. This is not legal in an underground carpark and the sustainability bonus target of BASIX 30 (BASIX 20 was current at the time) would not be met without additional initiatives if the car park ventilation was specified with a supply and exhaust system.

Energy efficiency dishwasher and washing machine appliances are not included in the energy certificate despite the fact that they are required in the water component of the certificate.

Residential Water

The water savings were achieved with the specification of 5 star dishwashers and clothes washer together with a central rainwater harvesting system. The 70kL rainwater tank is required with plumbed service to irrigation, toilet flushing and washing machines.

A review of the BASIX stamped drawing set found that the basement floors were not included. The rainwater tank is required to be shown on the DA drawings but is not shown in the upper and lower basement plans included in the architectural drawing set either.

Residential Thermal Comfort

The BASIX thermal comfort information provided was insufficient. The specification of requirements on the stamped plans lacked key information like openable window requirements.

The NatHERs certificates were produced without allowance for ceiling penetrations. Under BASIX rules the certificate would need to be relodged prior to construction to include all necessary allowances for downlights.

Glass type to building B was specified as dark tint with a high U value but low SHGC. The glass installed does not appear to have dark tint so a substitution may have been made.

The certification of thermal performance pre-dates the requirement to use QR codes on the certificates and stamped drawings and therefore spot checks of the certificates was not possible.

Residential other

The cross ventilation diagrams show the apartments achieve natural cross ventilation via a breeze way. There is a dedicated Louvre opening above the entrance door to allow air movement from the apartment to the breezeway.

In our view, the natural cross ventilation does not meet the objective of 4B-3 of the ADG due to the reliance on the breezeway and the resulting loss in exposure to the prevailing breeze. The apartments will be more reliant on air conditioning for comfort cooling, which will increase energy demands.

Commercial Energy

An energy efficiency report confirms the energy target is met on the basis of a GFA based target and with car park loads excluded from the assessment.

The report provides specifies only two initiatives required to meet the performance. These are efficient lighting and high efficiency space heating and cooling with a COP of a least 5.0.

The report provides summary results of calculations that include lighting and equipment but the ratios of loads are well outside the normal bounds expected. The base building component is shown at only 17% of the total building energy. Normally it would be in the order of 40-60% for and office.

The method of assessment lacks necessary information on assumptions and the specification of requirements is inadequate. However the areas affected are relatively small which will mitigate the impact.

Commercial Water

The sustainability report confirms the water target is met on the basis of a GFA based target.

The water efficiency requirements described seem abstract from the proposed design. For example, waterless urinals are specified and 5 Star WELS rating Kitchen taps. However, the plans show only a single unisex WC to serve both commercial tenancies and no kitchen facilities. The lack of basic coordination raises concern that the requirements will be delivered and are adequate to meet the target.

Other requirements include 4 star WELS toilets and 5 star WELS rated (other) taps. It likely that the only upgrades from BAU delivery will be the two taps in the WC and the toilet pan.

Summary

Our review finds the benefit of the improved energy efficiency targets is modest and may be lessened further still due to some under specification in the BASIX certification.

The piping of collected rainwater to toilets and washing machines within the apartments will make a significant improvement to water efficiency. Installation of the rainwater collection and dual piping should be able to be verified on site.

DA 594/2014 61 Rickard Road

The residential development comprises 62 units over 10 levels with 72 car parking spaces. There are two commercial office suites and three retail spaces at the lower levels.

Residential Energy

3 star dishwasher, 3 star clothes water and 1.5 star clothes dryer are included for energy efficiency There are no allowance for renewables.

A review of the BASIX certificate energy requirements found that the car park ventilation system was underspecified as an exhaust only system. This is not legal in an underground carpark and if correctly specified with a supply and exhaust system the sustainability bonus target of BASIX 30 (BASIX 20 was current at the time) would not be met without additional initiatives.

An inspection of the building showed that the residential energy commitments within the apartment itself had been successfully delivered.

The car park was inspected and found to have a supply and exhaust mechanical ventilation system. This confirms that the original BASIX submission was misleading and that additional measures would had been required to meet the target if the proposed development had been correctly described.

Residential Water

The water savings were achieved with the specification of 5 star dishwashers and 4 star clothes washer together with a central rainwater harvesting system. An 80kL rainwater tank was required with plumbed service to irrigation and toilet flushing but not washing machines according to the sustainability report supporting the application. However, the BASIX certificate only required the rainwater to serve irrigation. The recovery of sprinkler test water is also required in the BASIX certificate.

A BASIX stamped drawing set was not provided. The rainwater tank was however shown on the DA drawing of basement Level 1.

An inspection of the building showed that the in residential water commitments within the apartment themselves had been successfully delivered, with the exception of secondary piping to provide harvested rainwater to the toilets. This was to be expected given the conflict between the BASIX certification and the sustainability report.

No rainwater harvesting tank could be found in the building. The location shown on the DA plans had no tank present, no access or piping that would indicate a hidden tank. A detention tank was found on the lowest basement level but there was nothing to indicate any reuse was being provided.

There was no evidence of reuse water being piped through the basement, the buildings, or through the gardens. The taps provided in garden beds were served with green pipes and not the violet pipes required to indicate reuse water.

We conclude that the commitment to rainwater harvesting was not delivered. We were also not able to confirm the presence of sprinkler test water recovery.

Fig B1 - Photo of irrigation tap at 61 Rickard Road

Residential Thermal Comfort

No BASIX thermal comfort specification were included. This are required to be marked on a stamped plan set.

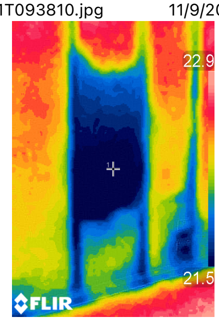
The certification of thermal performance pre-dates the requirement to use QR codes on the certificates and stamped drawings and therefore spot checks of the certificates was not possible.

A class 2 summary report was not provided, which is another significant omission from the BASIX documentation.

Whilst the thermal comfort requirements of BASIX were not able to be verified due to lack of documentation, thermal imaging taken onsite revealed that the installation of thermal insulation was patchy. Whilst the standard of installation would not meet the requirements of BASIX, it is perhaps not atypical given installation is not visible to an inspector or occupier.

The area where thermal insulation has not been properly installed is seen as the large blue area in the left most image of the figure below. This other blue areas in the image show a break in insulation around the electrical outlets and the stud work of the wall. The right most image show the same view and area of wall in a conventional photograph.

20200911T093810.jpg 11/9/20, 9:36 am



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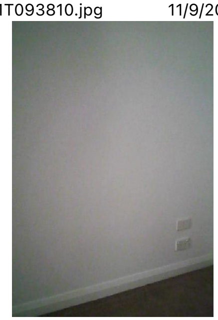

MEASUREMENTS (°C)

Spot	21.5

PARAMETERS

Emissivity	0.90
Refl. temp.	22.0 °C
Distance	3.00 m
Relative humidity	50 %

Fig B2 - Infrared image and photograph showing missing insulation in wall of apartment inspected

Commercial Energy

A sustainability report confirms the energy target is met on the basis of a GFA based target.

The report specifies only thee initiatives required to meet the performance. These are efficient lighting, high efficiency space heating and cooling with a COP of a least 5.0 and gas fired hot water.

Calculations are not provided and no mention is made of car parking.

The method of assessment lacks necessary information on assumptions and the specification of requirements is inadequate.

The air conditioning for the commercial component of the building was inspected on site. Two units were installed in the carpark and assumed to serve the Fitness First tenancy as no other non-apartment areas or the building require cooling. The name plate model numbers were taken and the energy efficiency rating extracted from the federal government MEPS database. Both units were found to be significantly less efficient that the recommendations in the sustainability report that were relied upon when the bonus floor space was awarded.

Model RZQ250L has a rated COP of 3.123, which is nearly 40% lower performance than specified. Model RZQ140L has a COP of 3.58, which is approximately 30% lower than required to be installed under the approved DA.

Fig B3 - Installed air conditioning for commercial tenancy

Commercial Water

The sustainability report also confirms the water target is met on the basis of a GFA based target.

The water efficiency requirements described seem abstract from the proposed design. For example, waterless urinals are specified and 5 Star WELS rating kitchen taps. However, the plans show only a single unisex WC to serve both commercial and retail tenancies and no kitchen facilities. The lack of basic coordination raises concern that the requirements will be delivered and are adequate to meet the target.

Other requirements include 4 star WELS toilets and 5 star WELS rated (other) taps. The only upgrades from BAU delivery will be the two taps in the WC and the toilet pan.

Summary

Our review of the documents supporting the DA found that the benefit of the improved energy efficiency target is modest and may be lessened further still due to under specification of some elements in the BASIX certification.

The piping of collected rainwater to toilets and the sprinkler water re-use would have made a significant improvement to water efficiency. Installation of the systems and dual piping should be able to be verified on site.

Our review of the outcomes delivered in the completed and occupied buildings found that the rainwater reuse and commercial energy efficiency requirements had not been delivered in accordance with the development consent.

We also found that our the original BASIX certificate had misrepresented the proposed building and in doing so had shown a better score than should have been given.

DA 738/2015 5-9 French Avenue

The residential development comprises 81 units over 10 levels with 88 car parking spaces. There is a single small retail space at ground level.

The BASIX reporting was generally acceptable. However stamped drawing DA_23M contradicts all the commitments in the BASIX certificate and misrepresents the basis of certification. It is usually the drawings that are relied upon to confirm requirements so this could greatly undermine actual delivered.

Residential Energy

4 star dishwasher and 2.5 star clothes dryer are included for energy efficiency There are no allowance for renewables.

The certification of thermal performance pre-dates the requirement to use QR codes on the certificates and stamped drawings and therefore spot checks of the certificates was not possible.

Residential Water

The water savings were achieved with the specification of 5 star dishwashers and 5 star clothes washer together with a central rainwater harvesting system. The 15kL rainwater tank was required with plumbed service to irrigation and toilet flushing and washing machines. The recovery of sprinkler test water is also required in the BASIX certificate.

The BASIX stamped drawing set does not show the location of the rain water tank. The stamped drawing set also contradicts the BASIX certificates and states that rainwater collection <u>is not</u> required.

Residential Thermal Comfort

BASIX thermal comfort specifications were included in the BASIX report but a report by a different company is referenced on the BASIX stamped plans to provide the thermal comfort requirements.

Other specifications of the stamped plans conflict with the basis of certification included stating the ceiling penetrations are included and nominating a lower number of apartments to have upgraded glazing performance.

The certification of thermal performance pre-dates the requirement to use QR codes on the certificates and stamped drawings and therefore spot checks of the certificates was not possible.

Summary

The conflicts in the stamped drawings on what is required for BASIX are likely undermine the delivery of improved energy and water efficiency outcomes.

The piping of collected rainwater to toilets and washing machines within the apartments and the sprinkler water re-use will make a significant improvement to water efficiency. Installation of the systems and dual piping should be able to be verified on site.

DA 957/2017 32 Kitchener Avenue

32 Kitchener Avenue is a 14 story mixed use building with 521 residential apartments, basement car parking retail tenancies, health services facility and child care centre.

Residential Energy

The LEP is misinterpreted in the energy and water efficiency report and BASIX 40 is stated to be required against the current minimum requirement for BASIX 25. Further the report claims BASIX 46 is achieved suggesting it is a significantly higher standard that the three development granted consent with the sustainability bonus floor space prior to 2017.

4 star dishwasher, 4 star clothes water, 4 star clothes dryer and 4 star fridge are all specified for energy efficiency. LED or fluorescent lighting is specified in the apartments while LED lighting is used exclusively elsewhere, including the car park and plant rooms. A 90kW PV array is also included to meet the energy targets.

The allocation of space for the PV array is shown on the roof of building 4 in the architectural drawing set although in BASIX its benefit has been assigned to all the buildings.

Residential Water

The water savings were achieved with the specification of 4 star dishwashers and 4 star clothes washer together with a central 19kL/day capacity grey water reuse scheme with plumbed service to irrigation and toilet flushing in all apartments. The recovery of sprinkler test water is also required in the BASIX certificate.

A grey water scheme is an expensive way to achieve the BASIX 60 water target as it requires a dedicated drainage from grey water waste sources in each apartment in addition to the reticulation of the ruse water.

The BASIX stamped drawing set show the location of the grey water reuse system at ground level.

Residential Thermal Comfort

BASIX thermal comfort specifications are included although key details are missing such as the openable area requirements for windows.

The certification of thermal performance uses the form of certificates with QR codes so a spot check of the certificates was undertaken.

The review found a number of errors in the certificates including the use of alternative performance glass to that specified in some apartments and the omission of ceiling penetrations for downlight and exhausts in all apartments. The thermal performance specifications in the stamped plan set indicates that both are included and is therefore misleading.

One apartment was found to have a garage included.

All the apartment modelled toilets and ensuite as unconditioned spaces, which is not permitted in the BASIX Thermal Comfort Protocol.

Some apartment had glazing omitted from key aspects in the modelling used to generate the certificates.

Many apartments had higher wind exposure that would be available on the site, which has the result of improving natural ventilation performance in those apartments.

The errors in the NatHERS certificated used to comply with the BASIX thermal comfort requirements are such that the certificates would fail and audit and would be required to be redone. The impact is expected to be apartments with more reliance on heating and cooling that is allowed by BASIX.

This extent of improper modelling to satisfy the BASIX thermal comfort is not unusual in class 2 apartment buildings.

Commercial Energy

An energy and water efficiency report confirms the energy target is met.

The report provides a comprehensive review of assumptions and applies simple had calculations to demonstrate compliance. This is appropriate given that the main determinate of compliance are the assumptions made for equipment loads, hours of use and diversity of use in the retail spaces.

The hours of use assumption for retail seem low and no information is provided on assumptions for days per week of operation. Hot water generation is also not considered.

The recommended initiatives are limited to air conditioning with COP of 3.0 and lighting power density limits for the retail. The report notes that this will be enacted through lease conditions governing the tenants fit out.

Reference is made to potentially using the power from the PV installation. This is not required to meet the targets and should not be done as the PVs are fully accounted for in BASIX.

Commercial Water

An energy and water efficiency report confirms the water target is.

Assumptions are detailed for a range of potential uses. Some assumption such a 2 min shower time in the Gym are shown to be critical to meeting the target with the specified water efficiency measures. If an extra 30 seconds were allowed for showering that retail use would be shown to not meet the target.

Requirements specified are limited to 5 start WELS tap ware, 5 star WELS toilets and 3 star WELS showers.

Appendix C: Basis of Assessment

Key references to data sources used in the estimation of environmental impacts have been published in the body oft he report. Other data points were not published in the interests of brevity and legibility. The appendix contains the remaining data points, sources and assumption that have underpinned the estimations in study.

Existing impacts

The section describes the approach taken to characterise the two study areas year 2020.

Site Coverage

Site coverage was broken down into primary horizontal surface characteristics /use type based on the urban heat and green cover datasets (NSW Government). Roof coverage was estimated using satellite imagery.

	Bankstown	Campsie
Roads	11.7%	12.7%
Railway	1.5%	0.5%
Pavements	9.8%	11.1%
Parks	6.9%	5.5%
Private Open Space	45.3%	45.2%
Roof	24.8%	25.0%

Transport

Greenhouse gas emissions for different modes of transport per km travelled were as follows:

	Emission Factor (kg CO2-e/km travelled)
Bicycle	0.000
Bus	0.105
Car (driver)	0.177
Car (passenger)	0.177
Walking	0.000
Ferry	0.004
Motorbike/scooter	0.116
Train	0.041
Tram	0.035
Truck	0.200

Traffic volumes commuter counts were:

	Bankstown (n)	Campsie (n)
Outbound Commuters	8,247	4,850
Inbound Workers	9,000	4,162

Renewable Energy

PV analysis in 2.5 was based on panel with 20% efficiency modelled using the System Advisor Model (SAM) software.

The weather data used in the PV modelling was assembled using different years for each month, that best represented the patterns of solar radiation over the last 18 years of available weather data for Sydney (Mascot weather station). The method applied was a modified version of the process developed by Flux to determine representative weather years for passive performance assessment[17].

Air conditioning

The refrigerant greenhouse gas warming potential (GWP) estimates were based on the publications from the Department of the Environment and Energy Cold Hard Facts 2019 utilised were:

	GWP ($kgCO_2/kg_{refrigerant}$)
Houses	1,844
Apartments	1,834
Non-residential	1,876

The refrigerant charge used for residential dwellings were:

	Refrigerant load (kg refrigerant/dwelling)
Houses	5.0
Apart-	2.8

For non-residential air conditioning systems an aggregated value of 0.21 $kW/kg_{refrigerant}$ charge was applied to the following heating / cooling loads:

	Bankstown and Campsie heating / cooling loads (W/m²)
Office	120
Education	70
Other	30
Retail	120
Retail (H)	200
Fitness	140
Vacant	120

A refrigerant leakage rate of 8% was considered as many installations have equipment which is expected to be well into their useful life.

Water

The non-residential estimates of water usage for non residential buildings calculated on a GFA basis using best available data were:

	Bankstown (kL/m²)	Campsie (kL/m²)
Offices	0.83	0.64
Education	0.40	0.40
Other	0.64	0.64
Retail	1.70	1.70
Retail (H)	1.24	1.24
Fitness	0.10	0.10
Vacant	0.25	0.25
Parks	0.25	0.25

Offices in Bankstown had increase water usage to account for cooling towers.

Rainfall

Recorded data for the weather station Bankstown Airport AWS (66137), from Jan 1968 to 2019 was used to determine a typical year of rainfall.

Typical years of rainfall were selected based on the year with the lowest error to the 75th, 85th and 95th percentile when compared to the full dataset. The following years were assessed as being representative of seasonal rainfall:

	Representative Year	Rainfall (mm/season)
Summer	2004	230
Autumn	1994	211
Winter	1988	425
Spring	2007	185

Anthropogenic heat

Estimated efficiencies of air-conditioner used were as follows:

	Compressor efficiency
Residential	2.0
Non-residential	3.0

The proportion of heat rejection assumed to be air cooled was 100% expected in the case of office and retail (H) which were taken to be 50% water cooled by installed capacity.

Private car use all vehicles were considered to be internal combustion engines with a 11 L/100km fuel usage and 3.8 MJ/km off heat transferred to the environment.

Greenhouse gas

The gas and electricity greenhouse gas conversion factors were sourced from the National Greenhouse Accounts Factors (Australian Government, Department of the Environment and Energy, August 2019).

	($kgCO_2$/kWh)	Scope
Electricity	0.900	Full fuel cycle.
Gas	0.235	

Building energy usage

The energy usage for dwellings was determined from the Australian Energy Market Operator (AEMO) for electricity and gas usage, climate zone 5, dwellings with no swimming pools and gas heating.

Electricity and gas usages were interpolated for each dwelling type using the average occupant density in each study area as found in section 2.2 of the body of the report. The estimates where cross checked with the Ausgrid published average electricity consumption for the LGA for 2018/2019.

	Bankstown		Campsie	
	Electricity (kwh/dwelling)	Gas (MJ/dwelling)	Electricity (kwh/dwelling)	Gas (MJ/dwelling)
Houses	6,541	21,697	6,200	20,873
Apartments	4,479	15,574	4,318	15,574

For non-residential building usages, the determination of energy, was undertaken on a GFA basis using best available data.

For retail usage unpublished data supplied by the Tokyo municipal government was used to weight and group the varying impacts by retail tenancy type.

The following table contains the values, applied to both sites:

	Electricity (kwh/m^2)	Gas (kwh/m^2)
Office	164	287
Education	52	203
Other	39	76
Retail	185	58
Retail (H)	191	1,198
Fitness	206	229
Vacant	5	5

Future impacts

The section describes the underlaying assumptions underpinning the future 2036 assessment.

Site Coverage

Redevelopment will result in and increase in roof areas while decreasing the private open spaces. The area mix for parks, roads, railways and pavements will not change from the existing study areas.

	Bankstown	Campsie
Roads	11.7%	12.7%
Railway	1.5%	0.5%
Pavements	9.8%	11.1%
Parks	6.9%	5.5%
Private Open Space	41.3%	43.7%
Roof Areas	28.9%	26.5%

BASIX occupancy

3.1 occupants per dwelling was used as occupant density in de dwellings for the future scenario. It corresponded to the maximum value published by the ABS for postcodes 2200 and 2194.

Transport

10% of electric vehicles were assumed on the road in 2036 with an emissions factor of 0.073 kgCO2/km.

Traffic volumes were:

	Bankstown (n)	Campsie (n)
Outbound Commuters	32,322	12,691
Inbound Workers	25,000	7,500

Renewable energy

PV efficiency was increased from 20 to 22.1% which is a conservative assumption for future technological improvements and applied to all building types in the sites.

Air conditioning

For residential the same refrigerant charge per dwelling as the existing study areas was applied.

Non-residential usages were assumed to the same refrigerant charge as the existing site.

The following presents an estimate of the installed air conditioning capacity on each study area for the existing, refurbished and new developments:

	Bankstown and Campsie heating / cooling loads (W/m²)
Office	96
Education	96
Other	96
Retail	96
Retail (H)	160
Fitness	112
Vacant	96

A refrigerant leakage rate of 8% for the existing buildings and 6% was applied to new developments and redevelopment.

Water

For new and refurbished residential developments minimum BASIX requirements (BASIX 40) were applied with adjustment to BASIX occupancy found in section 1.2.2.

	Water Usage (kL/dwelling.year)	Water Target
Separate Homes	168	BASIX 40
Apartments	168	BASIX 40

Specific water use for non-residential building usages in 2036 were assumed to decrease from the existing site due to increase efficiency gains in appliances and fixtures. Exceptions were considered for offices where an increase in people having showers is expected.

For parks a rise in evapotranspiration will increase the water usage.

The following table contains the values, applied to both study areas:

	Water Usage (kL/m².year)
Officies	0%
Education	-7%
Other	-20%
Retail	-20%
Retail (H)	-20%
Fitness	-20%
Vacant	-20%
Parks	10%

Rainfall

Consideration for future rainfall changes based on the City of Sydney Climate Change values were applied to the existing rainfall levels.

The resulting aggregate rainfall for each season was:

	Rainfall (mm/season)
Summer	231
Autumn	230
Winter	432
Spring	181

Anthropogenic heat

The air conditioning compressor efficiency considered for the future impacts were:

	Compressor efficiency
Residential	3.0
Non-residential	4.0

The proportion of air cooled heat rejection assumed for each site was, with remaining proportion being allocated to water cooled type heat rejection:

Building Usage	Bankstown			Campsie		
	Existing (%)	Refur-bished (%)	New (%)	Existing (%)	Refur-bished (%)	New (%)
Houses	100%	100%	100%	100%	100%	100%
Apartments	100%	100%	100%	100%	100%	100%
Office	50%	25%	25%	100%	50%	50%
Education	100%	25%	25%	100%	25%	25%
Other	100%	100%	100%	100%	100%	100%
Retail	100%	100%	100%	100%	100%	100%
Retail (H)	50%	10%	10%	100%	50%	50%
Fitness	100%	100%	100%	100%	100%	100%
Vacant	100%	100%	100%	100%	100%	100%

For the anthropogenic heat contribution of private car use, combustion engines were assumed to have an average fuel consumption of 11 L/100km and 3.8 MJ/km of heat transferred to the environment. Electric vehicles were considered to have a 0.15 kWh/km energy usage and 0.54 MJ/km off heat transferred to the environment.

Greenhouse Gas Factors

The same conversion factor for gas as the existing site was utilised while for electricity a 2036 conversion factor was calculated which is further detailed in section 3.3 Decarbonisation off the grid.

	($kgCO_2$/kWh)	Scope
Electricity	0.485	Full fuel cycle.
Gas	0.235	

Building energy usage

For new and refurbished residential developments minimum BASIX requirements were applied to both study areas with adjustment to BASIX occupancy found in section 1.2.2 and proportion of gas as found in section 2.4.2 of the body of the report, resulting in:

	Electricity (kwh/dwelling.year)	Gas (MJ/dwelling.year)	Emissions Target
Separate Homes	4,636	14,254	BASIX 50
Apartments	6,954	21,381	BASIX 25

The same electrical / gas split was used in future study areas as in the existing ones.

Non-residential future energy usages will correspond to the existing site values reduced by a percentage achievable through technical improvements in electrical and gas usages.

Offices were considered to have performance to equivalent to a 5.5 star NABERS Energy rating.

The following table contains the percentages reductions in energy usage considered for non-residential buildings compared to the 2020 performance:

	% Electrical Improvement (kWh/m^2 basis)	% Gas Improvement (kWh/m^2 basis)
Office	37%	10%
Other	30%	10%
Retail	30%	10%
Retail (H)	30%	10%
Fitness	30%	10%
Vacant	0%	0%

A significant proportion of new education floor space in Bankstown is anticipated to be more contemporary and flexible space supporting university functions it is expected that its energy use will be more in line with an office building, leading to an expected increase in energy use of 88% for electricity. A 10% improvement in gas is still considered.

For educational buildings in Campsie a 15% increase in electricity usage was considered to accomodate for more use of air-conditioning systems in schools. A 10% improvement in gas was considered.

Climate Change

The effects of climate change as described in section 3.4 of the main body of the report were associated to, study area specific, urban heat island (Section 3.5) and anthropogenic heat island affects.

The values considered on a study area basis for urban heat island and anthropogenic heat were:

Bankstown:

	Urban heat Island (°C)	Anthropogenic Heat (°C)
Summer	1.20	0.10
Winter	0.40	0.10
Autumn	0.80	0.10
Spring	0.80	0.10

Campsie:

	Urban heat Island rise (°C)	Anthropogenic Heat (°C)
Summer	0.80	0.10
Winter	0.27	0.10
Autumn	0.53	0.10
Spring	0.53	0.10

Strategies and Principals

The section describes the approach taken to characterise the Strategies and principles applied to the future study areas for the year 2036.

Improved natural ventilation of apartments

With the use of natural ventilation cooling loads in apartments can decrease as much as 70%. Considering that around 10.8% of the substation load in Campsie, which his dominated by residential buildings, is due to cooling the use of natural ventilation will result in a 7.5% decrease in residential electricity usage for each of the study areas.

Organic Waste to Energy

For dwellings the SSROC Kerbside Waste Audit City of Canterbury Bankstown Report 2019 was used as a source for organics percentages in waste specifically the loose food component.

The percentage of organics for non residential buildings was sourced in aggregate from the Trade Waste Audit November 2015 report prepared for Bankstown City Council by EC Sustainable. The proportion of organics was distributed among non-residential building use types as follows to achieve the same 44% aggregate organic waste proportion found in the trade waste audit. The final proportion of organic waste generation by building type is shown below:

	% of Organics
Residential	39%
Office	23%
Education	26%
Other	32%
Retail	26%
Retail (H)	63%
Fitness	26%
Vacant	0%
Parks	26%

The organic waste available for processing into energy was reduced to allow for reasonable levels of recoverability. A 60% recovery rate was applied.

The following table contains the key variables used to estimate the energy able to be produced from the organic waste:

	Unit	Value
Source Total Dissolved Solids	%	27%
Target Total Dissolved Solids	%	5%
Waste to water volume ratio	%	20%
Biogas availability in waste	m3/ton waste	112.5
Methane ratio	%	60%
Methane enthalpy	kJ/kg	55.5
Generator efficiency	%	35%
Hydraulic Retention Time	days	30.0

The volume of a centralised biodigestor and respective plant area for each study area was estimated to be as follows:

	Biodigestor Volume (m3)	Plant Room Required (m2)
Bankstown	10,370	950
Campsie	3,790	490

Plant room area estimates to accomodate stand alone composting on a individual / small group of buildings basis for all new retail and apartment usage were:

	Number of plant rooms (n)	Average Area (m2)	Total Plant Room Area Required (m2)
Bankstown	209	7.70	1,609
Campsie	163	5.00	815

Composter capacity (to process organic matter) and physical dimensions used in stand alone composting comparison were:

Composter capacity (kg/day)	physical dimensions (Width x Depth x Height) [m]
200	2.30 x 1.20 x 1.60
20	1.10 x 0.5 x 0.95

Natural refrigerants

The GWP for natural refrigerants is presented in the following table:

	GWP ($kgCO_2/kg_{refrigerant}$)
Houses	5
Apartments	5
Non-residential	5

A 50% reduction in refrigerant volume due to the use of natural refrigerants was considered.

Compressor efficiencies were also increased by 25% to account for the decrease in refrigerant volume.

Water resilience

For water resilience 95% of the rainfall on each site was harvested with the following efficiencies:

	Rainwater collection Efficiency (%)
Existing Buildings	80%
New Buildings	95%

Appendix D: Decarbonisation of the Grid

As of 2020 there remains considerable uncertainty with respect to the long term Green House Gas (GHG) coefficients of the NSW electricity grid when projecting beyond the mid 2030s.

Known GHG targets include a 28% reduction by 2030 from 2005 emissions (144.9 Mt for a 201.3Mt base in 2005) and a 70% reduction by 2050 from 2017 emissions (57.2Mt from 190.5Mt base in 2017). Both these targets have been applied by the NEM in their 2018 Integrated System Plan (ISP). It is noted that given the current Climate Emergency a 100% reduction may be required by 2050 however this is not allowed for in the NEM model at this time.

Known coal power station retirements in NSW (Aurora Energy Research, AEMO) are:

- Liddell in 2022 (2,000MW)
- Vales Pt in 2028 (1,320MW)
- Eraring in 2034 (2,880MW)
- Bayswater in 2035 (2,640MW)

The last remaining coal power station in NSW beyond 2035 is Mt Piper with 1400MW of capacity. Mt Piper is projected to operate into the 2040s (APH Hansard).

Whilst the ABS is projecting NSW to grow by 10 million people by 2042 (~30% > 2017) the NEM is projecting a slight (3.5%) reduction in overall demand over the same period due to rooftop solar and efficiency gains.

Based on these assumptions the following table has been developed:

Year	NEM GHG (Mt)	NEM National Forecast Demand (GWh)	Resulting National GHG Coefficient (tCO2/MWh)	NEM NSW Demand (GWh)	Resulting NSW GHG Coefficient (tCO2/MWh)
2005	201.3				
2017	190.5	184,839	1.031	67,717.2	0.82
2030	144.9	178,171	0.813	64,421.2	0.647
2040	101.0	189,313	0.534	68,411.5	0.425
2050	57.2	191,259	0.299	72,401.8	0.238

* 2040 NEM interpolated on linear trajectory for 2030 and 3050 data points.

An additional alternative analysis by Flux has also been conducted to factor in known generator retirements in NSW. This analysis has assumed half of the lost coal generation capacity is replaced with renewables with the remainder made up with new lower carbon fuel resources (gas, liquid fuels etc).

This analysis yields a 2050 GHG Coefficient for NSW of 0.235 and a Renewable Power Percentage (RPP) of 45.5%. This RPP is below the generally accepted ability of Snowy Hydro 2.0 and Battery of the Nation projects to support a 50% RPP and assumes no new coal generation is constructed.

This projection is also reasonably aligned with the NEM policy based analysis which yields a slightly higher GHG Coefficient 0.262 for NSW and is therefore considered a reasonable forecast for NSW.

If all retired coal generation is replaced with renewable generation, the NSW 2050 GHG Coefficient would be 0.135 however the resultant RPP of 79.7% would require a significant additional storage project to be completed prior to 2034 (when Eraring is retired). Given lead times for planning and construction such a project would need to be committed to in the next 3 – 5 years, or, a major disruptor that could be installed with short lead times in a distributed fashion (eg li-ion batteries becoming cheap enough). No such project is on the horizon at the time of this analysis so this outcome would be currently reliant on new disruptive technology.