SIGMAH

SOCIAL + GREEN BENEFITS CALCULATOR

SOCIAL INFRASTRUCTURE AND GREEN MEASURES FOR AFFORDABLE HOUSING

Technical Guide (v.1.1) February 2025

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SIGMAH

SIGMAH: Technical Guide

1.0 Introduction

SIGMAH is the result of a series of research projects commissioned by the Community Housing Industry Association (CHIA). SIGMAH was produced at the Centre for Urban Transitions, Swinburne University of Technology.

The document is a technical compendium to SIGMAH User Guide (v1) that sets out additional detail on how the benefit values utilised in the calculator are derived. Two factors determine the calculation of benefits.

1. The monetary value of an event. In the calculator events include access to secure and affordable accommodation, access to urban greenery, reduced stress levels, lower rents or escaping domestic violence. There is a substantial body of research establishing monetary values associated with people experiencing events such as these. This literature is detailed in Nygaard 2019.

2. The number of individuals who experience the events (impact ratio or incidence). In the calculator the number of individuals experiencing an event are determined by tenant characteristics either on a choice or probabilistic basis.

This Technical Guide provides information and details on both these aspects. In some cases, proprietary $-values (values used under license) are employed by the calculator. *These are not reproduced here* – details can be found in Nygaard (2019).

Sections 2 and 3 are primarily set out as tables, providing summary detail on impact ratios and $-values. Section 4 and 5 provide more in-depth discussion and detail on housing rental cost and energy efficiency estimates.

2.0 Calculation of housing development benefits

There is considerable literature and empirical evidence relating to public sector cost off-sets associated with housing people experiencing homelessness. An overview of this literature is available in Nygaard (2019) and Oberklaid and Alves (2022). Monetary values for public sector expenditure off-sets are sourced from ASVB. In each case these lie between the extremes of values found in empirical studies.

As noted in the User Guide, a distinction is made between Choice-based and Probability-based parameters. To avoid double counting, individuals are not attributed a benefit against both of these categories. For instance, housing a person experiencing homelessness results in significant health-expenditure savings. Similarly, the calculator estimates a probabilistic public-sector reduction in health expenditure. To avoid double counting, individuals are only counted in one of the categories.

- Number of adults: The Green+Social Interface makes a distinction between 1 and 2 parent allocations. Number of adults is the sum of number of properties classified as 1 parent plus the sum of number of properties classified as 2 parents times two.
- Number of children: This is a function of number of rooms. First room is allocated to the adult, all other rooms to children on the basis of 1 child per room. A two-bedroom apartment would thus have 1 or 2 parents, plus 1 child.

2.1 CHOICE-BASED PARAMETER

Table 1: Choice based

Variable	Description of monetary outcome calculation	Source	Beneficiary
Homelessness: to social housing, net/no program	Applied annually to housing of people experiencing homelessness when the 'Wrap-around homelessness service indicator' is set to 'No'. Without Wrap-around an attrition rate of 50 per cent is assumed. Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Monetary value from Wood et al 2016	Public
Homelessness: long-term (12mnts+), rough sleep to social housing	Applied annually to housing of people experiencing primary homelessness and 'Wrap-around homelessness services is set to 'Yes'. With Wrap-around an attrition rate of 20 per cent is assumed. Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public
Homelessness: Other homelessness (including temporary) to social housing	Applied annually to housing of people experiencing secondary and tertiary homelessness and 'Wrap-around homelessness services is set to 'Yes'. With Wrap-around an attrition rate of 20 per cent is assumed. Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public
Homelessness (with disability): long-term (12mnts+), rough sleep to social housing	Applied annually to housing of people experiencing primary homelessness and 'Wrap-around homelessness services is set to 'Yes'. With Wrap-around an attrition rate of 20 per cent is assumed. Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public
Homelessness (with disability): Other homelessness (including temporary) to social housing	Applied annually to housing of people experiencing secondary and tertiary homelessness and 'Wrap-around homelessness services is set to 'Yes'. With Wrap-around an attrition rate of 20 per cent is assumed. Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public

Table 2: Choice based benefits – other homelessness

Variable	Description of monetary outcome calculation	Source	Beneficiary
Homelessness: Presenting with Domestic Violence (one off: disability adjusted life years)	Applied once, upon entry into social/affordable housing and measures disability adjusted life years (DALYs) and monetised based on the value of statistical life year.	Equity Economics (2021): $13,554	Public
Homelessness: Presenting with Domestic Violence (annual: health)	Applied annually for individuals entering social/affordable housing and is a measure of reduced health costs. Production costs and consumption costs from Equity Economics (2021) not included in GPSC calculations.	Equity Economics (2021): $530	Public
Allocations to individuals exiting prisons	Applied annually to housing of individuals existing the prison system. Research finds that public sector cost off-sets initial are negative (increased service use) but turning positive over a 5-year period. This time profile is captured in the calculation of benefits and adjusted for the turnover rate (general 'Turnover rate' specified in the Housing Development Details interface).	Martin et al (2021): from -$3,360 to $3,962 over 5 years.	Public

Note: all $-values in 2022 dollars.

Table 3: Propensity to consume adjusted affordability benefits

Variable	Description of monetary outcome calculation	Source	Beneficiary
Rental reduction	Applied annually to each dwelling. Social and affordable rental housing provides access to housing at below market prices. The differential in rental prices constitutes a transfer of benefit from one group of users (landlords) to another group (tenants). The calculator uses a propensity to consume adjusted estimation of what the societal benefit (additional consumption) is resulting from this transfer. The benefit estimation is based on the assumption (supported by Australian research) that lower income group spend more of each additional dollar than higher income groups. The approach is described in Nygaard (2019). The rental reduction is a function of market rental values compared to affordable rental values (affordable housing) or social rental values on approximate benefits-based income for one and two parent households, with and without children. The impact ratio is 1.0 for affordable rental, and 0.3 for social rental. The affordable rental impact ratio is based on assumed entry from private rental sector. The social rental impact ratio is based on AIHW data (Last reported tenure, new clients) where over the period 2011-2022 an average of 30% of new clients previously lived in accommodation where they paid market rents. Additional rental information is provided in Section 3 of this Technical Appendix.	Each dollar in rental reduction results in a $0.16 increase in net spending in the economy (Nygaard 2019). AIHW (2022)	Private

2.2 PROBABILISTIC PARAMETERS

Table 4: Probabilistic benefits

Variable	Description of monetary outcome calculation	Source	Beneficiary
Make ends meet	Applied annually for individuals experiencing financial hardship/foregoing essential spending due to payment of private sector rents. Calculation of impact factor is described in Nygaard (2019). Impact factor 0.25, per dwelling.	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public
Complete Year 12	Applied annually to estimates number of Year 12 students. Proportion of Year 12 students in social and affordable housing based on age distribution in SHAF (AIHW 2020) and national age distribution. Approximately 5%. Number of children based on specified housing development (rooms). Impact ratio is more uncertain (see Nygaard 2019). Nygaard and Kollmann (2020) apply 0.05, per Year 12 student. Monetary value based on average of male and female students.	Applied Economics (2002): $3,430	Private
Personal spend other depression	Applied annually to estimates of people experiencing adverse effects on health and mental health related to housing affordability and tenure instability. Literature is reviewed in Nygaard (2019). Represents cost offsets for private households. Impact factor 0.06, per eligible adult. Eligible adults based on review of population experiencing rental housing affordability by income thresholds. 50% of renters in lowest income quintile, 30% of renters in second lowest income quintile.	Hawthorne (2003): $5,225	Private
Public spend other depression	Applied annually to estimates of people experiencing adverse effects on health and mental health related to housing affordability and tenure instability. Literature is reviewed in Nygaard (2019). Represents cost offsets for public sector. Impact factor 0.06, per eligible adult. Eligible adults based on review of population experiencing rental housing affordability by income thresholds. 50% of renters in lowest income quintile, 30% of renters in second lowest income quintile.	Hawthorne (2003): $1,371	Public
Overcrowding relief	Applied annually to estimates of people exiting over-crowding in the private sector. The indicator is discussed in Nygaard (2019). Represents cost offsets for public sector. Impact ration 0.1, per single person and single person with children (excluding DSP, old age pension holders).	Secondary benefit calculation from ASVB. Please contact info@asvb.com.au.	Public

2.3 WELLBEING VALUES – CHOICE AND PROBABILISTIC PARAMETERS

The Australian Social Value Bank (https://asvb.com.au/) has provided estimates of Wellbeing Values (primary benefit) and public expenditure benefits (secondary benefits) for a range of project scenarios developed for this report.[1] Wellbeing Values are used in the UK and a number of other OECD countries for measuring the social impact of projects.

According to the ASVB, the Wellbeing Values methodology 'analyses existing datasets of national surveys which […] reveal the effect of an outcome (for example, being employed) on wellbeing in a robust way. We can then value this by finding from the data the equivalent amount of money needed to increase someone's wellbeing' (Fuijiwara 2017:12). The primary benefit calculated by the ASVB includes estimates of the Wellbeing Value as well as any additional income effect generated through, for instance, employment or education. The secondary benefits provided by the ASVB calculates 'outcomes [that] impact on government resources, such as a reduction in government expenditure or an increase in tax receipts' (Fuijiwara 2017:13).

The ASVB adjusts for such outcomes that might have taken place also in the absence of any program delivery, referred to as *deadweight*. For instance, many children (most) will pass Year 12 whether or not their parents gain access to social or affordable housing. When reporting the Wellbeing Values (primary benefits) the estimates provided *always* includes the ASVB's deadweight measure. *In practice, this means that estimates provided are conservative and, in some cases, will underestimate the benefits that can be achieved through service design*. The deadweight measures thus adjust for such incidence that might have happened with or without the project delivery.

[1] All Wellbeing Values are based on calculations provided by the Australian Social Value Bank, and subsequently adjusted. Data inputs were provided by the Australian Social Value Bank, they are owned by Alliance Social Enterprises (www.asvb.com.au) and produced by Simetrica-Jacobs. These values are used under Licence # M8Ved5 with expiry date 4/10/24.

Table 5: Wellbeing values

Variable	Description of monetary outcome calculation	Source	Beneficiary
Homelessness to social housing	Applied in first year (once only) of housing people experiencing primary homelessness. With Wrap-around an attrition rate of 20% is assumed (impact factor 0.8). Without Wrap-around an attrition rate of 50% is assumed (impact factor 0.5). Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Temporary to social housing	Applied in first year (once only) of housing people experiencing secondary or tertiary homelessness. With Wrap-around an attrition rate of 20% is assumed (impact factor 0.8). Without Wrap-around an attrition rate of 50% is assumed (impact factor 0.5). Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Disability homelessness to social housing	Applied in first year (once only) of housing people experiencing primary homelessness. With Wrap-around an attrition rate of 20% is assumed (impact factor 0.8). Without Wrap-around an attrition rate of 50% is assumed (impact factor 0.5). Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Disability temporary to social housing	Applied in first year (once only) of housing people experiencing secondary or tertiary homelessness. With Wrap-around an attrition rate of 20% is assumed (impact factor 0.8). Without Wrap-around an attrition rate of 50% is assumed (impact factor 0.5). Calculations assume that tenants exiting are replaced by tenants with similar characteristics.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
In good condition for tenants with disability	Applied in first year (once only) for each dwelling designed for individuals with disability. Impact factor 1.0. The calculation of Wellbeing Values control for deadweight (outcomes taking place irrespective of intervention).	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private

Make ends meet	Applied in first year (once only) for individuals experiencing financial hardship/foregoing essential spending due to payment of private sector rents. Calculation of impact factor is described in Nygaard (2019). Impact factor 0.25, per dwelling.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Complete year 12	Applied in first year (once only) to estimate number of Year 12 students. Proportion of Year 12 students in social and affordable housing based on age distribution in SHAF (AIHW 2020) and national age distribution is approximately 5%. Number of children based on specified housing development (rooms). Impact ratio is more uncertain (see Nygaard 2019). Nygaard and Kollmann (2020) apply 0.05, per Year 12 student. Monetary value based on average of male and female students.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Personal spent other depression	Applied in first year (once only) for people experiencing adverse effects on health and mental health related to housing affordability and tenure instability. Literature is reviewed in Nygaard (2019). Represents cost offsets for private households. Impact factor 0.06, per eligible adult. Eligible adults based on review of population experiencing rental housing affordability by income thresholds. 50% of renters in lowest income quintile, 30% of renters in second lowest income quintile.	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private
Overcrowding relief	Applied in first year (once only) for people exiting over-crowding in the private sector. The indicator is discussed in Nygaard (2019). Represents cost offsets for public sector. Impact ration 0.1, per single person and single person with children (excluding DSP, old age pension holders).	Secondary benefit calculation from ASVB. Values used under license. Please contact info@asvb.com.au.	Private

3. Calculation of environmental and local amenities benefits

Benefits associated with environmental and/or local amenities benefits are not specific to the affordability status of residents. The calculator can, for these indicators, also be used for general housing and or public space design.

Variable	Description of monetary outcome calculation	Source	Beneficiary
WTP Large park (houses)	Applied annually when specific design features are added to housing developments. Here houses near parks (400m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to large parks. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private
WTP Access to public transport (houses)	Applied annually when specific design features are added to housing developments. Here houses near public transport (800m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to public transport. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private
WTP Balcony/private garden (flats)	Applied annually when specific design features are added to housing developments. Here if apartment is provided with balcony or private garden. The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private

	rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to balcony/private garden. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.		
WTP Medium parks (flats)	Applied annually when specific design features are added to housing developments. Here apartments near parks (200m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to medium parks. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private
WTP Large park (flats)	Applied annually when specific design features are added to housing developments. Here apartments near parks (400m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to large parks. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private
WTP Access to active transport (flats)	Applied annually when specific design features are added to housing developments. Here apartments near active transport (400m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private

	generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to active transport options. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.		
WTP Access to public transport (flats)	Applied annually when specific design features are added to housing developments. Here apartments near public transport (800m). The WTP values are only operational when 'Using own rental information' and 'Is rental data based on market valuation' are set to 'No'. The calculator is populated with lower quartile rents for each capital cities and rest of state. Rents reflect available amenities. High amenity locations typically have higher rents. In the calculator rental reductions generate propensity to consumed based benefits – these are higher in high amenity locations. Including the WTP measures in all cases would therefore potentially lead to double counting of benefits. The WTP measures were generated through primary research by UK-based Simetrica-Jacobs for the calculator. The WTP estimate is a measure of how much a tenant would pay additionally (value placed) on access to public transport options. This value is not propensity to consume adjusted as no actual transfer of resource is taking place.	Lagarde et al (2022), available at Capital City, Other Urban Centres, Rest of State levels.	Private
CO_2 sequestration	Applied annually to all <u>additional</u> tree/canopy coverage in a housing development. When using the calculator both the pre-development green space and new green space needs to be added. The inclusion of both enables calculation of the additional benefit. Sequestration rates vary with the age of tree/canopy growth. The calculator distinguishes between canopy aged 1-5, 6-10, 10-20 and 20+ years. GHG Sequestration=m2 of tree planting* C^{kgs} per m2*44/12*1/1000*CoC Where m2 of tree planting is additional tree/canopy planting, C^{kgs} per m2 is the carbon sequestered per m2 per year, 44/12 is the atomic weight of carbon dioxide divided by the atomic weight of carbon and CoC is the cost of carbon. In the calculator the recommended cost of carbon is based on the EU ETS.	NSW DPE (2022)	Public
Health benefit from cooling (canopy v no veg)	Health benefits from cooling (main benefit: mortality reduction): = number of people within impacted catchment (specified in calculator) x number of days above 30 degrees per year (specified in calculator) x reduction in temperature degrees (1.13°C for every additional 10 per cent of catchment covered	NSW DPE (2022)	Public

	by tree canopy) (calculated by calculator) x health benefit from 1°C in temperature per person per year ($3.05).		
Health benefit from cooling (green space v no veg)	Health benefits from cooling (main benefit: mortality reduction): = number of people within impacted catchment (specified in calculator) x number of days above 30 degrees per year (specified in calculator) x reduction in temperature in degrees (0.5°C for every additional 10 per cent of catchment covered by tree canopy) (calculated by calculator) x health benefit from 1°C reduction in temperature per person per year ($3.05).	NSW DPE (2022)	Public
Reduced cooling cost (canopy v no veg)	Reduced cooling costs = number of households in the catchment (specified in the calculator) x reduction in temperature in degrees (1.13°C for every additional 10 per cent of catchment covered by tree canopy) (calculated by calculator) x energy benefit per 1°C reduction in temperature per household ($14.18).	NSW DPE (2022)	Private
Reduced cooling cost green space v no veg)	Reduced cooling costs = number of households in the catchment (specified in the calculator) x reduction in temperature in degrees (0.5°C for every additional 10 per cent of catchment covered by tree canopy) (calculated by calculator) x energy benefit per 1°C reduction in temperature per household ($14.18).	NSW DPE (2022)	Private
Reduced GHG from cooling (canopy v no veg)	Reduced GHG emissions = number of households in catchment (specified in calculator) x reduction in temperature in degrees (1.13°C for every additional 10 per cent of catchment covered by tree canopy) (calculated by calculator) x GHG benefit per 1°C reduction in temperature per household (0.035 tons) x carbon price (EU ETS).	Calculated from NSW DPE (2022)	Public
Reduced GHG from cooling (green space v no veg)	Reduced GHG emissions = number of households in catchment (specified in calculator) x reduction in temperature in degrees (0.5°C for every additional 10 per cent of catchment covered by tree canopy) (calculated by calculator) x GHG benefit per 1°C reduction in temperature per household (0.035 tons) x carbon price (EU ETS).	Calculated from NSW DPE (2022)	Public

Air quality from tree canopy	Air quality improvement = reduction grams (0.25) of PM2.5 per m2 of tree canopy x population adjusted damage cost per ton of PM2.5 x increase in canopy/tree coverage (m2)	NSW DPE (2022)	Public
Air quality from extensive green roofs	Air quality improvement = reduction tons (0.00043267) of PM2.5 per hectare of extensive green roof x population adjusted damage cost per ton of PM2.5 x extensive green roof (hectare) The CIRIABEST (CIRIA's Benefits Estimation Tool) provides estimates of PM10 reduction associated with extensive green roofs. These were converted into PM2.5 using the NSW DPE association between PM10 and PM2.5 values. SIGMAH converts m2 entries to hectare.	CIRIA (2019) NSW DPE (2022)	Public
Reduced GHG emissions from improved building standards (NatHERS)	GHG emissions reduction = annual reduction in tons $CO_{2\text{-}e}$ per m2 specified NatHERS and energy rating relative to average rental sector NatHERS (3 star) and energy rating (cooling systems have 3 star energy rating, electrical heating systems have a 3.5 star energy rating, gas heating has an efficiency of 73 per cent and wood systems have a efficiency of 76 per cent.) x Size of dwelling (m2)	CSIRO (2023 a,b)	Public
Reduced GHG costs from improved building standards (NatHERS)	GHG cost reduction = annual reduction in tons $CO_{2\text{-}e}$ x carbon price (EU ETS). In the calculator the recommended cost of carbon is based on the EU ETS.	NSW DPE (2022)	Public

4. Housing Rental Cost Estimates

To provide the baseline estimates of the benefits, our calculator relies on either user-supplied estimates of market rents or the estimates we have derived for each Significant Urban Area (SUAs).[2] Estimates are required across a range of typologies for both detached/semi-detached/townhouses (detached) as well as apartment style flats (flats) across the typical range of bedrooms. For detached housing, these can range from 1-bedroom up to 5-bedroom. Flats can range between studios to 4-bedrooms.

Given the lack of widely, publicly available data on the distribution of rents across each of the SUAs that is broken down by the number of bedrooms, we have based our estimates using simple splits between capital city rents and regional city rents for each of the eight main state and territories in Australia. The base data on rental prices was based on the March Quarter 2022 issue of REIA's Real Estate Market Facts. This issue has the benefit of providing estimates of the bottom quartile rents for both housing and units across each state and territory in Australia. Furthermore, it generally breaks the capital city into several areas and provides rental coverage for several regional cities.

We assumed that tenants of social and affordable housing, if renting in the private market, would be more likely to locate within an outer suburban region. **Table A** provides a list of our reference groups for each capital and regional city market. For the regional cities, we selected the largest regional city that was provided within the Real Estate Market Facts with housing characteristics that differed from those of the capital city. For example, Geelong in Victoria had rental rates that largely resembled those of outer Melbourne. Therefore, we selected Ballarat as an alternate large regional city that may better reflect non-metropolitan rental conditions. While it is theoretically possible to categorise each of the SUAs into a more nuanced real estate market available, in practice, the time available to operationalise such a task was beyond what was available. Therefore, it will be up to the user to verify the relevance of our estimated rents for their selected SUA.

[2] The Australian Bureau of Statistics (ABS) defines a SUA as an "Urban Centre, or groups of Urban Centres, that contain population of 10,000 persons or more."

Table A: References for Rental Price Data in Real Estate Market Facts

State or Territory	Location	Market Facts Reference
ACT	Capital City	West and North Canberra
ACT	Regional City	Outer South Canberra
NSW	Capital City	Outer Sydney
NSW	Regional City	Wollongong
NT	Capital City	Northern Suburbs Darwin
NT	Regional City	Alice Springs
Qld	Capital City	Outer Brisbane
Qld	Regional City	Townsville
SA	Capital City	Outer Adelaide
SA	Regional City	Mt. Gambier
Tas	Capital City	Outer Hobart
Tas	Regional City	Launceston
Vic	Capital City	Outer Melbourne
Vic	Regional City	Ballarat
WA	Capital City	Outer Perth
WA	Regional City	Albany

While REIA (2022) provides a range of bedrooms for both house and units within each market, they do not provide the full breadth of options required for our calculator. Therefore, it was necessary to use the data as a basis for our estimates and then extrapolate using an alternate source. Thus for each reference we use the 2-bedroom house and flat price for each market segment defined in **Table A**. We then scale the 2-bedroom price in each market by a ratio that was derived from 2021 residential rental bond lodgements in NSW.

To estimate the rental ratios relative to two-bedrooms, we classified all rental bond lodgements within NSW as either outside Sydney or within the Greater Sydney area where the latter excludes all postcodes within five kilometres of the centroid of the 2000 postcode. The inner-city rental bond data was excluded due to the presence of a large number of "premium" rental units that were not likely to be relevant to the potential tenants who would require affordable or social housing.

With the remaining bond data, we then found the bottom quartile rental rates for each combination of bedroom (studio to five-bedroom), housing type (flat or house) and location (Outside Sydney and Greater Sydney). With each ratio calculated, we then applied that ratio across the other markets in Australia as detailed in **Table A**. For example, the five-bedroom to two-bedroom ratio for Greater Sydney homes are used to estimate the rental price for five-bedroom homes in the Melbourne outer suburbs that are based on the two-bedroom rents that were found within REIA (2022) multiplied by that ratio. Spot checks of the ratios derived from REIA suggest that the ratios are generally consistent but given that ratios may vary across specific sub-markets or across time, users should conduct a sanity check of any of the pre-populated data.

5. Energy Efficiency Estimates

The calculator also derives the benefits in improving the thermal loads for cooling and heating through the compilation of several complex data sources. The baseline data is the thermal cooling and heating load estimates by climate zone provided by Tony Isaacs (2019).[3] The report provides the latest estimates of thermal loads for cooling and heating using the Nationwide House Energy Rating Scheme (NatHERS), a comprehensive nationwide accreditation system used by state and territory governments for regulatory purposes.

NatHERS provides the estimates for cooling and heating requirements for 69 climate zones across Australia. The ratings are reported as the kJ required to comfortably cool and heat a property over the course of a year. These estimates vary depending on the given NatHERS rating of the dwelling which can range between 0 and 10. Tony Isaacs (2019) provides the latest estimates for total load estimates between 0 and 10 at 1-point increments as well cooling and heating loads separately for the 5, 6 and 7 ratings. As our calculations require cooling and heating separately due to the differences in energy sources, we extrapolate the heating and cooling separately by averaging out the share of cooling thermal load based on the detailed data and applying the load mixtures for the total thermal loads for the entire range of NatHERS ratings. In addition, we interpolate the values to get estimates of thermal loads for 0.5-point increments.

While the NatHERS rating for new affordable and social housing is a choice parameter that is entered into the model by the user, we needed to estimate the energy efficiency of a typical dwelling for tenants. This is driven by the fact that we want to capture only the benefits driven by the relative improvements in energy efficiency. While no nationwide comprehensive study has been conducted on the energy efficiency of housing stock relevant to potential tenants, we set the baseline NatHERS rating to 3 which is based on an estimate for the median existing unit dwellings surveyed by the CSIRO for the NatHERS platform. This survey was conducted on housing stock based largely on housing stock for Victoria and Tasmania (CSIRO 2023b). Nonetheless, the limited data on other states and territories suggest that the NatHERS ratings are similar.

While the NatHERS will provide estimates of thermal load corresponding to the climate zone of the project, modelling the energy efficiency of the appliances cooling and heating the space are critical. As with the NatHERS rating, the chosen energy efficiency of heating and cooling appliances is a choice parameter within the worksheet. We utilise the Energy Star rating system in our modelling, which is a 10-point system that maps the stars to a seasonal energy efficiency ratio (SEER).[4] Higher SEERs equate to higher efficiency and ultimately less energy required to provide the thermal requirements to heat and cool dwellings.

As a baseline for a comparison, we assume that electrical cooling systems have a 3-star energy rating and electrical heating systems have a 3.5-star energy rating which is based on a CSIRO survey of existing air conditioning appliances (CSIRO 2023a). A desktop review of gas heating systems suggested that they have a general efficiency of 73 per cent (i.e. 0.73 BTU of heat into a system requires 1.0 BTU of input energy). Likewise, a similar desktop review suggested wood and wood pellet systems had a general efficiency of 76 per cent.

The final component is to determine the typical energy cost per kWh for heating and cooling within a state.[5] We began by collecting data on the type of fuel used by households which was found within Table F of the Australian Energy Statistics (Department of Industry, Science, Energy and Resources, 2022). The table provides a detailed breakdown of energy usage by type of energy source across ANZSIC Industries and residential use for each state

[3] Thermal Loads are the amount of heat energy required to add or remove from a space in order to maintain the desired room temperature.
[4] The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electric energy input during the same period.
[5] Energy use at finer geographical area is not available thus we assume the costs are homogenous across a state or territory.

and territory. For our purposes, we calculate the energy used for residential and aggregated into three broader categories: wood, gas and electricity.[6]

When calculating the baseline energy costs for households, we assume thermal load requirements for heating will be sourced in a manner reflective of the observed distribution of energy sources for the given state and territory. Heating sources can generally include furnaces powered by wood, wood pellets, gas, or electricity. However, we assume the thermal requirements for cooling will use only electricity.

We then combine the energy distribution with the cost of fuel. Energy prices for electricity and gas were derived from energy comparison websites such as Canstar and comparethemarket.[7] The cost for wood per kWh was based on the retail price of wood pellets in Melbourne on the basis that the energy content of wood pellets is 4 kWh per kg. However, we assume that all cooling and heating for new dwellings will be sourced exclusively with electricity.

For the purposes of the calculator, we assume that the monetary benefits that accrue to household's savings increases at the rate of the CPI. While recent historical data suggests that energy prices from both electricity and gas have been rising faster than inflation, due to the complex nature of supply and demand for each type of flows, it is beyond the scope of the report to model how the benefits may vary over time in a more nuanced fashion.

When modelling the benefits, the previous exercise allows us not only to derive an estimate of the financial savings that are provided to the tenants, but also a reduction in Carbon Dioxide Equivalent (CO_2-e) emissions.

To estimate the CO_2-e emissions, we use estimates of the emission factors from the 2021 Greenhouse Accounts Factors (DISER, 2021). They estimate the emissions in kg of CO_2-e per Gigajoule, so we use a standard conversion of 1 Gigajoule per 277.778 kWh to standardise the emission factors with our thermal load estimates. For wood sources, we use the estimates of 1.2 kg of CO_2-e per Gigajoule for Dry Wood in Table 1. For gas sources, we use the estimated 51.53 kg of CO_2-e per Gigajoule based on the estimate for Natural gas distributed in a pipeline found in Table 2. For electricity sources, we use estimates from Tables 1-3 from DISER 2021 combined with the sources of electricity by state found in Table O9 of Table O9 of the Australian Energy Statistics (DISER, 2022). We estimate that emissions range on the low end at 0.0846 kg of CO_2-e per kWh in Tasmania, driven through its use of renewable biofuels. On the top end, we estimate that electricity in New South Wales and the ACT emits 0.2574 kg of CO_2-e per kWh due to its relatively high reliance on coal.

[6] Solar energy is aggregated into electricity for the purposes of this project.
[7] Reference prices for electricity and gas by state and territory were accessed on 18 October 2022. A review of those prices in April 2023 suggest that prices have remained stable over the period.

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