LANDCOM TRIPLE BOTTOM LINE 2008/2009

ENERGY EFFICIENT DESIGN (INDICATOR 8) AND RENEWABLE/ SUSTAINABLE ENERGY SUPPLY (INDICATOR 10)

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FINAL REPORT

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1 Purpose

The purpose of this report is to provide information as part of Landcom's Triple Bottom Line reporting for the year 2008/2009. Jay Rutovitz (formerly of Mark Ellis and Associates, MEA) was asked to assess Landcom's performance in residential buildings in relation to Indicator 8, Energy Efficient Design, and Indicator 10, Renewable and Sustainable Energy Supply.

2 Background

Landcom has developed 34 indicators for Triple Bottom Line reporting, to monitor progress towards sustainability in their operations. The indicators relevant to energy and greenhouse performance are:

Indicator 8, Energy Efficient Design: is an indicator of the greenhouse gas savings associated with Landcom residential projects. The proportion of dwellings achieving a NatHERS rating of 4.5 stars or higher is reported. 'Energy efficient design' has been taken to include the fabric of the house, heating and cooling equipment, and cooking equipment.

Indicator 10: Renewable and Sustainable Energy Supply: the proportion of dwellings which have gas boosted solar or heat pump hot water heaters, and any other renewable energy generation technologies installed.

Estimation of the resulting greenhouse savings
Greenhouse savings from heating and cooling, water heating, and cooking, are expressed as a percentage of all the emissions likely from the 'base case' house, including appliances. The base case is taken as a 3.5 star house, with gas storage water heating (for more details see Section 4.1)

To undertake this assessment, data collected from seven Landcom developments was analysed to estimate the greenhouse gas savings associated with 227 dwellings completed during 2008/09. This included:

- MacArthur Gdns - 26 dwellings
- Newbury - 91 dwellings
- Park Central - 20 dwellings
- Redgum - 12 dwellings
- Rouse Hill - 7 dwellings
- Park Bridge - 56 dwellings
- Waterford - 15 dwellings

The methodology used was developed by MEA in the *Energy Smart Urban Solutions* project in 2002/3, and is used in the TBL reporting from 2002/03 onwards. This methodology was refined in the 2003/04 TBL report, and the 2002/03 results recalculated using the modified methodology. In 2007/08 adjustments were introduced for dwellings that install zoning for airconditioning, or ceiling fans

Two methodology modifications have been made for the 2008/09 report. Firstly, the energy reduction for solar water has been refined to reflect additional information, as the number of renewable energy certificates generated by the particular system is specified in the dwelling's BASIX certificate. Secondly, the emission factors for gas and electricity have been updated in line with the 2009 Commonwealth emission factors workbook.[1] As this has a noticeable effect on the calculated emissions, saving from previous years have been recalculated using the new factors in order to compare this years performance with previous years.

3 Results

Overall Landcom completed 227 dwellings during 2008/09. These included twenty one dwellings reaching 4★ (9%), sixty at 4.5★(26%), and one hundred and forty six at 5★ or above (64%). There were ninety two dwellings with solar water systems, or 41% of the total.

Total annual greenhouse emissions from the dwellings completed during 2008/09 are estimated as 1,037 tonnes of CO_2[a]. Estimated savings are 219 tonnes CO_2 per year compared to base case dwellings, a reduction of 17%.

There is a significant potential for error in these estimates. Sensitivity analysis indicates a realistic estimate of greenhouse emissions is 1,037 tonnes ± 15%, and an estimate of greenhouse savings is 219 tonnes ±19%. Overall CO_2 emissions are reduced by 17%. There is very little variation in the percentage savings (± 0.6%). The results for the individual developments are listed in Table 2.

Table 1. 2008/09 – star rating and solar water heating percentages

	Climate zone	Number of dwellings	3.5 ★	4 ★	4.5 ★	5 ★	With solar water heating	
							gas	electric
MacArthur Gdns	28	26	-	4	10	12	9	
Newbury	28	91	-	7	24	60		-
Park Central	28	20	-	2	-	18	13	
Redgum	28	12	-	1	1	10		-
Rouse Hill	28	7	-	-	1	6	7	
Park Bridge	28	56	-	7	24	25	56	
Waterford	28	15	-	-	-	15		7
TOTAL	**28**	**227**	**-**	**21**	**60**	**146**	**85**	**7**

Table 3 shows the results for Indicators 8 and 10 for the six years 2002/03 to 2008/09.

Percentage savings increased from 6.6% in 2002/03 to 19.6% in 2007/08, and have dropped to 17.4% in 2008/09. Other major results are:

- 90% of houses attain 4.5★or better NatHERS energy rating, up from 74% last year.
- The percentage of houses with gas solar water heating has dropped slightly, from 47% in 2007/8 to 37% in 2008/09 (41% with solar water heating).

The star ratings for a just under a quarter of dwellings include a small dwelling concession. Without this concession, 79% rather than 90% of dwellings would be 4.5★ or 5 ★.

No new photovoltaic systems were installed during 1008/09.

[a] CO_2 is used instead of CO_2-e (CO_2 equivalent) throughout the report. It represents the equivalent of all greenhouse gases emitted in terms of tonnes of carbon dioxide.

Table 2. 2008/09 – annual CO_2 emissions and savings

	HOT WATER [a]			HEATING, COOLING & COOKING		
	Emissions (tonnes)	Savings (tonnes)	Savings %	Emissions (tonnes)	Savings (tonnes)	Savings %
MacArthur Gdns	18	11	8%	28	12	9%
Newbury	88	19	4%	100	38	8%
Park Central	13	10	9%	16	20	17%
Redgum	10	4	7%	11	3	4%
Rouse Hill	2	6	16%	6	5	13%
Park Bridge	11	56	18%	69	24	7%
Waterford	23	-4	-5%	12	14	15%
All projects	**164**	**104**	**8.2%**	**242**	**115**	**9.2%**

	TOTAL CO_2		
	Emissions (tonnes)	**Savings (tonnes)**	**Savings %**
MacArthur Gdns	115	23	17%
Newbury	440	57	12%
Park Central	83	30	27%
Redgum	54	7	11%
Rouse Hill	27	11	29%
Park Bridge	239	80	25%
Waterford	79	10	11%
All projects	**1,037**	**219**	**17.4%**

Table 3. Comparison of annual results for Indicators 8 and 10, 2002 - 2009

	Number of dwellings	Annual CO_2 emissions (tonnes)	Annual CO_2 savings (tonnes)	Percentage reduction	Percentage 4.5★or 5★	Percentage with solar water heating	Other renewable energy
2002/3	190	712	50	**7%**	**22%**	**0%**	**none**
2003/4	226	1,181	122	**9.3%**	**35%**	**44%**	**none**
2004/5	251	1,269	218	**14.7%**	**47%**	**36%**	**None**
2005/6	167	834	133	**13.7%**	**58%**	**32%**	**None**
2006/7	161	793	141	**15.0%**	**75%**	**18%**	**11 kW PV**
2007/8	477	1,870	437	**18.9%**	**74%**	**47%**	**31.2 kW PV**
2008/9	227	1,037	219	**17.4%**	**91%**	**41%**	**none**

Note: previous years results have been revised to take account of new fuel emissions factors

Table 4 shows the average BASIX scores recorded for each project. Overall the average is 43. However, after the BASIX certificates were obtained for Park Bridge it was decided to install gas boosted solar water heating which qualifies for 42 RECs. If this were included,

[a] 'Hot water' savings includes the effects of solar water heating, low flow shower heads, and the installation of efficient gas water heaters. Solar water heating accounts for approximately 60% of the hot water savings, and efficient shower heads 38% of the total savings from hot water.

the average score for this project would be at least 51, which would take the average for all projects to 46.

Table 4. 2008/09 – comparison of BASIX score and CO2 heating percentages

	Number of dwellings	Average score	% CO2 savings from TBL report
MacArthur Gdns	26	45	16.9%
Newbury	91	43	11.5%
Park Central	20	47	26.5%
Redgum	12	42	11.2%
Rouse Hill	7	55	29.3%
Park Bridge	56	41 (51) *	25.1%
Waterford	15	40	10.9%
TOTAL	**227**	**43 (46)**	**17.4%**

** The score recorded on the certificates gives an average of 41, but solar water heating was subsequently installed. If this is included the average score would be 51.*

4 Methodology

The methodology adopted for calculation of greenhouse savings is shown schematically in Figure 1. It is the same as used in previous years, apart from the noted modifications. It is described in detail in the Triple Bottom Line report for 2003/4. All modelling was undertaken using an Excel spreadsheet.

Sensitivity analysis on single variables was performed in order to identify key factors. These were then used to derive a 'best case' and a 'worst case' for emissions. It should be noted that the greatest savings usually coincide with the higher CO_2 emission scenarios, so that the 'best case' for emissions has lower absolute savings. The best and worst case for emissions were tabulated in order to calculate variability in data.

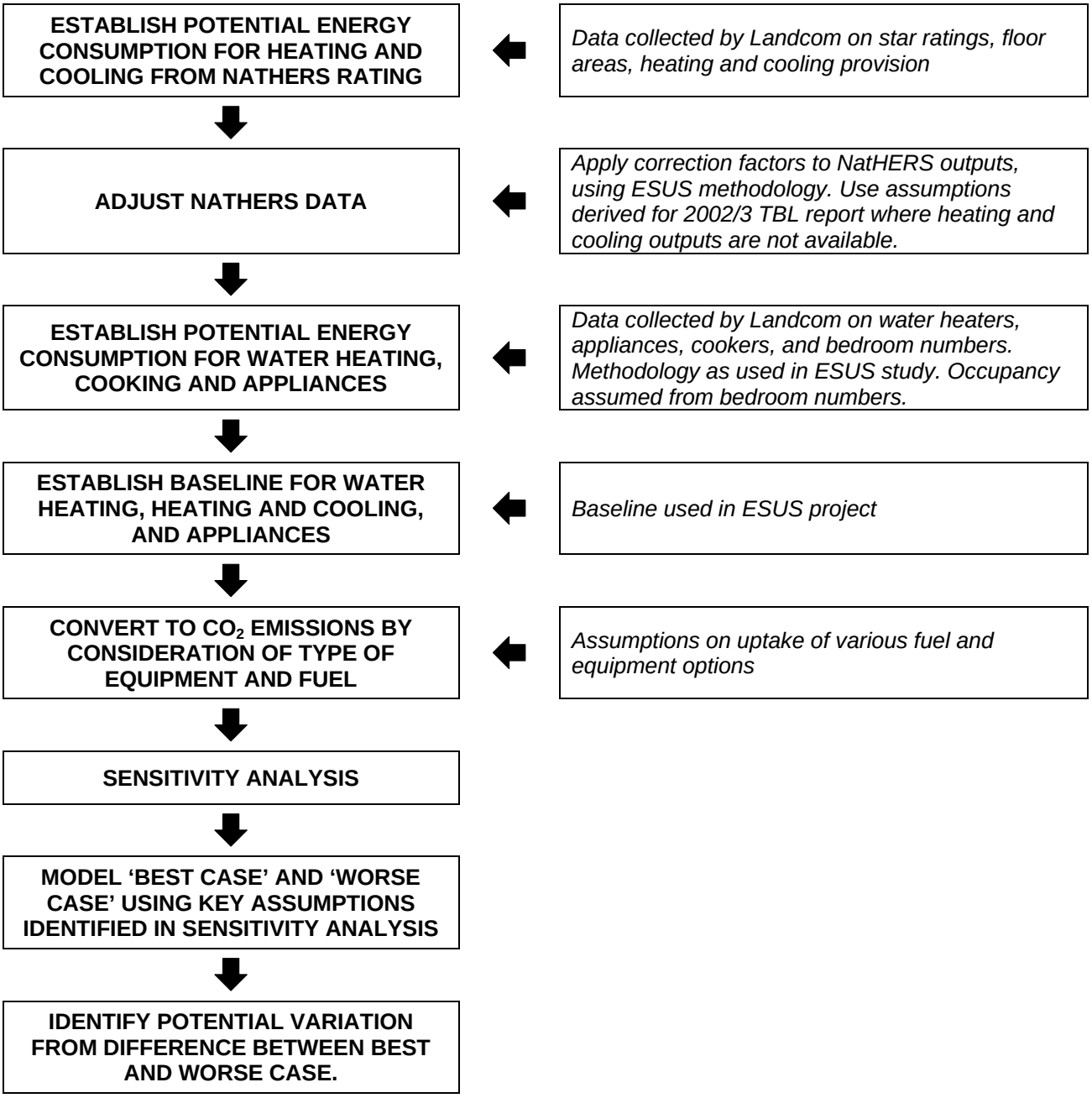
The correction factors and assumptions needed in order to model energy use and CO_2 emissions from the competed dwellings may be summarised as:

- Assumptions on base case for comparison,
- NatHERS correction factors (to adjust simulated output to realistic energy use),
- Assumptions on take up and efficiencies of different equipment and fuel choices,
- Assumption on the fraction of water heating energy supplied by solar panels,
- Assumption on the percentage reduction in hot water from using AAA shower heads
- Assumptions on occupancy,
- Assumptions on the relationship of appliance and water heating energy use to occupancy.
- Assumptions on the alteration to cooling correction factors if ceiling fans are fitted.
- Assumptions on the alteration to heating factors if air-conditioning is zoned.
- Assumptions to derive heating and cooling loads if these are not supplied (note this only applied to six dwellings 2008/09).

The last three items were added in 2007/8, and the same modifications have been used this year. Details are available in the 2007/8 triple bottom line report.[2]

Key assumptions and variables are given in Appendix 1, and correction factors for NatHERS are given in Appendix 2 and discussed further in the Triple Bottom Line report for 2003/4.

Figure 1: Methodology for calculating greenhouse savings from completed dwellings



4.1 Methodology modifications for 2008/09

Water heating

The fraction of water heating provided by solar water systems varies considerably. As BASIX certification requires the REC eligibility to be specified, this has been added to the calculations for the fraction of energy provided by the solar water heater. The default value is 60%. Where the REC eligibility of the system is known, this is incorporated into the calculation as follows:

$$\text{Final energy}_{\text{water heating}} = \text{energy without solar} - [\text{number of RECs} \times 100]$$

The maxiumum allowable contribution is 80% of calculated energy use. If the specific REC eligibility is provided by Landcom, that is used in the calculations; otherwise the lower limit of the range specified on the BASIX certificate is used.

Emission factors

The Department of Climate Change published a new workbook of emission factors in June 2009. The new factors are used, and results from previous years have been recalculated taking these into account. The factors are for the full fuel cycle. Table 5 shows the new and the previous factors.

Table 5. Emission factors – 2008/09 and previous

	Gas kg CO2-e / kWh	NSW electricity kg CO2-e / kWh	
Previous factor	0.23	0.902	Department of Climate Change. 2009. National greenhouse accounts (NGA) factors
Revised factor	0.24	1.07	Australian Greenhouse Office. 1999. Australian Residential Buildings Greenhouse Gas Emissions 1990-2010

4.2 Base case

The base case is described in detail in the Energy Smart Urban Solutions report.[3] The building fabric has been taken as 3.5✯, at the mid point of the band.

It is assumed that half of dwellings will install air-conditioning. This is assumed to be 1 star reverse cycle in houses, and cooling alone in apartments.

Electric heating in houses is assumed to be reverse cycle air-conditioning when fitted, otherwise resistive electric room heaters. Electric heating in all apartments is assumed to be resistive electric room heaters.

Gas points are assumed to be installed in the base case if gas is available on site. Assumptions regarding how many dwellings go on to fit gas heaters, and the proportion of heating energy supplied by the gas fires, are given in Appendix 1. Water heating in the base case is assumed to be 3 star gas storage heating. Note that this is considerably better than the NSW average case. A standard shower head is assumed for the base case. Gas hobs and electric ovens are assumed for the base case.

4.3 Data collection

The following information was collected from individual projects:

- Project name, address, and postcode,
- Dwelling type,
- Number of bedrooms,
- Conditioned floor area,
- NatHERS energy rating, including energy requirements for heating and cooling,
- Type of heating and cooling plant provided, specifically, whether and what type of air-conditioning was provided, whether ducting for air-conditioning was installed, whether gas points and gas heaters were installed, and whether ceiling fans were provided.
- Occupancy times (option to use ‘standard’ times, or explain reasons for altered times),
- Type of water heating,
- Type of cooking,
- Type of shower head,
- Types of appliances (where appliances are fitted).

BASIX certificates were suppled for all projects, and the certificates included heating and cooling loads for all but 6 properties at MacArthur Gardnes.

4.4 Individual project variations

MacArthur Gardens: six detached houses had used the 'deemed to comply' method for obtaining BASIX certificates. Thirteen other detached houses used the simulation method, and therefore had heating and cooling loads. Using the methodology developed in 2007/8, three different calculation methods are used.

- *The reported case*: the midway point between 3.5✯ and the averages value for the development is used for houses without specified thermal loads. 85% of dwellings at MacArthure are 4.5✯ or above, and total emissions are 115 tonnes CO_2.
- *The worst case:* all houses without thermal loads are assumed to be 3.5✯. Only 69% of houses are 4.5✯ or above, and total emissions are 116 tonnes..
- *The best case:* all houses without thermal loads are taken as the average for that house type in that development. 92% of dwellings at MacArthur are 4.5✯ or above, and total emissions are 114 tonnes.

The average BASIX score for the 13 dwellings and the 6 deemed to comply was identical, namely 46, so the best case may be the most likely. However, in order to be consistent with the 2007/08 methodology, the mid-point of the average thermal load for the same house type and 3.5✯ is used.

5 Sensitivity analysis

Sensitivity analysis was carried out on most variables. Occupancy rates and efficiency factors for heating and cooling appliances were varied by ± 10%, and most other factors by ± 20%. The resulting variation in CO_2 savings and total CO_2 emissions is shown for each factor in the Table 6, arranged with the most significant factors at the top.

The most critical variables are the correction applied to the heating energy to allow for the fact that residents do not keep their homes exactly at the simulated temperatures, and the reduction in hot water from AAA showers. The percentage of heating which is supplied by gas fires when no air-conditioning is fitted, the percentage of people who get gas heaters installed if they don't have airconditioning, the occupancy of 3 bedroom houses, and the heating efficiency assumed for base case air conditioning, are the next most significant.

In general, any increase in savings corresponds with an increase in total CO_2 emissions, as the relative difference between 3.5 star and higher rated properties also increases. There are several exceptions:

- Increasing the solar fraction increases savings and decreases total emissions,
- Increasing the reduction in hot water for AAA showers increases saving and decreases total emissions,
- Increasing the percentage assumed to retrofit air-conditioning increases savings and reduces emissions,

Following the sensitivity analysis for each factor, a best and worst case for CO_2 emissions was calculated using all the factors which resulted in greater than 1% variations in savings. The variables used in this analysis and the relevant values are shown in Table 7.

The results corresponding to these 'best' and 'worst' cases for annual CO_2 emissions are shown in Tables 8 and 9.

The variation in total CO_2 emissions is ± 15%. The variation in the percentage emission reduction (savings) is much smaller, and changes only from 18% in the worst emissions case, to 16.8% in the best emissions case. The best and worst case for emissions from heating, cooling and cooking, and from water heating, are given separately in Appendix 3.

The percentage reduction in CO_2 emissions is relatively insensitve to most variables. In this instance the percentage savings are almost the same in each case, although actual emissions are nearly 14% lower in the best case than in the reported case. This is because variables tend to increase or decrease emissions in the base case and the project being assessed in roughly equal proportions.

Table 6. Sensitivity analysis for single variables

VARIABLE	Variation	CHANGE IN CO_2 SAVINGS		CHANGE IN TOTAL CO_2 EMISSIONS	
		Decrease variable	Increase variable	Decrease variable	Increase variable
Heating correction	± 20%	-9.1%	9.1%	-3.2%	3.2%
Adjustment for AAA shower	± 5%	-3.8%	5.6%	0.8%	-1.2%
% heating fuel gas (no AC)	± 20%	3.1%	-4.9%	0.8%	-1.3%
% get gas heaters installed (gas points no aircon)	± 20%	3.1%	-4.9%	0.8%	-1.3%
Occupancy of 3 Bedroom dwellings	± 10%	-2.0%	2.7%	-3.1%	4.2%
Assumed heating efficiency for base case AC	± 10%	2.0%	-2.3%	0.5%	-0.6%
Assumed cooling efficiency for base case AC	± 10%	1.6%	-2.0%	0.5%	-0.6%
Cooling correction	± 20%	-1.5%	1.5%	0.0%	0.0%
Occupancy of 4 bedroom dwellings	± 10%	-1.4%	1.8%	-3.1%	4.1%
Adjust heating & cooling correction for zoning	± 100%	-1.3%	2.7%	0.3%	-0.6%
Solar contribution (with gas boost)	± 20%	-0.6%	1.0%	0.1%	-0.2%
Assumption for missing NatHers data	n/a	-0.5%	0.4%	0.1%	-0.1%
% without AC that will get it	± 20%	-0.3%	0.3%	0.1%	-0.4%
% heating fuel gas (for dwellings with AC)	± 20%	-0.4%	-1.1%	-0.1%	-0.4%
% of dwellings that get gas heaters installed (which have gas points and AC)	± 20%	0.2%	-0.2%	0.1%	-0.1%
% of energy used for cooling	± 30%	-0.1%	0.1%	0.07%	-0.1%
Adjust cooling correction for ceiling fans	± 100%	0.0%	0.0%	0.0%	0.0%

Note 1 : where heating and cooling data was not available, the point midway between 3.5 stars and the average heating and cooling value for similar dwellings in each project was used. The best case was obtained by using the average heating and cooling values for nearby dwellings, and the worst case by using the value for 3.5 stars.

Table 7. Variables used to calculate best and worst case for CO_2 savings

	WORST CASE	Estimate	BEST CASE
Heating correction	1.2	1	0.8
Adjustment for AAA shower	84%	80%	76%
% heating fuel gas (no AC)	48%	60%	72%
% get gas heaters installed (gas points no AC)	56%	70%	84%
Occupancy of 3 Bedroom dwellings	3.3	3	2.7
Assumed heating efficiency for base case AC	2.1	2.3	2.5
Assumed cooling efficiency for base case AC	1.8	2	2.2
Cooling correction	0.8	1	1.2
Occupancy of 4 bedroom dwellings	3.6	3.3	3
Adjust heating & cooling correction for zoning	0	-15%	-30%

Table 8. Annual CO_2 emissions from 'best case' and 'worst case'

	TOTAL CO_2 EMISSIONS (tonnes)			% variation from calculated value	
Project	**Worst case**	**Reported**	**Best case**	**Worst case**	**Best case**
MacArthur Gdns	131	115	101	14%	-12%
Newbury	506	440	380	15%	-14%
Park Central	93	83	74	12%	-11%
Redgum	62	54	47	14%	-13%
Rouse Hill	31	27	24	13%	-12%
Park Bridge	276	239	205	16%	-14%
Waterford	92	79	66	17%	-16%
All projects	**1,190**	**1,037**	**897**	**15%**	**-14%**

Table 9. Annual CO_2 savings from 'best case' and 'worst case' for emissions

	CO_2 SAVINGS (tonnes)		
Project	**Worst case**	**Reported**	**Best case**
MacArthur Gdns	28	23	19
Newbury	69	57	47
Park Central	38	30	23
Redgum	8	7	6
Rouse Hill	14	11	9
Park Bridge	94	80	68
Waterford	10	10	9
All projects	260	219	181

APPENDIX 1 Variables used in modelling for the TBL report

Variable	Value used
Tonnes CO_2 per kWh gas	0.00023472 [4]
Tonnes CO_2 per kWh electricity	0.000902 [5]
Heating and water efficiency	
Gas heating - coefficient of utilisation	0.9
Electric heating - coefficient of utilisation (COU)	1
AAA rated shower heads – reduction in hot water usage	20%
Solar contribution to hot water	60%
Heat pump contribution to hot water	60%
Adjust heating & cooling correction for zoning	-15%
Adjust cooling correction for ceiling fans	-20%

	Base case - 1✯	2✯	3✯	4✯	5✯
COU reverse cycle heating	2.3	2.6	2.9	3.2	3.5
EER reverse cycle cooling	2	2.3	2.6	2.9	3.2

Uptake of appliances and fuels	
% of dwellings with air-conditioning and gas points that install gas heaters	50% [6]
% of dwellings without air-conditioning & with gas points that install gas heaters	70% [7]
% of heating supplied by gas for houses with gas heaters and no air conditioning	60% [b]
% of heating supplied by gas for houses with gas heaters and air conditioning	30% [c]
% of dwellings without air-conditioning that will install it	50%

***Appliance energy use* (kWh/yr)**	***Constant***	***Per person energy use***
Energy use cooktop	-	21
Oven	-	17
Fridge/Freezer	500	150
Microwave	20	25
Lighting	50	150
Washing Machine	5	25
Clothes Dryer	20	60
Other Appliances	20	230
Water Heating Energy Use		
Electric instantaneous	382	107
Electric storage	425	1190
Gas instantaneous - 3 Star	500	1400
Gas instantaneous – 3.5 Star	482.5	1351
Gas instantaneous – 4 Star	465	1302
Gas instantaneous - 4.5 Star	448	1253
Gas instantaneous – 5 Star	430	1204
Gas instantaneous - 6 Star	395	1106
Gas Storage – 1 Star	575	1610
Gas storage – 2 Star	552.5	1547
Gas storage – 3 Star (base case)	500	1400
Gas storage - 3.5 Star	483	1351
Gas storage – 4 Star	465	1302
Gas storage – 4.5 Star	447.5	1253
Gas storage – 5 Star	430	1204
Gas storage - 6 Star	395	1106
Heat pump (electric)	425	1190
Solar + electric boost	500	1400
Solar + gas boost	500	1400

APPENDIX 2 Correction factors for NatHERS data

Unconstrained energy requirements from star ratings

Table 10 gives the energy bands for the NatHERS star ratings in the two applicable climate zones. The table gives the *maximum* star rating; in the modelling the midpoint value has been used. For 5✯ dwellings there is no lower limit, so energy has been taken as:

5✯energy value used = Maximum 5✯ energy - ½ 4.5 ✯band width

For Sydney East, this is equal to 102.5 MJ/m^2, For Sydney West, 123.5 MJ/m^2.

Table 10. NatHERS star ratings - predicted energy loads (maximum Mj/m^2) [8,9]

Stars		**<0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
Climate Zone	**Zone no**										
Sydney East	**17**	550	470	400	330	265	210	170	145	125	110
Western Sydney	**28**	560	485	418	350	296	242	211	180	158	135

Corrections for occupancy, winter cooling/summer heating, and set points

Energy requirements from NatHERS do not correspond to data for measured energy consumption. The discrepancy arises primarily because the 'unconstrained' rating tool calculates energy requirements to heat and cool dwellings to prescribed set points 24 hours per day, 365 days per year. This is unrealistic because people are out for considerable periods, frequently do not heat or cool the whole of their houses, and may not have sufficient heating and cooling appliances to reach the specified set points.

One study estimated that the ratio of constrained energy use (to reflect realistic times of occupancy) to unconstrained energy use was 32% overall, and 19% in NSW [10]. Correction factors are therefore needed to adjust the NatHERS output.

No methodology has been established to reliably correlate simulated household energy use for heating and cooling with likely actual use. The approach adopted here is derived from the *Energy Smart Urban Solutions* (ESUS) project undertaken for Landcom. In that study a number of dwelling types were modelled for climate zones 28 and 17, with set points and occupancy modified as detailed in Table 11.

In addition aggregated winter cooling loads (May to September) and summer heating loads (November to March) were disregarded, on the basis that occupants are unlikely to bring dwellings to set points for the few hours that they may deviate.

Finally, a correction factor of 0.7 was applied to the simulation predictions for heating, to account for the discrepancy between the modified NatHERS predicted hours of use and data of appliance use from Australian Bureau of Statistics (ABS 8218.0). For a more detailed discussion of this methodology see the ESUS report[3].

If day/night zoning is installed for air-conditioning, a further correction of -15% is applied to the heating load.

Table 11. Modifications to NatHERS settings - description and explanation

Description	Existing Setting	Adjusted Setting
External Blind drawing temperatures to control overheating – changed to better reflect drawing in summer before overheating occurs	24°C	20°C
Thermostat Settings for each climate zone – when heating or cooling is assumed for internal spaces	Western Sydney Heating: 21°C Cooling: 26°C Eastern Sydney Heating: 21°C Cooling: 26°C	Western Sydney Heating: 20°C Cooling: 26°C Eastern Sydney Heating: 20°C Cooling: 26°C
Summer Venting. When the internal temperature drops below this setting the windows are assumed to be shut and the ventilation thus reduced.	24°C	20°C
Hours of Heating and Cooling – i.e. when the occupants are assumed to be home and wanting to maintain the thermostat settings. It is not possible to describe more than one daily regime in NatHERS	All Zones: 7.00am to 12midnight every day of the year	Living Zone: 7.00am to 10am then 3pm to 11pm every day of the year Bedroom Zones: 7.00am to 9am then 6pm to 11pm every day of the year

Correction factors on unconstrained energy use have been calculated for each house type, and for dwellings at 3.5 ★ and 4.5 ★ from the simulations in the ESUS project, as:

$$\text{Correction factor} = \frac{\text{Constrained and discounted energy}}{\text{Unconstrained energy}}$$

Table 12. NatHERS correction factors

Dwelling description	Heating correction		Cooling correction		Cooling % (of unconstrained energy)
	3.5 ★	4.5 ★	3.5 ★	4.5 ★	
Climate zone 28					
Apartment	0.47	0.44	0.86	1.35	0.22
Terrace/ townhouse	0.41	0.39	0.88	0.98	0.34
Semi	0.4	0.43	0.89	0.92	0.36
Detached 2 storey	0.44	0.43	0.38	0.37	0.25
Climate zone 17					
Apartment	0.46	0.48	0.52	0.54	0.42
House	0.37	0.36	0.49	0.53	0.48

A percentage split between heating and cooling was also estimated for those projects which do not supply complete NatHERS energy data. This percentage was taken from the ESUS simulations, and the correction factors used are shown in Table 12.

From 2005/6 onwards, the same percentage allocation is used for unimproved and improved dwellings (prior to this date a higher proportion went to cooling energy in improved dwellings). Heating and cooling loads are now supplied for most dwellings. In this case the percentage allocation in the completed dwelling is used for the base case split, as it is more likely to be representative of the specific circumstances, such as aspect. Using the same assumed allocation of heating and cooling loads for base case and improved dwellings therefore gives a more consistent approach between projects.

APPENDIX 3 Best and worst case – detailed emissions and savings

Table 13. Best and worst case for heating, cooling and cooking CO_2 emissions

	HEATING, COOLING AND COOKING EMISSIONS					
	CO_2 emissions			% savings		
	Worst case	Estimate	Best case	Worst case	Estimate	Best case
MacArthur Gdns	36.6	27.6	19.7	10.6%	8.7%	6.5%
Newbury	134.5	100.1	70.1	9.0%	7.7%	6.1%
Park Central	20.5	15.9	11.9	21.0%	17.3%	13.1%
Redgum	14.6	10.9	7.6	5.3%	4.4%	3.5%
Rouse Hill	7.3	6.1	5.0	17.6%	13.3%	8.8%
Park Bridge	92.8	69.3	48.7	8.9%	7.5%	5.9%
Waterford	17.0	12.3	8.4	17.6%	15.5%	12.9%
TOTAL	**323**	**242**	**171**	**10.9%**	**9.2%**	**7.2%**

Table 14. Best and worst case for water heating CO_2 emissions

	HOT WATER EMISSIONS					
	CO_2 emissions			% savings		
	Worst case	Estimate	Best case	Worst case	Estimate	Best case
MacArthur Gdns	20.3	17.9	15.7	7.0%	8.2%	9.5%
Newbury	99.7	87.8	76.7	2.9%	3.9%	4.9%
Park Central	14.2	12.6	11.1	8.1%	9.2%	10.5%
Redgum	11.3	10.0	8.8	5.9%	6.8%	7.8%
Rouse Hill	2.8	1.9	1.2	13.5%	16.0%	18.8%
Park Bridge	12.6	11.1	9.7	16.5%	17.7%	19.0%
Waterford	28.2	22.8	17.7	-7.6%	-4.6%	-0.9%
TOTAL	**189**	**164**	**141**	**7.0%**	**8.2%**	**9.6%**

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[4] Full fuel cycle emissions for NSW/ACT from Department of Climate Change. 2009. National greenhouse accounts (NGA) factors. Commonwealth of Australia, June 2009. Table 39, p59

[5] Full fuel cycle emissions for NSW/ACT from Department of Climate Change. 2009. National greenhouse accounts (NGA) factors. Commonwealth of Australia, June 2009. Table 2 p13 and Table 37, p58

[6] Based on the percentage of households who have reverse cycle air-conditioning who do not use it for their main source of heat (it is assumed that they are using gas); derived from ABS4602.2, March 2002.

[7] Calculated as number of dwellings that use gas as their main source of heat (from ABS4602.2, March 2002) divided by the number of dwellings that have gas reticulation (personal communication AGL, 2003)

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