LANDCOM TRIPLE BOTTOM LINE 2006/2007
ENERGY EFFICIENT DESIGN (INDICATOR 8) AND RENEWABLE/ SUSTAINABLE ENERGY SUPPLY (INDICATOR 10)
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FINAL REPORT

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CONTENTS

1 Purpose

The purpose of this report is to provide information as part of Landcom's Triple Bottom Line reporting for the year 2007/2008. 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 477 dwellings completed during 2007/8. This included:

- Bonnaccordo - 2 dwellings
- MacArthur Gdns - 32 dwellings
- Minto - 11 dwellings
- Mt Annan - 17 dwellings
- Newbury - 70 dwellings
- Park Central - 20 dwellings
- Prince Henry - 164 dwellings
- Redgum - 6 dwellings
- Rouse Hill - 120 dwellings
- Sanctuary - 7 dwellings
- The Ponds - 16 dwellings
- Waterford - 12 dwellings

The methodology used was developed by MEA in the *Energy Smart Urban Solutions* project in 2002/3, and was used in the TBL reporting from 2002/3 onwards. This methodology was refined in the 2003/4 TBL report, and the 2002/3 results recalculated using the modified methodology. The only change for the 2007/08 report is that adjustments have been introduced for dwellings that install zoning for airconditioning, or ceiling fans. While these features are included in Landcom's policy guidance, this is the first time that they have been used in any significant way.

3 Results

Overall Landcom completed 477 dwellings during 2007/8. These included one 3✯ dwelling, twenty five dwellings reaching 3.5✯ (5%), one hundred at 4✯ (21%), seventy seven at 4.5✯(16%), and two hundred and seventy four at 5✯(57%). There were two hundred and twenty four dwellings with solar water systems, or 47% of the total.

Total annual greenhouse emissions from the dwellings completed during 2007/8 are estimated as 1,618 tonnes of CO_2[a]. Estimated savings are 393 tonnes CO_2 per year compared to base case dwellings, corresponding to a reduction of 19.6%. There is a significant potential for error in these estimates. Sensitivity analysis indicates a realistic estimate of greenhouse emissions is 1,618 tonnes ± 12%, and an estimate of greenhouse savings is 393 tonnes ±10%. Overall CO_2 emissions are reduced by 19.6%. There is very little variation in the percentage savings (± 0.6%). The results for the individual developments are listed in Table 2.

Table 1. 2007/8 – star rating and solar water heating percentages

	Climate zone	Number of dwellings	3.5 ★	4 ★	4.5 ★	5 ★	With solar water heating
Bonnaccordo	28	2	0	0	2	0	0
MacArthur Gdns	28	32	10	7	7	8	11
Minto	28	11	0	3	0	8	6
Mt Annan	28	17	1	7	5	4	0
Newbury	28	70	0	12	14	44	0
Park Central	28	20	2	1	2	15	17
Prince Henry	17	164	12	63	43	45	164
Redgum	28	6	0	1	2	3	0
Rouse Hill	28	120	0	5	0	115	16
Sanctuary	28	7	0	0	0	7	4
The Ponds	28	16	0	1	2	13	6
Waterford	28	12	0	0	0	12	0
TOTAL		**477**	**25**	**100**	**77**	**274**	**224**

Table 3 shows the results for Indicators 8 and 10 for the six years 2002/3 to 2007/8.

Percentage savings increased from 6.6% in 2002/3 to 15.5% in 2004/5, dropped slightly to in 2005/6, and are 19.6% in 2007/8. Other major results are:

- 74% of houses attain 4.5✯or better NatHERS energy rating (1% below the 200/8 value, but still a significant increase from 22%. In 2002/3.
- The percentage of houses with solar water heating has increased from zero in 2002/3, to 47% in 2007/8.

Photovoltaic systems were installed on 3 apartment buildings (138 apartments) in 2007/8, with a total installation of 31.2 KW, compared to 11 kW in 2006/7. The 2007/8 installation will have estimated greenhouse gas savings of 37 tonnes. This brings total savings from PV to 50 tonnes, with 42.2 kW installed.

[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. 2007/8 – annual CO_2 emissions and savings

	HOT WATER [a]			HEATING, COOLING & COOKING		
	Emissions (tonnes)	Savings (tonnes)	Savings %	Emissions (tonnes)	Savings (tonnes)	Savings %
Bonnaccordo	2	1	7%	2	1	9%
MacArthur Gdns	24	12	7%	41	15	9%
Minto	6	5	11%	7	9	17%
Mt Annan	15	3	4%	16	3	4%
Newbury	65	14	4%	65	28	8%
Park Central	10	12	13%	13	15	16%
Prince Henry	56	78	13%	121	48	8%
Redgum	5	2	7%	5	1	4%
Rouse Hill	89	19	4%	52	84	18%
Sanctuary	4	4	11%	6	5	13%
The Ponds	11	8	9%	14	16	19%
Waterford	12	3	4%	8	9	14%
All projects	**298**	**160**	**8.0%**	**349**	**234**	**11.6%**

	Savings from PV systems	TOTAL CO_2 Emissions (tonnes)	TOTAL CO_2 Savings (tonnes)	TOTAL CO_2 Savings %
Bonnaccordo	-	9	2	16%
MacArthur Gdns	-	138	27	16%
Minto	-	37	14	28%
Mt Annan	-	70	7	9%
Newbury	-	294	42	13%
Park Central	-	68	27	28%
Prince Henry	37	468	126	21%
Redgum	-	24	3	11%
Rouse Hill	-	371	103	22%
Sanctuary	-	27	9	24%
The Ponds	-	62	24	28%
Waterford	-	49	11	18%
All projects	**37**	**1,618**	**393**	**19.6%**

Table 3. Comparison of annual results for Indicators 8 and 10, 2002 - 2008

	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	**6.6%**	**22%**	**0%**	**none**
2003/4	226	1,023	113	**10.0%**	**35%**	**44%**	**none**
2004/5	251	1,095 [b]	201 [a]	**15.5%** [a]	**47%**	**36%**	**none**
2005/6	167	721	122	**14.5%**	**58%**	**32%**	**none**
2006/7	161	686	128	**15.7%**	**75%**	**18%**	**11 kW PV**
2007/8	477	1,618	393	**19.6%**	**74%**	**47%**	**31.2 kW PV**

[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 48%, efficient shower heads 41%, and efficient gas 10% of the total savings from hot water.
[b] Values for 2004/5 were recalculated because 81 dwellings did not have gas points fitted.

4 Methodology

The methodology adopted for calculation of greenhouse savings is shown schematically in Figure 1, and is the same as used in previous years. 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.

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.

4.1 Methodology modifications for 2007/8

Zoning and ceiling fans

Additional adjustments have been included to allow for the effects of zoned air-conditioning and ceiling fans made in the 2007/8 analysis. These items were recommended in the Landcom Energy Smart Policy, but have not been fitted in previous years dwellings to any significant extent.

When day/night zoning is installed, a further factor of –15% is applied to the heating and cooling correction factors. These factors vary from 0.37 to 0.52, depending on the climate zone, the star rating, and the house type (details are given in Appendix 1). Thus the correction equates to an altered heating or cooling energy use of between 5% and 8%.

When ceiling fans are installed, a further factor of –20% is applied to the cooling correction factor. The cooling correction factor varies from 0.37 to 1.35, depending on the house type and climate zone (details are given in Appendix 1). The 20% factor equates to a reduction of between 7% and 27% in cooling energy use.

These additional factors were included in the sensitivity analysis.

Homes without heating and cooling loads

A systematic methodology for dealing with homes without heating and cooling loads supplied was developed for the first time for 2007/8.

BASIX certificates may be obtained using either the simulation method, where the developer enters the simulated heating and cooling loads for the dwelling, or using

'deemed to comply' where various construction details are entered. Some properties therefore do not have heating and cooling loads available. Heating and cooling loads are required in order to assign a star rating to the dwelling, and to calculate the greenhouse gas savings from the various improvements. Although this was not a significant number overall (32 out of 477, or 7%), in some projects more than half of dwellings had neither star ratings or heating and cooling loads.

In order to undertake the analysis, heating and cooling loads (and therefore star rating) have to be assumed. Three methods were used, and the different assumptions included in the sensitivity analysis.

Reported case assumption: a mid way point between the average of the project heating and cooling load (or the individual developer, in the case of MacArthur gardens), and 3.5✯. Where a project includes detached homes and apartments, the average for that type of dwelling was used, rather than the overall project average.

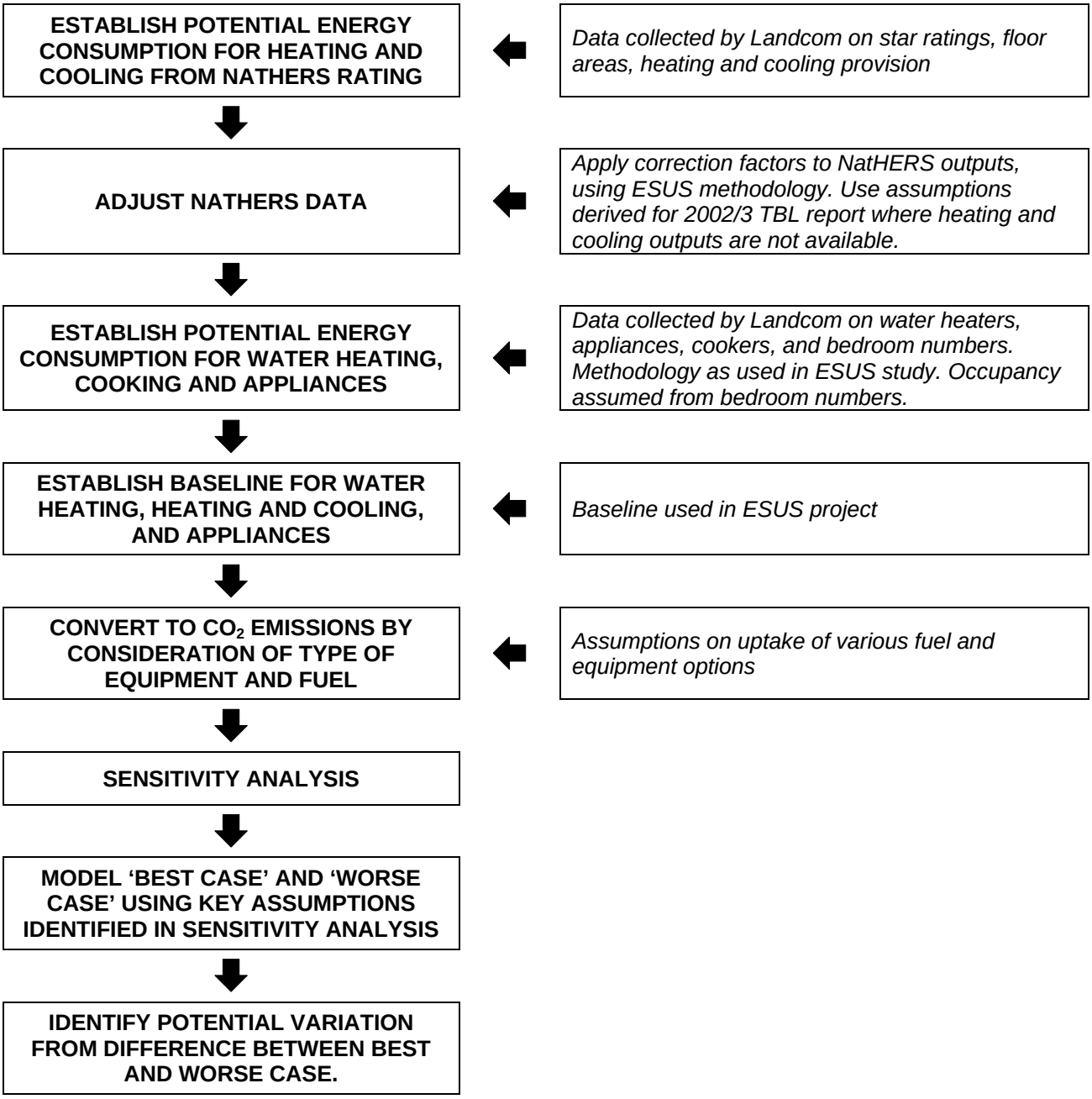
Worst case assumption: all dwellings without NatHERS certicates are assumed to be 3.5✯. If this assumption is used, the overall percentage of Landcom dwellings achieving 4.5✯ or greater falls to to 73%.

Best case assumption: the average heating and cooling loads for dwellings with simulations for the individual developer (or project) are used. Where a project includes detached homes and apartments, the average for that type of dwelling was used, rather than the overall project average. If this assumption is used, the overall percentage of Landcom dwellings achieving 4.5✯ or greater rises to 77%

The assumptions had an effect on the number of dwellings achieving 4.5✯or greater. In the reported case 74% of dwellings achieve 4.5✯ or greater; this was reduced to 73% in the worst case, and rose to 77% in the best case.

Also see 'Individual Project Variations' below.

Figure 1: Methodology for calculating greenhouse savings from completed dwellings



4.2 Base case

The base case is described in detail in the Energy Smart Urban Solutions report.[1] 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).

NatHERS data or BASIX certificates were suppled for all but 4 projects (heritage listed cottages at Prince Henry). Heating and cooling loads were supplied for all but 32 properties (7%).

4.4 Individual project variations

MacArthur Gardens: twenty dwellings had used the 'deemed to comply' method for obtaining BASIX certificates. A number of factors influence the choice of star rating to use:

- Three different developers built homes on this project, and there was a noticable difference in the star ratings and heating and cooling loads in each case (for those dwellings which had undertaken simulation). The average energy consumption for the three developers were 109 MJ/ m^2/ year (5✯), 122 MJ/ m^2/ year (5✯), and 175 MJ/ m^2/ year (5✯). The overall average for the project was 123 MJ/ m^2/ year (5✯), but this was skewed towards the best performing developer as those properties included the most with simulation data supplied.
- The average BASIX score for the twenty dwellings was 43, compared to 42 for the twelve dwellings with simulated energy consumption, so there should not be a significant difference in the performance of the dwellings.

The midway point between 3.5 ✯ and the averages value for each developer. Averages by developer, rather than for the whole project, were used as it was thought this would be a better reflection of the individual house performance. The worst case, reported case, and best case assumptions as described above were used.

Minto: three dwellings had used the simulation method to obtain BASIX certificates, and the midway point between 3.5 ✯ and the project average for heating and cooling loads was used in the reported case.

Rouse hill: five dwellings had used the simulation method to obtain BASIX certificates, and the midway point between 3.5 ✯ and the project average value for heating and cooling loads was used in the reported case.

Prince Henry: four heritage properties had no heating and cooling loads, as no simulation was undertaken, and no BASIX certificates. A star rating of 3.5✯ was assigned to these properties in all cases.

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 below, arranged with the most significant factors at the top.

Table 4. 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%	-11.8%	11.8%	-2.5%	2.5%
Adjustment to heating & cooling corrections for AC zoning	± 100%	-6.3%	6.3%	1.5%	-1.5%
% heating fuel gas (no AC)	± 20%	4.9%	-4.9%	0.2%	-0.2%
% get gas heaters installed (gas points no aircon)	± 20%	4.9%	-4.9%	0.2%	-0.2%
Solar contribution	± 5%	-4.2%	4.2%	1.0%	-1.0%
Adjustment for AAA shower	± 10%	-3.1%	3.1%	0.7%	-0.7%
Adjust cooling correction for ceiling fans	± 100%	-1.9%	1.9%	0.5%	-0.5%
Assumed heating efficiency for base case AC	± 9%	1.6%	-1.3%	0.5%	-0.4%
Occupancy of 4 bedroom dwellings	± 20%	-1.4%	1.4%	-1.8%	1.8%
Assumption for missing NatHers data [1]	n/a	-1.4%	1.0%	0.4%	-0.2%
Occupancy of 3 Bedroom dwellings	± 10%	-1.1%	1.1%	-2.1%	2.1%
Assumed cooling efficiency for base case AC	± 10%	1.2%	-1.0%	0.6%	-0.5%
Cooling correction	± 20%	-0.8%	0.8%	0.0%	0.0%
% without AC that will get it	± 20%	-0.6%	0.6%	0.1%	-0.4%
% of energy used for cooling	± 30%	0.8%	-0.8%	-0.1%	0.1%
% heating fuel gas (for dwellings with AC)	± 20%	0.1%	-0.1%	0.1%	-0.1%
% of dwellings that get gas heaters installed (which have gas points and AC)	± 20%	0.1%	-0.1%	0.1%	-0.1%

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.

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 correction applied to this factor when dwellings have zoning. 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 assumed solar contribution when solar water heating is installed, the reduction in hot water from AAA showers, and the adjustment applied to cooling correction factors when ceiling fans are fitted 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 5.

Table 5. Variables used to calculate best and worst case for CO_2 savings

	WORST CASE	Estimate	BEST CASE
Heating correction (multiply listed factor by..)	1.2	1	0.8
Adjust heating & cooling correction for zoning	0	-15%	-0.3
% heating fuel gas (gas heaters no AC)	48%	60%	72%
% gas heaters installed (gas points no AC)	56%	70%	84%
Solar contribution	48%	60%	72%
Reduction in hot water use for AAA shower	84%	80%	76%
Adjust cooling correction for ceiling fans	0	-20%	-40%
Assumed heating efficiency for base case AC	2.1	2.3	2.5
Occupancy of 4 bedroom dwellings	3.63	3.3	2.97
Assumption for missing NatHers data (dwellings without data for heating and cooling energy)	Assume 3.5★	Midpoint between worst and best case	Average value for similar dwellings in project
Occupancy of 3 Bedroom dwellings	3.3	3	2.7
Assumed cooling efficiency for base case AC	1.8	2	2.2

The results corresponding to these 'best' and 'worst' cases for annual CO_2 emissions are shown in Tables 6 and 7.

The variation in total CO_2 emissions is ± 12.6%. The variation in the percentage emission reduction (savings) is much smaller, and changes only from 19% in the worst emissions case, to 19.6% 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 the same in the estimate and the best case, although actual emissions are nearly 11% lower in the best case than in the estimate. 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. 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**
Bonnaccordo	10	9	8	12.6%	-11.5%
MacArthur Gdns	160	138	120	15.9%	-13.0%
Minto	43	37	32	16.9%	-14.3%
Mt Annan	79	70	61	12.9%	-12.0%
Newbury	337	294	255	14.5%	-13.4%
Park Central	77	68	61	12.3%	-11.2%
Prince Henry	527	468	419	12.6%	-10.5%
Redgum	28	24	21	13.5%	-12.6%
Rouse Hill	407	371	342	9.6%	-7.8%
Sanctuary	30	27	24	11.8%	-11.0%
The Ponds	70	62	54	13.4%	-12.1%
Waterford	55	49	44	11.8%	-11.2%
All projects	**1,822**	**1,618**	**1,441**	**12.6%**	**-10.9%**

Table 7. Annual CO_2 savings from 'best case' and 'worst case' for emissions

	% CO_2 SAVINGS		
Project	**Worst case**	**Reported**	**Best case**
Bonnaccordo	17%	16%	14%
MacArthur Gdns	16%	16%	16%
Minto	26%	28%	28%
Mt Annan	8%	9%	9%
Newbury	12%	13%	13%
Park Central	29%	28%	27%
Prince Henry	19%	21%	22%
Redgum	11%	11%	12%
Rouse Hill	22%	22%	21%
Sanctuary	26%	24%	22%
The Ponds	30%	28%	25%
Waterford	20%	18%	17%
All projects	**19.0%**	**19.6%**	**19.6%**

APPENDIX 1 Variables used in modelling for the TBL report

Variable	**Value used**
Tonnes CO_2 per kWh gas	0.00023472 [2]
Tonnes CO_2 per kWh electricity	0.000902 [3]
Appliance 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%

	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% [4]
% of dwellings without air-conditioning & with gas points that install gas heaters	70% [5]
% 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 – 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 – 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 8 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 8. NatHERS star ratings - predicted energy loads (maximum Mj/m^2) [6,7]

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 [8]. 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 9.

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.

Table 9. 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 10. 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

The correction factors for Climate Zone 28 were used for Woodlands (Climate Zone 18).

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 10.

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 11. 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
Bonnaccordo	2.8	2.3	1.8	11.6%	9.0%	5.7%
MacArthur Gdns	54.0	41.3	32.1	10.1%	9.4%	7.0%
Minto	10.2	7.2	4.8	17.9%	16.9%	14.9%
Mt Annan	19.5	15.5	12.0	4.7%	4.2%	3.7%
Newbury	86.5	65.1	46.3	8.6%	8.3%	7.9%
Park Central	15.6	13.1	10.9	19.2%	15.6%	11.6%
Prince Henry	157.9	120.5	91.3	9.0%	8.1%	6.4%
Redgum	6.8	5.2	3.9	4.4%	3.8%	3.2%
Rouse Hill	75.4	51.6	33.9	19.1%	17.8%	15.7%
Sanctuary	6.5	5.7	4.9	16.8%	12.9%	8.6%
The Ponds	17.0	13.7	10.9	22.5%	18.8%	14.1%
Waterford	9.6	7.8	6.1	16.3%	14.2%	11.9%
TOTAL	**462**	**349**	**259**	**12.8%**	**11.6%**	**9.7%**

Table 12. 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
Bonnaccordo	1.9	1.7	1.5	5.8%	6.7%	7.8%
MacArthur Gdns	27.5	23.6	20.1	5.7%	7.1%	8.6%
Minto	7.3	5.9	4.7	8.6%	10.7%	12.8%
Mt Annan	17.5	15.4	13.5	3.4%	4.4%	5.4%
Newbury	74.0	65.2	56.9	3.3%	4.2%	5.2%
Park Central	12.8	9.9	7.5	9.9%	12.5%	15.2%
Prince Henry	70.8	55.8	42.7	10.2%	13.1%	16.1%
Redgum	5.5	4.9	4.3	6.4%	7.4%	8.5%
Rouse Hill	95.9	88.8	82.4	2.8%	3.9%	5.2%
Sanctuary	5.4	4.4	3.5	9.1%	11.2%	13.3%
The Ponds	12.7	10.6	8.8	7.2%	9.0%	10.8%
Waterford	13.4	11.8	10.3	3.4%	4.3%	5.3%
TOTAL	**345**	**298**	**256**	**6.2%**	**8.0%**	**9.8%**

REFERENCES

[1] Mark Ellis and Associates, Hill PDA, and Solarch. 2003. *Energy Smart Urban Solutions Final Report May 2003.*

[2] Australian Residential Buildings Greenhouse Gas Emissions 1990-2010, table 74, pg94

[3] Australian Residential Buildings Greenhouse Gas Emissions 1990-2010, table 73, pg94

[4] 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.

[5] 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)

[6] NSW HERS Management Body *HMB Accredited Assessor Handbook*

[7] ABCB 2005. *Protocol for house energy rating software version 2005.1*

[8] ABCB 2002. Energy Efficiency Measures BCA Volume Two (Housing Provisions) Regulatory Assessment (*Final Regulatory Impact Statement RIS 2002/04*)