

To:

James Piko (Department of the Environment and Energy)

CC:

Hilary Rossow (Department of the Environment and Energy)
Jodie Pipkorn (Department of the Environment and Energy)

Project name:

Whole of House - Stage 3

Project ref:

60580556

From:

Sian Willmott

Date:

September 05, 2018

Class 1 dwelling modelling results

Introduction

The following memorandum is provided to summarise the results of the typical 2018 Class 1 dwellings under the following scenarios:

- Base Case (this is a Business as Usual (BAU) scenario);
- A Tailored Climate scenario; and
- '7 Star scenario' (with concessions applied for particular climates)

Approach

Due to previous identified limitations in both the residential baseline study (RBS) and the NatHERS operational profiles, the approach taken to estimate the heating and cooling loads was based on the following methodology:

1. Use the NatHERS heating/cooling loads as modelled by the AusZEH software;
2. Modify the occupancy profile and thermostat settings to match the Composite Weekday Profile and cooling thermostat settings adopted in the RBS;
3. Apply the heating and cooling efficiencies as provided by the RBS

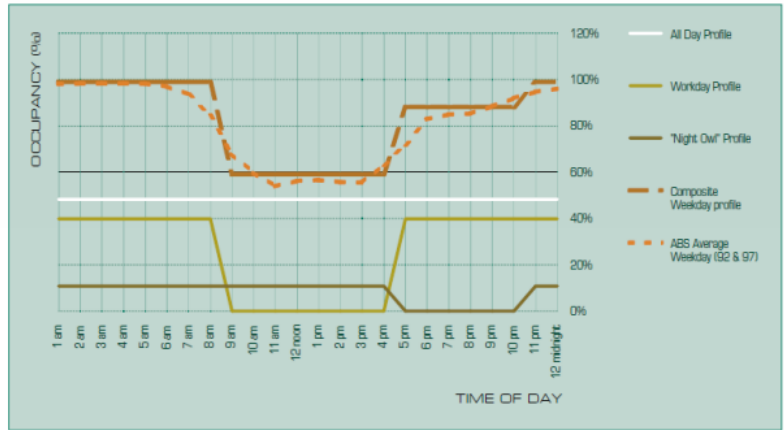


Figure 1: RBS Composite weekday profile (brown dotted line)

Thermostat settings were altered based on location as follows:

Table 1. Altered thermostat settings

NCC Climate Zone	1	2	3	4	5	6	7
Thermostat Setting	24	23.5	23.5	23	23	23	23

Base Case

Base Case dwellings consist of business as usual elements as defined by Table 2 below.

Table 2. Base Case

Class 1 Building	Equivalent to: <ul style="list-style-type: none"> • 6.0 Star (with regional variations between jurisdictions and NCC climate zones, and good passive solar) • Heating cap • Cooling cap
Class 1 Services	Overall carbon/energy load equivalent to the combined use of: <ul style="list-style-type: none"> • 4* gas or 3.5* electric conditioning • Solar or gas instant hot water • LED lighting • Energy loading to allow for cooking and plugged appliances • Renewable energy uptake as per AEMO data

Source: Department of the Environment and Energy

The star ratings as determined under the NatHERS protocol are identified in

Table 3 below.

Table 3: Base Case Star Ratings (modelled as per NatHERS protocol)

Location	NatHERS Climate Zone	Required Jurisdiction Star Rating	Base Case 1 Star rating
Canberra	24	6.0	6.5
Richmond	28	5.5	5.8
Wagga Wagga	20	5.5	5.5
Nowra	18	5.5	5.7
Moree	8	5.5	5.5
Sydney East	17	5.5	5.6
Sydney	56	5.5	5.5
Alice Springs	6	5.0	5.0
Darwin	1	5.0	5.4
Charleville	19	5.0	5.0
Brisbane	10	4.5	4.6
Townsville	5	4.5	4.8
Oakey	50	4.5	4.5
Adelaide	16	6.0	6.1
Mt Lofty	59	6.0	6.3
Mt Gambier	61	6.0	6.3
Woomera	45	6.0	6.1
Hobart	26	6.0	6.2
Mildura	27	6.0	6.2
Ballarat	66	6.0	6.3
Melbourne	21	6.0	6.3
Katanning	49	6.0	6.5
Newman	40	6.0	6.2
Manjimup	57	6.0	6.3
Broome	33	5.0	5.3
Halls Creek	37	6.0	6.3
Albany	58	6.0	6.0
Perth	13	6.0	6.2
Swanbourne	52	6.0	6.0

Table 4. Base Case – Class 1 2018 - Results

Location	NatHERS Climate Zone	Total Annual Values					PV Offsets				
		Operating Cost to consumer (\$)	LPG (MJ)	Gas (MJ)	Elec (MJ)	Total Energy (MJ)	GHG emissions (kgCO2-e)	PV array size offset elec (kWp)	PV offset elec capital cost (\$)	PV array size offset emissions (kWp)	PV offset emissions capital cost (\$)
Canberra	24	\$1,869		39,597	14,314	53,911	5,625	2.84	\$3,145	4.23	\$4,684
Richmond	28	\$2,175		12,284	19,129	31,414	5,681	4.13	\$4,657	4.64	\$5,241
Wagga	20	\$2,411		12,284	21,728	34,012	6,366	4.46	\$5,088	4.96	\$5,650
Wagga											
Nowra	18	\$2,106		12,284	18,372	30,656	5,481	4.01	\$4,570	4.53	\$5,166
Moree	8	\$2,529		12,284	23,021	35,305	6,708	4.20	\$5,247	4.63	\$5,794
Sydney East	17	\$2,100		12,284	18,311	30,595	5,465	4.06	\$4,496	4.59	\$5,085
Sydney	56	\$2,028		12,284	17,520	29,804	5,256	3.89	\$4,302	4.42	\$4,890
Alice Springs	6	\$2,506	13,131	-	26,690	39,821	6,202	4.55	\$11,355	5.22	\$13,012
Darwin	1	\$3,343	13,131	-	38,392	51,523	8,575	6.99	\$18,170	7.70	\$20,013
Charleville	19	\$2,790		639	31,818	32,456	8,252	5.61	\$8,646	5.63	\$8,680
Brisbane	10	\$2,283		639	25,948	26,587	6,736	5.12	\$6,309	5.14	\$6,340
Townsville	5	\$2,848		639	32,492	33,131	8,427	6.41	\$8,453	6.43	\$8,487
Oakey	50	\$2,404		639	27,353	27,992	7,099	5.16	\$6,489	5.18	\$6,519
Adelaide	16	\$2,428		11,011	18,321	29,333	3,519	3.72	\$4,464	4.43	\$5,322
Mt Lofty	59	\$2,841		11,011	22,252	33,263	4,152	4.52	\$7,049	5.23	\$8,164
Mt Gambier	61	\$2,511		11,011	19,113	30,124	3,646	4.34	\$5,991	5.14	\$7,094
Woomera	45	\$2,693		11,011	20,842	31,853	3,925	3.72	\$5,808	4.35	\$6,789
Hobart	26	\$1,748		722	26,745	27,467	1,300	6.87	\$9,301	7.07	\$9,575
Mildura*	27	\$2,210		16,310	17,991	34,300	6,647	3.53	\$4,969	3.98	\$5,601
Ballarat*	66	\$2,458		42,511	15,098	57,609	6,826	3.42	\$4,580	4.71	\$6,318
Melbourne*	21	\$2,059		23,899	14,995	38,893	5,991	3.39	\$4,549	4.14	\$5,545
Katanning	49	\$1,871		11,821	18,345	30,166	4,482	3.72	\$4,463	4.30	\$5,165
Newman	40	\$2,727		11,821	29,689	41,510	6,876	5.15	\$8,164	5.65	\$8,957
Manjimup	57	\$1,832		11,821	17,822	29,643	4,371	3.50	\$4,031	4.06	\$4,683
Broome	33	\$3,439		11,821	39,121	50,942	8,868	6.52	\$9,387	7.00	\$10,079
Halls Creek	37	\$2,793		11,821	30,560	42,381	7,060	5.24	\$8,044	5.73	\$8,803
Albany	58	\$1,775		11,821	17,068	28,889	4,212	3.84	\$4,238	4.49	\$4,954
Perth	13	\$1,886		11,821	18,542	30,363	4,523	3.45	\$3,312	3.99	\$3,827
Swanbourne	52	\$1,770		11,821	16,996	28,817	4,197	3.16	\$3,036	3.70	\$3,551

Source: AECOM

*Base case includes gas boosted solar hot water

Tailored Climate Scenario

The Tailored Climate Scenario is a potential step change in energy/emissions efficiency that could be considered within a national legislation. Thermal upgrades have been considered based on NCC climate zones.

Table 5. Tailored climate scenario

Class 1 Building	Equivalent to: <ul style="list-style-type: none"> Thermal upgrades: <ul style="list-style-type: none"> NCC Climate Zone 2,3&4 – 6 Stars NCC Climate Zone 1&5 – 6.5 Stars NCC Climate Zone 6,7&8 – 7 Stars Heating cap Cooling cap
Class 1 Services	Overall carbon/energy load equivalent to the combined use of: <ul style="list-style-type: none"> 5* gas or 4* electric conditioning Solar or heat pump hot water LED lighting Energy loading to allow for cooking and plugged appliances Renewable energy

Upgrades to achieve the required Star rating were taken on a case by case basis. To understand their rating increase, they were first modelled using the NatHERS protocol, before applying the final modelling approach. A summary of upgrades, capital costs and simple paybacks are illustrated in Table 6 below.

Table 6. Upgrades to achieve tailored climate scenario – Class 1 2018

Location	NatHERS Climate Zone				Capital Costs			Simple Payback (years)	
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)		Total (\$)
Canberra	24	Roof insulation to R4.1 Wall insulation to R2.5	Hot water to heat pump COP 3.53 Heating to RCAC COP 3.92 Cooling to RCAC EER 5.63	0.50	7.1	\$1,652	-\$702	\$950	1.23
Richmond	28	Roof insulation to R5.0 Wall insulation to 2.5 Double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	1.25	7.0	\$5,700	\$1,960	\$7,660	31.31
Wagga Wagga	20	Roof insulation to R3.5	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	0.65	6.2	\$1,328	\$1,960	\$3,288	13.59
Nowra	18	Roof insulation to R4.1 Double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	1.35	7.0	\$5,063	\$1,960	\$7,023	31.62

Location	NatHERS Climate Zone	Capital Costs							Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)	Total (\$)	
Moree	8	Roof insulation to R4.1 Improved tinted glazing to N, E, W (U: 6.29, SHGC: 0.52)	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	0.50	6.0	\$3,883	\$1,960	\$5,843	21.34
Sydney East	17	Roof insulation to R4.1 Low e glazing (U:5.32, SHGC:0.47)	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	0.95	6.5	\$1,677	\$1,960	\$3,637	17.93
Sydney	56	Roof insulation to R4.1 Low e glazing (U:5.32, SHGC:0.47)	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	1.00	6.5	\$1,677	\$1,960	\$3,637	21.26
Alice Springs	6	Roof insulation to R3.0 Wall insulation to R2.0	Hot water to heat pump COP 4.72 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.65	1.00	6.0	\$2,595	\$1,960	\$4,555	7.27
Darwin	1	Roof insulation to R5.0 Wall insulation to R2.5 Low e glazing (U:5.32, SHGC:0.47) 600mm shading to N	Hot water to heat pump COP 4.72 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.65	1.15	6.5	\$3,604	\$1,960	\$5,564	6.21
Charleville	19	Roof insulation to R4.1 Wall insulation to R2.0	Hot water to heat pump COP 4.46 Heating to RCAC COP 5.14 Cooling to RCAC EER 6.04	1.00	6	\$3,472	\$1,960	\$5,432	8.20
Brisbane	10	Roof insulation to R5.0 Wall insulation to R2.5 Improved Single glazing	Hot water to heat pump COP 4.1 Heating to RCAC COP 5.2 Cooling to RCAC EER 6.39	1.45	6.0	\$6,682	\$1,960	\$8,642	16.92
Townsville	5	Roof insulation to R4.1 Wall insulation to R1.0 Low e glazing to N,E,W	Hot water to heat pump COP 4.46 Heating to RCAC COP 5.14 Cooling to RCAC EER 6.04	1.25	6.0	\$7,212	\$1,960	\$9,172	14.06

Location	NatHERS Climate Zone	Capital Costs					Simple Payback (years)		
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)		Appliances (\$)	Total (\$)
Oakey	50	Roof insulation to R3.0 Wall insulation to R1.0 Standard DGU (U: 4.95, SHGC: 0.69)	Hot water to heat pump COP 4.1 Heating to RCAC COP 5.2 Cooling to RCAC EER 6.39	1.95	6.5	\$5,991	\$1,960	\$7,951	14.04
Adelaide	16	Roof insulation to R5.0	Hot water to heat pump COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32	0.50	6.6	\$1,903	\$1,960	\$3,863	21.61
Mt Lofty	59	Improved double glazing (U:3.95 SHGC: 0.69)	Hot water to heat pump COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32	0.70	7.0	\$3,962	\$1,960	\$5,922	14.42
Mt Gambier	61	Standard DGU (U: 4.95, SHGC: 0.69)	Hot water to heat pump COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32	0.65	7.0	\$5,039	\$1,960	\$6,999	24.32
Woomera	45	-	Hot water to heat pump COP 4.04 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.15	0.00	6.1	-	\$1,960	\$1,960	8.70
Hobart	26	Roof insulation to R5.0 Improved double glazing (U:3.95 SHGC: 0.69)	Hot water to heat pump COP 3.31 Heating to RCAC COP 5.08 Cooling to RCAC EER 5.68	0.80	7.0	\$4,263	\$2,533	\$6,796	19.48
Mildura	27	-	Hot water to heat pump COP 3.84 Heating to RCAC COP 4.82 Cooling to RCAC EER 5.45	0.00	6.2	-	-\$702	-\$702	-11.92
Ballarat	66	Wall insulation to R2.5 Double glazing	Hot water to heat pump COP 3.6 Heating to RCAC COP 5.22 Cooling to RCAC EER 5.5	0.70	7.0	\$4,443	-\$702	\$3,741	10.94
Melbourne	21	Wall insulation to 2.5	Hot water to heat pump COP 3.6	0.75	7.0	\$4,443	-\$702	\$3,741	26.61

Location	NatHERS Climate Zone	Capital Costs							Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)	Total (\$)	
		Double glazing	Heating to RCAC COP 5.22 Cooling to RCAC EER 5.5						
Katanning	49	-	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	0.00	6.5	-	\$1,960	\$1,960	7.71
Newman	40	-	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.48	0.00	6.2	-	\$1,960	\$1,960	4.45
Manjimup	57	Wall insulation to R2.0	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	0.80	7.0	\$2,458	\$1,960	\$4,418	14.65
Broome	33	Roof insulation to R5.0 Wall insulation to R2.5 Toned double glazing (U:4.92, SHGC:0.49)	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.48	1.25	6.5	\$6,940	\$1,960	\$8,900	8.41
Halls Creek	37	-	Hot water to heat pump COP 4.81 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.03	0.00	6.3	-	\$1,960	\$1,960	5.44
Albany	58	Wall insulation to R1.5 Improved single glazing	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	1.10	7.1	\$6,002	\$1,960	\$7,962	26.24
Perth	13	Wall insulation to R1.5	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	0.50	6.7	\$1,980	\$1,960	\$3,940	13.39
Swanbourne	52	Low-e glazing (U: 5.32 SHGC: 0.47)	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21	0.60	6.5	\$381	\$1,960	\$2,341	7.99

Location	NatHERS Climate Zone	Capital Costs					Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	
		Cooling to RCAC EER 5.48					

Source: AECOM

Table 7. Tailored climate scenario - Class 1 2018 - Results

Location	NatHERS Climate Zone	Total Annual Values					PV Offsets				
		Operating Cost to consumer (\$)	LPG (MJ)	Gas (MJ)	Elec (MJ)	Total Energy (MJ)	GHG emissions (kgCO2-e)	PV array size offset elec (kWp)	PV offset elec capital cost (\$)	PV array size offset emissions (kWp)	PV offset emissions capital cost (\$)
Canberra	24	\$1,100	-	-	21,472	21,472	5,666	4.26	\$4,718	4.26	\$4,718
Richmond	28	\$1,930	-	-	20,906	20,906	5,517	4.51	\$5,089	4.51	\$5,089
Wagga Wagga	20	\$2,169	-	-	23,533	23,533	6,210	4.84	\$5,511	4.84	\$5,511
Nowra	18	\$1,884	-	-	20,396	20,396	5,382	4.45	\$5,073	4.45	\$5,073
Moree	8	\$2,255	-	-	24,477	24,477	6,459	4.46	\$5,579	4.46	\$5,579
Sydney East	17	\$1,897	-	-	20,547	20,547	5,422	4.56	\$5,045	4.56	\$5,045
Sydney	56	\$1,857	-	-	20,105	20,105	5,306	4.46	\$4,937	4.46	\$4,937
Alice Springs	6	\$1,880	-	-	26,293	26,293	5,332	4.49	\$11,186	4.49	\$11,186
Darwin	1	\$2,446	-	-	34,212	34,212	6,937	6.23	\$16,192	6.23	\$16,192
Charleville	19	\$2,128	-	-	24,065	24,065	6,217	4.24	\$6,539	4.24	\$6,539
Brisbane	10	\$1,772	-	-	19,945	19,945	5,153	3.93	\$4,850	3.93	\$4,850
Townsville	5	\$2,196	-	-	24,853	24,853	6,420	4.90	\$6,466	4.90	\$6,466
Oakey	50	\$1,838	-	-	20,708	20,708	5,350	3.91	\$4,913	3.91	\$4,913
Adelaide	16	\$2,249	-	-	21,005	21,005	3,384	4.27	\$5,118	4.27	\$5,118
Mt Lofty	59	\$2,431	-	-	22,733	22,733	3,663	4.62	\$7,201	4.62	\$7,201
Mt Gambier	61	\$2,223	-	-	20,761	20,761	3,345	4.72	\$6,507	4.72	\$6,507
Woomera	45	\$2,468	-	-	23,084	23,084	3,719	4.12	\$6,433	4.12	\$6,433
Hobart	26	\$1,399	-	-	21,236	21,236	1,003	5.46	\$7,385	5.46	\$7,385
Mildura	27	\$2,151	-	-	20,762	20,762	6,840	4.08	\$5,735	4.10	\$5,764
Ballarat	66	\$2,116	-	-	20,418	21,085	6,727	4.62	\$6,194	4.65	\$6,226
Melbourne	21	\$1,919	-	-	18,507	19,174	6,100	4.19	\$5,614	4.21	\$5,646
Katanning	49	\$1,617	-	-	21,010	21,010	4,435	4.26	\$5,112	4.26	\$5,112
Newman	40	\$2,287	-	-	29,889	29,889	6,310	5.19	\$8,220	5.19	\$8,220
Manjimup	57	\$1,530	-	-	19,861	19,861	4,193	3.90	\$4,491	3.90	\$4,491
Broome	33	\$2,381	-	-	31,134	31,134	6,573	5.19	\$7,471	5.19	\$7,471
Halls Creek	37	\$2,433	-	-	31,819	31,819	6,717	5.45	\$8,375	5.45	\$8,375
Albany	58	\$1,472	-	-	19,082	19,082	4,028	4.29	\$4,738	4.29	\$4,738
Perth	13	\$1,592	-	-	20,677	20,677	4,365	3.85	\$3,693	3.85	\$3,693

Location	NatHERS Climate Zone	Total Annual Values					PV Offsets				
		Operating Cost to consumer (\$)	LPG (MJ)	Gas (MJ)	Elec (MJ)	Total Energy (MJ)	GHG emissions (kgCO2-e)	PV array size offset elec (kWp)	PV offset elec capital cost (\$)	PV array size offset emissions (kWp)	PV offset emissions capital cost (\$)
Swanbourne	52	\$1,476		-	19,146	19,146	4,042	3.56	\$3,420	3.56	\$3,420

Source: AECOM

Gas Sensitivity Analysis

A sensitivity analysis was undertaken for gas space heating and gas boosted solar hot water in Canberra, Sydney, Mildura, Ballarat and Melbourne. The gas space heating system was assumed at 91% efficient (6 Star).

Table 8. Tailored climate scenario - Class 1 2018 - Gas sensitivity - Results

Location	NatHERS Climate Zone	Total Annual Values					PV Offsets				
		Operating Cost to consumer (\$)	LPG (MJ)	Gas (MJ)	Elec (MJ)	Total Energy (MJ)	GHG emissions (kgCO2-e)	PV array size offset elec (kWp)	PV offset elec capital cost (\$)	PV array size offset emissions (kWp)	PV offset emissions capital cost (\$)
Canberra	24	\$1,450		23,349	15,202	38,551	5,024	3.02	\$3,340	3.78	\$4,183
Sydney	56	\$1,829		6,958	17,196	24,154	4,868	3.82	\$4,222	4.09	\$4,529
Mildura	27	\$2,063		14,430	17,095	31,525	6,240	3.36	\$4,722	3.74	\$5,258
Ballarat	66	\$2,108		29,535	14,646	44,181	6,033	3.32	\$4,443	4.17	\$5,584
Melbourne	21	\$1,844		17,302	14,417	31,719	5,476	3.26	\$4,373	3.78	\$5,068

Source: AECOM

7 Star Scenario

The 7 Star scenario is the next potential step change in energy/emissions efficiency that could be considered within a national legislation. Elements as defined by Table 9 below.

Table 9. 7 Star Scenario

Class 1 Building	Equivalent to: <ul style="list-style-type: none"> • 7 Star thermal except for Climate Zones 1 and 2 (6 Star upgrade)) • Heating cap • Cooling cap
Class 1 Services	Overall carbon/energy load equivalent to the combined use of: <ul style="list-style-type: none"> • 5* gas or 4* electric conditioning • Solar or heat pump hot water • LED lighting • Energy loading to allow for cooking and plugged appliances • Renewable energy

Upgrades to achieve the 1.0 Star increase were taken on a case by case basis. To understand their rating increase, they were first modelled using the NatHERS protocol, before applying the final modelling approach. A summary of upgrades, capital costs and simple paybacks are illustrated in **Error! Reference source not found.** below.

Table 10. Upgrades to achieve 7 Star Scenario – Class 1 2018

Location	NatHERS Climate Zone	Capital Costs				Star Rating Increase	Total Star Rating	Simple Payback (years)			
		Materials Upgrade	Appliances Upgrade	Thermal (\$)	Appliances (\$)			Total (\$)			
Canberra	24	Roof insulation to R4.1 Wall insulation to R2.5	Hot water to heat pump COP 3.53 Heating to RCAC COP 3.92 Cooling to RCAC EER 5.63			0.50	7.1	\$1,652	-\$702	\$950	1.23
Richmond	28	Roof insulation to R5.0 Wall insulation to 2.5 Double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37			1.35	7.0	\$5,700	\$1,960	\$7,660	31.31
Wagga Wagga	20	Roof insulation to R4.1 Double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37			1.50	7.0	\$5,063	\$1,960	\$7,023	19.81
Nowra	18	Roof insulation to R4.1 Double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37			1.35	7.0	\$5,063	\$1,960	\$7,023	31.62
Moree	8	Roof insulation to 5.0 Wall insulation to 2.5 Improved double glazing	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER			1.50	7.0	\$8,467	\$1,960	\$10,427	28.42

Location	NatHERS Climate Zone	Capital Costs							Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)	Total (\$)	
			5.37						
Sydney East	17	Roof insulation to 5.0 Improved double glazed toned	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	1.45	7.0	\$8,186	\$1,960	\$10,146	45.04
Sydney	56	Improved double glazed toned Roof 4.1	Hot water to heat pump COP 3.82 Heating to RCAC COP 4.56 Cooling to RCAC EER 5.37	1.50	7.0	\$8,930	\$1,960	\$10,890	57.58
Alice Springs	6	Roof insulation to R5.0 Wall insulation to R1.0 Low e glazing to N, E, W (U: 5.32 SHGC: 0.47)	Hot water to heat pump COP 4.72 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.65	2.05	7.0	\$5,999	\$1,960	\$7,959	11.34
Darwin	1	Roof insulation to R5.0 600mm shading to N Low e glazing (U: 5.32 SHGC: 0.47)	Hot water to heat pump COP 4.72 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.65	0.60	6.0	\$1,356	\$1,960	\$3,316	4.74
Charleville	19	Roof insulation to R5.0 Wall insulation to R2.5 Double glazing	Hot water to heat pump COP 4.46 Heating to RCAC COP 5.14 Cooling to RCAC EER 6.04	2.05	7.1	\$9,781	\$1,960	\$11,741	15.42
Brisbane	10	Roof insulation to R5.0 Wall insulation to R2.5 Improved Single glazing	Hot water to heat pump COP 4.1 Heating to RCAC COP 5.2 Cooling to RCAC EER 6.39	1.45	6.0	\$6,682	\$1,960	\$8,642	16.92
Townsville	5	Roof insulation to R4.1 Wall insulation to R1.0 Low e glazing to N,E,W	Hot water to heat pump COP 4.46 Heating to RCAC COP 5.14 Cooling to RCAC EER 6.04	1.25	6.0	\$7,212	\$1,960	\$9,172	14.06
Oakey	50	Roof 3.5 Walls 2.0 Double glazing	Hot water to heat pump COP 4.1 Heating to RCAC COP 5.2 Cooling to RCAC EER 6.39	2.45	7.0	\$7,035	\$1,960	\$8,995	15.15
Adelaide	16	Roof insulation to	Hot water to heat pump	1.00	7.1	\$5,681	\$1,960	\$7,641	32.20

Location	NatHERS Climate Zone	Capital Costs							Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)	Total (\$)	
		R4.1	COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32						
Mt Lofty	59	Improved double glazing	Hot water to heat pump COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32	0.70	7.0	\$3,962	\$1,960	\$5,922	14.42
Mt Gambier	61	Standard Double glazing (U: 4.95 SHGC: 0.69)	Hot water to heat pump COP 3.76 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.32	0.65	7.0	\$5,039	\$1,960	\$6,999	24.32
Woomera	45	Wall insulation to 2.5 Double glazing toned	Hot water to heat pump COP 4.04 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.15	0.90	7.0	\$4,051	\$1,960	\$6,011	17.65
Hobart	26	Roof insulation to R5.0 Improved double glazing (U:3.95 SHGC: 0.69)	Hot water to heat pump COP 3.31 Heating to RCAC COP 5.08 Cooling to RCAC EER 5.68	0.80	7.0	\$4,263	\$2,533	\$6,796	19.48
Mildura	27	Wall insulation to 2.5 Improved double glazing	Hot water to heat pump COP 3.84 Heating to RCAC COP 4.82 Cooling to RCAC EER 5.45	0.85	7.0	\$6,666	-\$702	\$5,964	35.36
Ballarat	66	Wall insulation to R2.5 Double glazing	Hot water to heat pump COP 3.6 Heating to RCAC COP 5.22 Cooling to RCAC EER 5.5	0.70	7.0	\$4,443	-\$702	\$3,741	10.94
Melbourne	21	Wall insulation to 2.5 Double glazing	Hot water to heat pump COP 3.6 Heating to RCAC COP 5.22 Cooling to RCAC EER 5.5	0.75	7.0	\$4,443	-\$702	\$3,741	26.61
Katanning	49	Wall insulation to R1.5	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16	0.60	7.0	\$2,475	\$1,960	\$4,435	14.69

Location	NatHERS Climate Zone	Capital Costs							Simple Payback (years)
		Materials Upgrade	Appliances Upgrade	Star Rating Increase	Total Star Rating	Thermal (\$)	Appliances (\$)	Total (\$)	
			Cooling to RCAC EER 5.4						
Newman	40	Wall insulation to R1.5	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.48	0.85	7.1	\$3,267	\$1,960	\$5,227	8.32
Manjimup	57	Wall insulation to R2.0	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	0.80	7.0	\$2,458	\$1,960	\$4,418	14.65
Broome	33	Wall insulation to R2.0	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.48	0.80	6.1	\$3,073	\$1,960	\$5,033	5.15
Halls Creek	37	Roof insulation to R5.0 Wall insulation to R1.5 Improved double glazing toned Fan in each bed/living room	Hot water to heat pump COP 4.81 Heating to RCAC COP 5.14 Cooling to RCAC EER 5.03	0.70	7.0	\$11,852	\$1,960	\$13,812	26.50
Albany	58	Wall insulation to R1.5 Improved single glazing	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	1.10	7.1	\$6,002	\$1,960	\$7,962	26.24
Perth	13	Wall insulation to R1.5 Improved single glazing	Hot water to heat pump COP 3.97 Heating to RCAC COP 5.16 Cooling to RCAC EER 5.4	0.80	7.0	\$5,219	\$1,960	\$7,179	23.18
Swanbourne	52	Wall insulation to 2.0 Double glazing	Hot water to heat pump COP 4.74 Heating to RCAC COP 5.21 Cooling to RCAC EER 5.48	1.05	7.0	\$5,287	\$1,960	\$7,247	23.93

Source: AECOM

Table 11. 7 Star Scenario – Class 1 2018 - Results

Location	NatHERS Climate Zone	Total Annual Values					PV Offsets				
		Operating Cost to consumer (\$)	LPG (MJ)	Gas (MJ)	Elec (MJ)	Total Energy (MJ)	GHG emissions (kgCO2-e)	PV array size offset elec (kWp)	PV offset elec capital cost (\$)	PV array size offset emissions (kWp)	PV offset emissions capital cost (\$)
Canberra	24	\$1,100		-	21,472	21,472	5,666	4.26	\$4,718	4.26	\$4,718
Richmond	28	\$1,930		-	20,906	20,906	5,517	4.51	\$5,089	4.51	\$5,089
Wagga Wagga	20	\$2,056		-	22,296	22,296	5,884	4.58	\$5,221	4.58	\$5,221
Nowra	18	\$1,884		-	20,396	20,396	5,382	4.45	\$5,073	4.45	\$5,073
Moree	8	\$2,162		-	23,453	23,453	6,189	4.27	\$5,346	4.27	\$5,346
Sydney East	17	\$1,875		-	20,300	20,300	5,357	4.50	\$4,984	4.50	\$4,984
Sydney	56	\$1,839		-	19,906	19,906	5,253	4.42	\$4,888	4.42	\$4,888
Alice Springs	6	\$1,804		-	25,232	25,232	5,116	4.31	\$10,735	4.31	\$10,735
Darwin	1	\$2,643		-	36,964	36,964	7,495	6.73	\$17,494	6.73	\$17,494
Charleville	19	\$2,029		-	22,913	22,913	5,919	4.04	\$6,226	4.04	\$6,226
Brisbane	10	\$1,772		-	19,945	19,945	5,153	3.93	\$4,850	3.93	\$4,850
Townsville	5	\$2,196		-	24,853	24,853	6,420	4.90	\$6,466	4.90	\$6,466
Oakey	50	\$1,811		-	20,391	20,391	5,268	3.85	\$4,837	3.85	\$4,837
Adelaide	16	\$2,190		-	20,449	20,449	3,295	4.15	\$4,983	4.15	\$4,983
Mt Lofty	59	\$2,431		-	22,733	22,733	3,663	4.62	\$7,201	4.62	\$7,201
Mt Gambier	61	\$2,223		-	20,761	20,761	3,345	4.72	\$6,507	4.72	\$6,507
Woomera	45	\$2,352		-	21,987	21,987	3,542	3.93	\$6,127	3.93	\$6,127
Hobart	26	\$1,399		-	21,236	21,236	1,003	5.46	\$7,385	5.46	\$7,385
Mildura	27	\$2,042		667	19,697	20,365	6,491	3.87	\$5,441	3.89	\$5,469
Ballarat	66	\$2,116		667	20,418	21,085	6,727	4.62	\$6,194	4.65	\$6,226
Melbourne	21	\$1,919		667	18,507	19,174	6,100	4.19	\$5,614	4.21	\$5,646
Katanning	49	\$1,569		-	20,378	20,378	4,302	4.13	\$4,958	4.13	\$4,958
Newman	40	\$2,099		-	27,392	27,392	5,783	4.76	\$7,533	4.76	\$7,533
Manjimup	57	\$1,530		-	19,861	19,861	4,193	3.90	\$4,491	3.90	\$4,491
Broome	33	\$2,461		-	32,197	32,197	6,797	5.37	\$7,726	5.37	\$7,726
Halls Creek	37	\$2,272		-	29,686	29,686	6,267	5.09	\$7,814	5.09	\$7,814
Albany	58	\$1,472		-	19,082	19,082	4,028	4.29	\$4,738	4.29	\$4,738
Perth	13	\$1,576		-	20,472	20,472	4,322	3.81	\$3,657	3.81	\$3,657
Swanbourne	52	\$1,467		-	19,017	19,017	4,015	3.54	\$3,397	3.54	\$3,397

Source: AECOM