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Effects of Combined Insulation & Draught Proofing Strategies

Report Prepared By

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1. Introduction

Energy Partners has performed studies to investigate the effects of various strategies aimed at improving dwellings originally rated as within the regulatory impact star range of 3.5-4.5 stars. These strategies have included increasing external bulk wall, ceiling, and underfloor insulation, adding insulation to internal walls between differently conditioned zones, and draught proofing the dwellings. These strategies have each been tested individually and showed encouraging results for improving the star rating of a dwelling for their relatively low cost. This study tests how the energy star rating is improved when the strategies are applied in combination.

2. Methodology

A sample of 10 dwellings with timber floors and enclosed subfloors were randomly selected by Energy Partners from the sample of 132 dwellings used in the previous studies for ICANZ in order to test the different improvement strategies in combination. Please see Appendix 1 for sample dwelling details and descriptions.

2.1. Version Creation

Six versions of each dwelling were created as shown below. Each version is an additional improvement on the previous version so that Version 6 combines all five improvement strategies:

Version 1: 'Original'

Original Dwellings (small gaps in windows and doors)

Version 2: 'External Wall Insulation'

As per Version 1 plus additional R1.0 bulk insulation in external walls

Version 3: 'Under Floor Insulation'

As per Version 2 plus additional R2.0 bulk insulation under timber floor

Version 4: 'Internal Wall Insulation'

As per Version 3 plus R1.0 added to internal walls between differently conditioned zones

Version 5: 'Weather-stripped'

As per Version 4 plus all windows and doors weather-stripped

Version 6: 'Sealed Vents'

As per Version 5 plus all 'vents[1]' sealed

Version 7: 'Downlights Removed'

As per version 6 plus all downlights removed (see methodology 2.2 for details)

All versions were simulated using the 2nd generation energy rating software, AccuRate (version 1.1.2). The files were simulated in the hot climate, temperate climate, and cool climates of Darwin, Sydney East, Hobart, and Canberra respectively. Additional simulations were run in the climates covering Tasmania (4 climates) and the Victorian climates (8 Climates).

2.2. "Removing" vented Downlights

The original AccuRate files did not include any vented downlights since none of the architectural plans that they were created from showed downlights. This was judged unrealistic and a separate version (version 7: 'Downlights Removed') was developed to test the effect on the energy rating of removing vented downlights. In practice, this benefit can be obtained by actually removing the downlights (from the plans) or retaining the same number of downlights but requiring them to be of the non-venting type. These non-venting downlights will have LED (Light Emitting Diode) or CFL (Compact Fluorescent Lamp) luminaries whose cool operation obviates the need for the venting.

Downlights were added to the living and dining areas of all 10 dwellings with the number of downlights based on 1 downlight per 3 square metres. AccuRate applies a maximum of 20 in any one zone. Where the calculated number of downlights exceeded this limit, the maximum 20 downlights was used. The benefit of removing the downlights was deemed to be equivalent to the detriment to the simulated star rating caused by adding the downlights.

[1] 'Vents' refers to exhaust fans, ceiling/wall vents, unsealed downlights, unflued gas heaters, and unsealed chimneys.

3. Results

Figures 1-5 illustrate the results for the major climate zones tested. They show the variation in star rating improvement for each dwelling and the different proportions of each strategy in the overall improvement. Large differences between version 5 and version 6 show where dwellings had significant leakages from 'vents' that were sealed (see Appendix 1 for vent details for each dwelling). Some of the strategies show negative effects in dwellings in the hot climate of Darwin and the temperate climate of Sydney. The dwellings are ordered in ascending floor area from left to right.

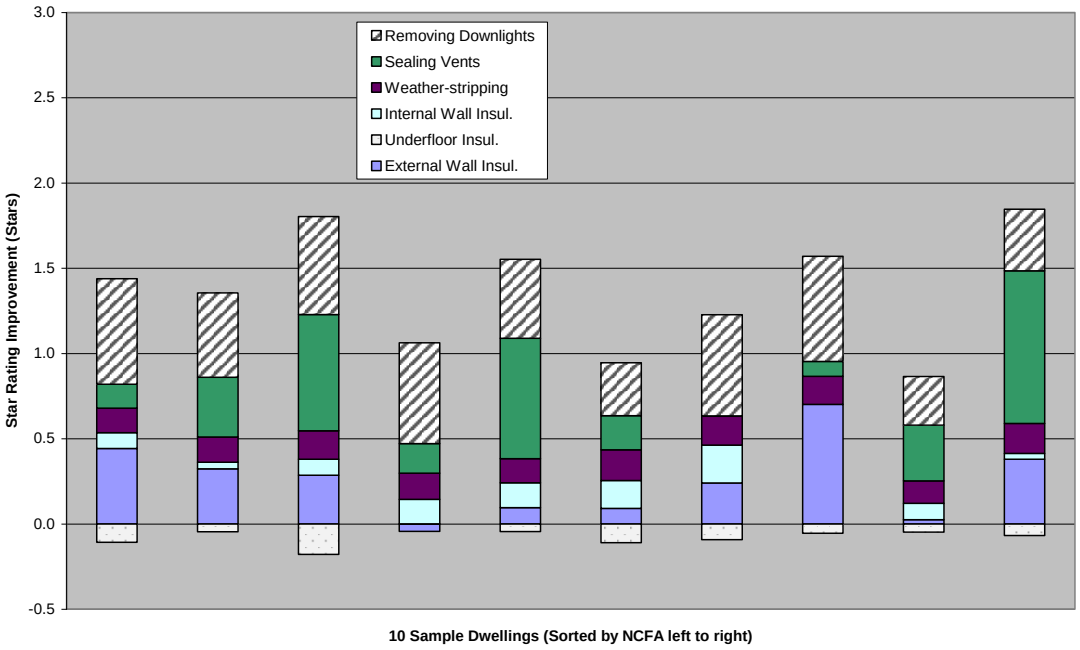

Figure 1: Combined Star Rating Improvement in Darwin

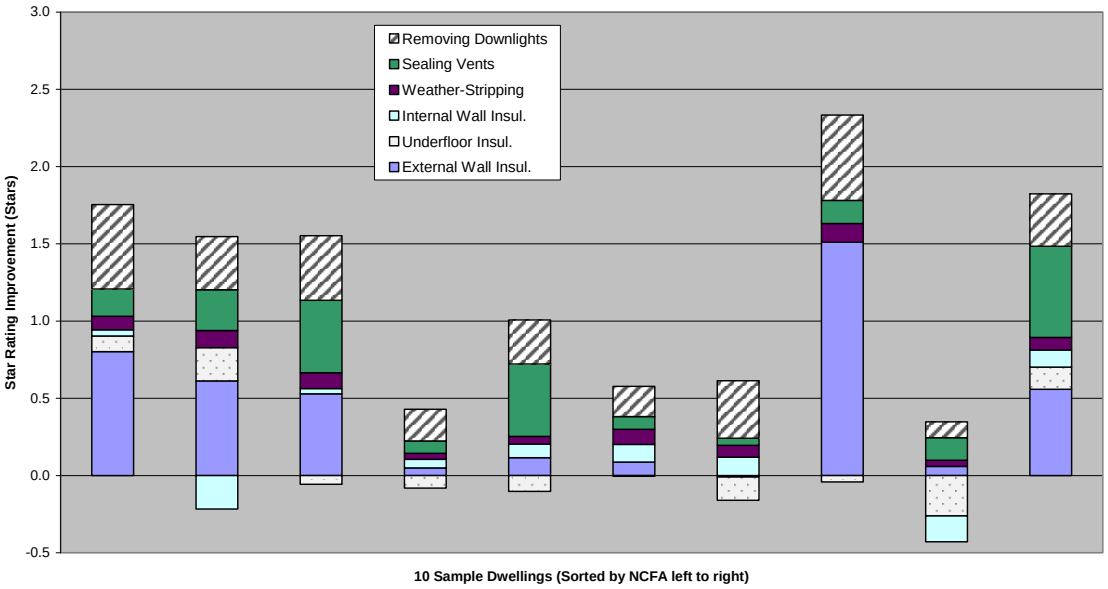

Figure 2: Combined Star Rating Improvement in Sydney East Climate

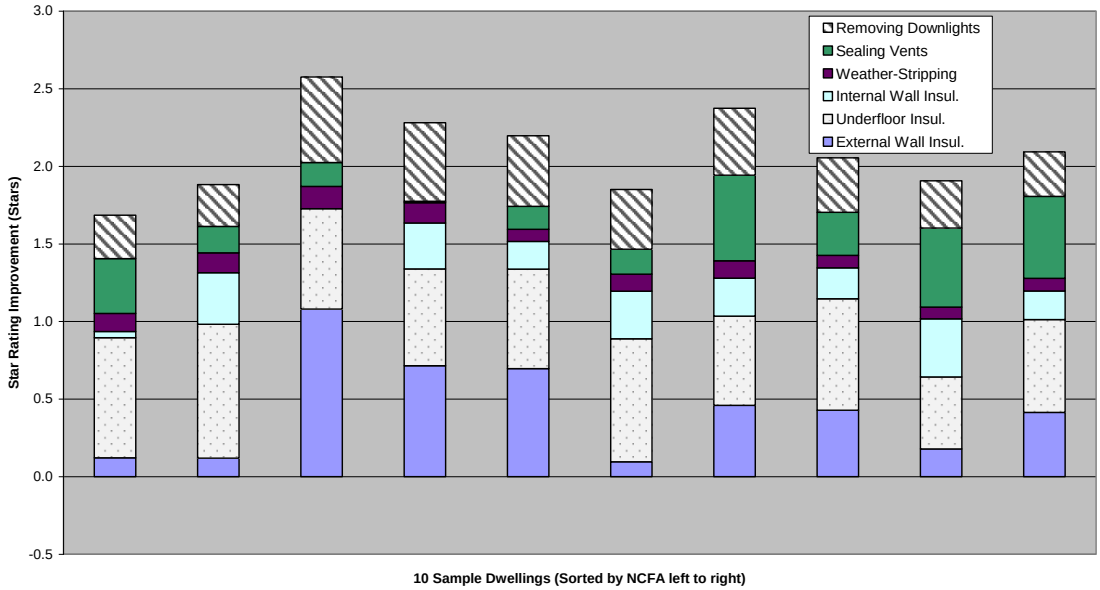

Figure 3: Combined Star Rating Improvement in Hobart Climate

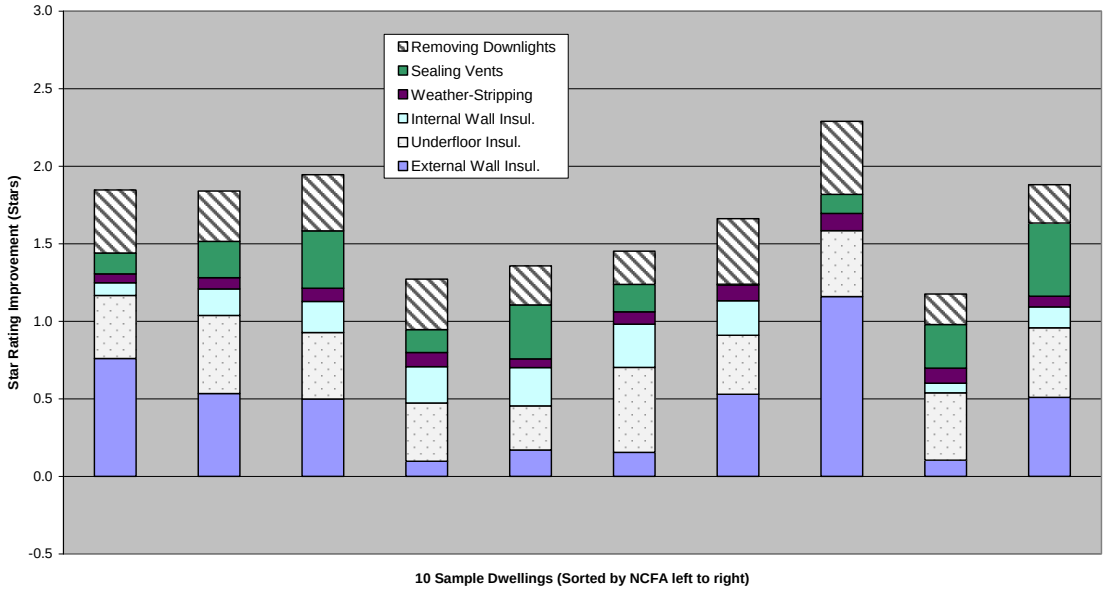

Figure 4: Combined Star Rating Improvement in Canberra Climate

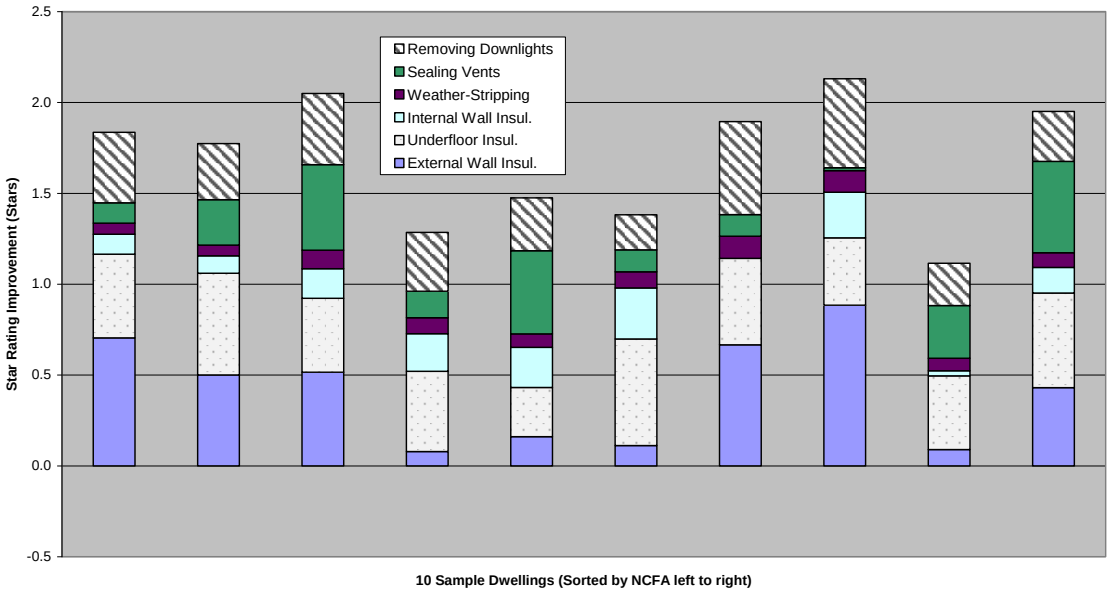

Figure 5: Combined Star Rating Improvement in Melbourne Climate

The graphs show the difference between the hotter climates and the cooler climates with the Melbourne, Canberra and Hobart graphs all following similar patterns. In these cooler climates a number of houses were improved by a star with only the additional R1.0 wall insulation and R2.0 underfloor insulation.

The tables below show the average star rating improvements of each version as a stepped improvement over the previous version (Table 1) and as combined improvement strategies over the original dwelling average rating (Table 2). See Appendix 2 for other Tasmanian climate results and appendix 3 for further Victorian climate results. Note that the 'Sydney' and 'Melbourne' results in Table 1 and 2 are actually the Mascot and Moorabbin climate results respectively since the Sydney Royal Observatory and Melbourne Royal Observatory climate data is only used for the city centres and not the majority of the city.

Version	Star Rating Difference (stepped improvement)				
	Darwin	Sydney	Hobart	Canberra	Melbourne
Additional R1.0 Ext wall insulation	0.254	0.431	0.431	0.452	0.414
Additional R2.0 underfloor insulation	-0.075	-0.024	0.670	0.423	0.450
Additional R1.0 Internal wall insulation	0.103	0.018	0.216	0.163	0.150
Weather-stripping all doors and windows	0.157	0.081	0.106	0.082	0.087
Sealing all external vents	0.356	0.247	0.286	0.229	0.248
Removing downlights	0.491	0.336	0.382	0.322	0.340
Star Rating increase of all improvements	1.287	1.088	2.090	1.672	1.689

Table 1: Results Summary - Stepped improvement of combined strategies

Version	Star Rating Difference wrt Original dwelling				
	Darwin	Sydney	Hobart	Canberra	Melbourne
Additional R1.0 Ext wall insulation	0.254	0.431	0.431	0.452	0.414
As above plus additional R2.0 floor insulation	0.179	0.407	1.100	0.875	0.864
As above plus R1.0 Internal wall insulation	0.282	0.425	1.316	1.038	1.014
As above plus weather-stripping all doors and windows	0.440	0.505	1.422	1.121	1.100
As above plus sealing all external vents	0.796	0.753	1.708	1.350	1.349
As above plus removing all downlights	1.287	1.088	2.090	1.672	1.689

Table 2: Results Summary - Star Rating Improvement over original dwelling

4. Conclusion

The strategies of installing additional insulation to different areas of the dwellings, draught proofing the dwellings, and removing unnecessary downlights were trialed in combination to test their grouped effect on the energy star rating of a dwelling. The results illustrate how these inexpensive and practical modification strategies can lower thermal energy demand and star ratings without affecting the fundamental elements of the design. Underfloor insulation was found to only be beneficial in the cooler climates. The results show the star ratings of dwellings within the regulatory impact star range can be improved on average by over a star in all climates and up to 2 stars in cold climates by combining these insulation and draught proofing strategies.

Appendix 1: Sample dwellings - details and descriptions

Orig Design Location	Filename	NCFA (m^2)	Wall construct	Window Area (m^2)	Description	Vents and other Leakages					
						Chimneys	Wall/ceiling Vents	Exhaust Fans	Original Downlights	New Downlights	Unflued Gas Heaters
ACT	1MDB1006	148.6	Cavity Brick (Uninsul)	41.90	Standard Passive Solar design used for 'Cost Benefit Analysis' study. Rectangular with long edges facing north/south. Northside shading, R1.5 ceiling insulation, metal deck roofing.	0	0	3	0	21	0
Stirling - WA	1WDB1690	157.6	BV (Uninsul)	49.42	North facing separate 4 bedroom with ensuite. Double garage on north-east corner. 480mm eaves plus large west shading to family. Metal deck roof with R2.5 ceiling insulation.	0	4	4	0	20*	0
Swan - WA	1WDB1683	163.8	Cavity Brick (Uninsul)	44.65	4 bedroom with ensuite, open pla meals/kitchen/family, separate games room and dining/lounge area. Garage on northeast corner. Tiled roof, R2.5 ceiling insulation.	0	2	2	0	22	1
VIC - Mornington Peninsula	1PDL1600	176.1	BV + R1.5	41.76	North facing separate 4 bedroom with ensuite. Attached garage on north-west corner. Tiled roof with no eaves and R4.5 ceiling insulation.	0	0	4	0	24	0
WA	1WDB1701	177.5	Cavity Brick (Uninsul)	56.63	4 bedroom, north facing dwelling with aattached garage on northwest corner.R2.5 ceiling insulation, metal deck roof.	0	1	4	0	20*	1
VIC - Casey	1CDB1905	180.4	Cavity Brick + R1.5	41.61	North facing 3 bedroom plus study and ensuite. Separate lounge and dining room, bathroom and garage on southside of building, R2.5 ceiling insulation, metal deck roof.	0	0	3	0	13	0
VIC - Hume	1HDC1621	209.3	BV (Uninsul)	36.81	Separate 4 bedroom with ensuite. Attached garage on north-west corner, north facing living area. Tiled roof with R3.5 ceiling insulation and no eaves.	0	0	3	0	28*	0

Orig Design Location	Filename	NCFA (m^2)	Wall construct	Window Area (m^2)	Description	Vents and other Leakages					
						Chimneys	Wall/ceiling Vents	Exhaust Fans	Original Downlights	New Downlights	Unflued Gas Heaters
VIC - Hume	1HDC1621	209.3	BV (Uninsul)	36.81	Separate 4 bedroom with ensuite. Attached garage on north-west corner, north facing living area. Tiled roof with R3.5 ceiling insulation and no eaves.	0	0	3	0	28*	0
VIC - Hume	1HDC1915	209.3	Cavity Brick (Uninsul)	36.81	Separate 4 bedroom with ensuite. Attached garage on north-west corner, north facing living area. Tiled roof with R3.5 ceiling insulation and no eaves.	0	0	3	0	28*	0
ACT	1BDC1511	215.3	AAC200 + R1.5 & WB + R1.5	70.25	North Facing separate 4 bedroom with trome wall on north wall ans north facing clerestory windows. Half ceiling is insulated with R2.5, raked metal deck with sisalation over other half.	0	1	6	0	18	0
WA	1WDB1705	249.4	Cavity Brick (Uninsul)	51.08	4 bedroom with ensuite and small study. Attached garage, metal deck roof with R2.5 ceiling insulation.	0	1	4	0	18	1

Table 3: Dwelling details and descriptions (*denotes where total downlights installed was limited by the simulation software limit of 20 downlights per zone)

HOUSE #	Darwin	Sydney E	Hobart	Canberra	Melbourne
006	3.8	4.2	4.9	3.7	3.6
690	4.2	3.6	3.8	2.9	2.8
683	3.1	3.8	4.3	3.3	3.0
600	3.2	3.9	4.6	4.4	4.2
701	3.0	3.9	3.5	3.8	3.5
905	3.7	3.8	4.7	4.0	3.8
915	4.0	4.8	2.9	4.6	4.5
621	3.7	4.0	2.6	4.2	4.1
511	1.9	3.4	3.3	4.6	4.3
705	3.7	3.0	2.5	2.9	2.6
Mean	**3.4**	**3.8**	**3.7**	**3.8**	**3.6**

Table 4 **Baseline Star Ratings for Each Dwelling** (see commentary at right)

Baseline star values shown at left are those lowest values for each dwelling in the parametric task of improving the rating by individual improvements to the construction – leaving the plans and elevations unchanged. In several cases, these baseline values fall well below the 4 star value set as a parameter for dwelling selection in this project. Several factors are at work here:

- the original selection was made using the April version of AccuRate,
- the original files had their exhaust fans and other vents previously sealed which were changed to unsealed for this exercise, and
- the generic window definitions and values have been changed.

Appendix 2: Tasmanian Simulation Results

Version Difference	Star Rating Difference			
	Hobart	Launceston (Ti Tree)	Low Head	Launceston (Airport)
"Ext Wall" - "Original"	0.431	0.425	0.395	0.424
"Floor" - "Ext Wall"	0.670	0.591	0.698	0.709
"Int Wall" - "Floor"	0.216	0.193	0.193	0.215
"Weather-stripping" - "Int Wall"	0.106	0.100	0.126	0.106
"Sealed Vents" - "Weather-stripping"	0.286	0.263	0.329	0.284
"Removed Downlights" - "Sealed Vents"	0.382	0.351	0.368	0.361
Combined Strategies - "Original"	2.090	1.924	2.108	2.099

Table 5: Average Star Rating Improvement per additional strategy (Tasmanian Climates)

Version Difference	Star Rating Difference wrt Original dwelling			
	Hobart	Launceston (Ti Tree)	Low Head	Launceston (Airport)
"Ext Wall" - "Original"	0.431	0.425	0.395	0.424
"Floor" - "Original"	1.100	1.016	1.093	1.133
"Int Wall" - "Original"	1.316	1.209	1.285	1.349
"Weather-stripping" - "Original"	1.422	1.309	1.411	1.454
"Sealed Vents" - "Original"	1.708	1.573	1.740	1.738
"Removed Downlights" - "Original"	2.090	1.924	2.108	2.099

Table 5: Average Star Rating Improvement over Original dwellings (Tasmanian Climates)

Appendix 3: Victorian Simulation Results

Simulations were run for the climates listed in Table 6, covering all major Victorian climates. Simulation results are shown in Table 7 and 8.

Climate Code	Climate Name	AccuRate Climate #
CZ0411	Mildura	57
CZ0606	Tullamarine	90
CZ0608	Melbourne RO	51
CZ0609	Moorabbin	92
CZ0610	East Sale	52
CZ0611	Warrnambool	93
CZ0612	Cape Otway	94
CZ0704	Ballarat	96

Table 6: Victorian Climates

Version Difference	Star Rating Difference							
	Mildura	Tullamarine (Melbourne Airport)	Melbourne RO	Moorabbin	East Sale	Warrnambool	Cape Otway	Ballarat
"Ext Wall" - "Original"	0.403	0.441	0.442	0.414	0.428	0.459	0.428	0.464
"Floor" - "Ext Wall"	0.426	0.450	0.328	0.450	0.446	0.486	0.459	0.467
"Int Wall" - "Floor"	0.159	0.163	0.164	0.150	0.159	0.172	0.154	0.157
"Weather-stripping" - "Int Wall"	0.099	0.097	0.094	0.087	0.094	0.095	0.090	0.085
"Sealed Vents" - "Weather-stripping"	0.234	0.251	0.262	0.248	0.261	0.256	0.256	0.236
"Removed Downlights" - "Sealed Vents"	0.343	0.343	0.334	0.340	0.352	0.351	0.346	0.306
Combined Strategies - "Original"	1.663	1.744	1.624	1.689	1.740	1.818	1.734	1.715

Table 7: Stepped Star Rating Improvements in Victoria

Version Difference	Star Rating Difference wrt Original dwelling							
	Mildura	Tullamarine (Melbourne Airport)	Melbourne RO	Moorabbin	East Sale	Warrnambool	Cape Otway	Ballarat
"Ext Wall" - "Original"	0.403	0.441	0.442	0.414	0.428	0.459	0.428	0.464
"Floor" - "Original"	0.828	0.891	0.770	0.864	0.874	0.945	0.887	0.931
"Int Wall" - "Original"	0.987	1.054	0.935	1.014	1.033	1.116	1.041	1.088
"Weather-stripping" - "Original"	1.086	1.150	1.029	1.100	1.128	1.211	1.131	1.173
"Sealed Vents" - "Original"	1.320	1.402	1.290	1.349	1.388	1.467	1.387	1.410
"Removed Downlights" - "Original"	1.663	1.744	1.624	1.689	1.740	1.818	1.734	1.715

Table 8: Star Rating Difference over Original Dwelling (Victorian Climates)