

# BUILDING ENERGY & ENVIORNMENTAL PERFORMANCE ASSESSMENT



STEVE PETTITT | S3418953 | BUSM4460 | 02/05/2021 I declare that in submitting all work for this assessment I have read, understood and agree to the content and expectations of the Assessment Declaration.

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# EXECUTIVE SUMMARY

Two versions of the YourHome Design for Place houses were modelled under both the Reference Meteorological (RMY) and Ersatz Future Meteorological Year (EFMY) climate scenarios. The RMY is based on weather data from 1976 to 2004, whilst the EFMY is based on climate projections to 2050. The two houses assessed were the Banksia House, specified to 8.1-stars, and a modified version with a hipped roof and specified to the NCC DTS minimum standards (BCA House).

Each climate scenario modelled both houses with and without space conditioning. The results for the historical climate scenario were mostly unsurprising, with Banksia House 47% less energy intensive. The two surprises from these two simulations were the Banksia House providing the highest maximum temperature (thought to be attributable to the higher levels of internal thermal mass), and the significant energy impacts of seemingly small internal temperature changes. The outcomes of the simulations without space heating led to the assumption that Banksia House performs better when the heat flow direction is outwards, whereas when the direction is inwards the two designs are of virtually equal performance.

The future climate scenario simulations revealed that seemingly minor increases in temperature resulted in a projected increase in annual energy intensity of 11.22MWh (20%) and 19.57MWh (19%) for Banksia House and BCA House, respectively. This is even though the annual heating load for both designs dropped by 67% (Banksia House) and 68% (BCA House), demonstrating a potential shift from heating-dominated climate to a potentially cooling-dominated climate.

Three optimisation options were presented, along with their outcomes:

- Optimisation 1:
- Optimisation 2:
- Optimisation 3:
- Combined Optimisation:

The outcomes of the simulations led to the discussion of possible key consequences and considerations. These included:

- The inadequacy of current energy efficiency standards for a changing climate.
- The potential risk of future temperature extremes and the possible need for climate safe rooms.
- The potential shift from a heating to cooling dominated climate.
- The potential impact of a changing of our seasons.

All of these elements led to the conclusion that homes built today must be done so with consideration of their potential future climate and what that means for both the designers and builders, along with the occupants of such buildings.

# INTRODUCTION

Scientific consensus tells us that our climate is changing and its cause it largely anthropogenic (Cook et al. 2016; Oreskes 2004; Oreskes 2014; Powell 2016; William et al. 2010). Yet, NatHERS accredited energy rating software currently derives its Reference Meteorological Year (RMY) from the Australian Bureau of Meteorology weather data for the period 1976 to 2004 (NatHERS 2019a). Given that the Australian Building Codes Board assumes an average minimum design life of residential buildings to be 50 years (ABCB 2015, p.4), achieving compliance under "current" modelling parameters may prove insufficient for even the current climate.

Within this context, this report aims to assess two versions of the freely available three-bedroom, two-bathroom Banksia House provided via the YourHome *Design for Place* initiative (YourHome 2021a). YourHome is an Australian Government initiative intended to provide impartial best-practice guidance on the design and construction of sustainable homes (YourHome 2021b).

# METHODOLOGY

Banksia House (Figure 1) comes with an 8.1-star specification guide, which was utilised for this report. The second house assessed in this report was the modified Banksia House (BCA House) (Figure 2). This differed to Banksia House by its hipped roof (removal of clerestory windows), and its minimum specifications as per the National Construction Code Volume 2 (NCC Vol.2) elemental deemed to satisfy (DTS) energy efficiency provisions (ABCB 2019b).



Figure 1 Banksia House



Figure 2 BCA House

Both versions were assessed under the RMY and Ersatz Future Meteorological Year (EFMY) (projected climate to 2050) climate scenarios for Moorabbin, via Integrated Environmental Solutions Virtual Environment (IES VE) software. Whilst IES VE is not an accredited NatHERS software (NatHERS 2012), it was chosen as it allows for modelling under custom climate scenarios such as the EFMY.

## ASSUMPTIONS & JUSTIFICATIONS

Firstly, it must be acknowledged that climate modelling, as with the modelling of any complex system, is not a perfect science and should be used as a guide not a definitive scenario (Raäisaänen 2007; Webster et al. 2002). As such, whilst this report will provide recommendations, the main purpose is not to provide definitive outcomes, but to provide a level of understanding of potential scenarios.

As models are not exact replicas of reality, there are many assumptions and simplifications that must be integrated to provide a simple, yet accurate model. Table 1 outlines the inputs, assumptions, and justifications of the modelling of both houses.

Building	Banksia House	Justification	BCA House	Justification
Element				
Root	Metal sheet roofing, 20mm cavity, reflective foil wrap, R1.3 bulk insulation (Appendix 1).	As specified, with cavity added to allow for correct installation of reflective foil	Pitched roof with 12mm clay tiles (solar absorptance of 0.5) and R5.0 bulk insulation (Appendix 2).	As specified, with bulk insulation required to meet the minimum total system R-value of R5.1 as per NCC Vol.2 Part 3.12.1.1f (climate zone 6) (ABCB 2019b), and plasterboard modelled separately as the ceiling.
Ceiling	R4.1 bulk insulation on 10mm plasterboard (Appendix 3)	As specified.	10mm plasterboard.	As specified.
External Walls	Reverse brick veneer: 9mm timber weatherboard, 20mm cavity, vapour permeable membrane, R2.5 bulk insulation, 10mm plasterboard (Appendix 4).	As specified, with reflective foil replaced with vapour permeable wrap and 20mm cavity added to avoid condensation issues (ABCB 2019a).	Plaster render externally (15mm) on 110mm brick, 20mm cavity, vapour permeable sarking, R2.4 bulk insulation in 90 mm timber frame and 10mm gypsum plasterboard	As specified, with cavity added to allow for proper installation of wall wrap and condensation management (ABCB 2019a), and bulk insulation added to achieve the
	Lightweight weatherboard: 9mm timber weatherboard, 20mm cavity, vapour permeable membrane, R2.5 bulk insulation, 10mm plasterboard (Appendix 6)	As specified, with reflective foil replaced with vapour permeable wrap and 20mm cavity added to avoid condensation issues (ABCB 2019a).	plasterboard (Appendix 5).	minimum total system R-value of 2.8 as per NCC Vol.2 Part 3.12.1.4(b)(ii) (ABCB 2019b).

#### Table 1 Specifications

Internal	Uninsulated timber stud: 10mm	As specified.	10mm plasterboard,	As specified.
Walls	plasterboard, 90mm cavity,		90mm cavity, 10mm	
	10mm plasterboard.		plasterboard.	
	Insulated timber stud: 10mm			
	plasterboard B2.5 bulk insulation			
	10mm plasterboard			
	110mm single briek			
		A	200	A
FIOOF	(CCOC) it has a state of ground	As specified, with	200mm concrete	As specified. Left
	(CSOG) with burnished concrete	concrete tiles	floor.	untinished
	to living and bedrooms (Appendix	used as a proxy		throughout to
	7), carpet to walk in robe (WIR)	for ceramic tiles		maximise impact of
	(Appendix 8), and concrete tiles	as there were		thermal mass.
	to wet areas (Appendix 9).	unavailable in the		
		software. (Note		
		that wet areas as		
		defined by the		
		NCC Vol.2 do not		
		include kitchens		
		(ABCB 2019b).		
Doors	Internal 45mm solid timber door	As specified, as	Internal 45mm solid	As per NatHERS
20013	(height 2340mmm) with	ner NatHFRS	timber door (height	Technical Note 2019
	openable area of 90% and crack	Technical 2019	2340mmm) with	and IFS MacroFlow
	flow efficient of 1.3	and the JES	openable area of	Opening Types
	now encient of 1.5.		00% and crack flow	(2021) respectively
			90% and crack now	(2021), respectively.
	Futamal 45 mars as list time have do an	Upening Types	Encient of 1.3.	
	External 45mm solid timber door	User Guide	External 45mm solid	
	(neight 2400mmm), with	(2021),	timber door (neight	
	openable area of 90% and crack	respectively	2400mmm), with	
	flow efficient of 2.7.	(Appendix 10).	openable area of	
			90% and crack flow	
			efficient of 2.7.	
Windows	All double glazed, 6mm panes,	As specified, with	Aluminium framed	As specified, with
	with 12mm argon-filled cavity	openable areas	single glazed	openable areas and
	(Appendix 11), with multiple	and crack flow	window, 6mm clear	crack flow efficiency
	types:	efficiency as per	glass. Openable	as per NatHERS
	<ul> <li>Fixed window, 0%</li> </ul>	NatHERS	areas and crack flow	Technical Note 2019
	openable area, 0.0 crack	Technical Note	coefficients as per	and IES MacroFlow
	flow coefficient.	2019 (Table 5,	Banksia House.	(2021), respectively.
	Casement window, 90%	p.10) and IES		Openable area of
	openable area, 0.13 crack	MacroFlow (2021,		windows with
	flow coefficient.	p.12-13),		multiple opening
	Half casement. half fixed	respectively.		types determined on
	window, 45% openable	Openable area of		a proportional basis
	area. 0.13 crack flow	windows with		
	coefficient	multiple opening		
	One third casement two	types determined		
	+ One third casement, two	on a proportional		
	openable area 0.12 areal	hasis		
	upenable area, U.13 CraCK			
	TIOW coefficient.			
	Halt awning, half fixed			
	window, 45% openable			
	area, 0.13 crack flow			
	coefficient.			

	<ul> <li>Sliding window, 45% openable area, 0.15 crack flow coefficient.</li> </ul>			
Space Conditioning	Central heating and cooling via	As specified.	As per Banksia	Kept the same as
System	Heating and cooling profiles and internal gains as per the NatHERS Protocol (2012) (Appendix 13).		nouse.	allow for comparison between the two thermal envelopes.
Natural Ventilation	As per Baharun and Chen (2009) (cited in NatHERS protocol 2012). Air changes per hour (ACH) as per NCC Vol.2 Part 2.6.2.2(b)(ii) (ABCB 2019b).	As specified.	As per Banksia House. Air changes per hour (ACH) as per NCC Vol.2 Part 2.6.2.2(b)(ii) (ABCB 2019b).	As specified.

### ADDITIONAL ASSUMPTIONS

- No hot water system or mechanical ventilation systems were modelled.
- Assumed 450mm eaves for entire perimeter of the BCA House.
- The ceiling for both houses was modelled as 2.55m as a halfway point between the two ceiling heights or 2.4m for the Kitchen, Bathroom, Ensuite, Garage, Study, Laundry, WIR, and both Halls and 2.7m for Bed 2 and Bed 3.
  - Bed 1 and Kitchen/Dining were modelled as raked ceilings as per the supplied plans.
  - The averaging of the remaining ceiling heights was done to simplify the model and reduce errors.
- All finished floor levels (FFL) modelled as 0m to simplify the model.
- It is assumed that both houses are all-electric, supplied by the Victorian electricity grid.
  - Such electricity is considered to have an emissions factor of 1.09kg CO<sub>2</sub>-e/GJ (DISER 2020, p.71).

### LIMITATIONS

Used with an understanding of its limitation, building simulations provide an opportunity to effectively test the suitability of multiple design options. However, using such models under the pretence of real-world replication can lead to ineffective and costly design solutions.

Due to the nature of building simulations, the need for simplicity often exceeds that of accuracy. Consequently, there were several additional limitations encountered throughout the modelling process. These were:

- The Entry Hall skylight was not modelled.
  - This was due to recurring errors in the simulation, and it being deemed an element of only minor importance.
- The eaves of the BCA House were modelled as floors.
  - This was due to a software bug that was unable to be remedied. It was not considered to have a major impact on results.
- Overall limits to complexity.
  - Optimisation options were limited to specification adjustments due to the difficulty in simulating complex geometry changes.

# RESULTS & FINDINGS

Included in this section of the report are the results and findings from the simulations of both design options, with and without space conditioning, along with three design optimisation strategies for Banksia House in the future climate. Detailed analysis was conducted on both the Kitchen/Living/Dining (KLD) open plan area as well as Bed 2. These two rooms were selected as the KLD was the largest daytime occupied room, and Bed 2 was located on the north west corner, making it the most susceptible room to overheating in a warming future climate.

## HISTORICAL CLIMATE SCENARIO

### WITH SPACE CONDITIONING

The outcomes presented in Table 2 were largely expected given the purported star ratings of the two designs (8.1 stars for Banksia House and 6-star minimum for BCA House). As expected, Banksia House significantly outperformed BCA House on all the energy, and subsequently environmental, performance metrics. This is best presented by the annual energy intensity difference of almost 50%.

Performance Metric		Banksia House	BCA House	Difference	
				Total	%
Annual Energy In	tensity (kWh/m2)*	44.42	83.43	39.01	47
Annual Heating L	oads (MWh)	5.90MWh	8.78MWh	2.88	33
Annual Cooling L	oads (MWh)	1.74MWh	5.57MWh	3.83	69
Peak Heating Loads (kW)		6.28 7.30am 21 July	12.37 7.30am 21 July	6.05	49
Peak Cooling Loads (kW)		23.14 4.30pm 25 Jan	26.32 4.30pm 7 March	3.18	12
Kitchen/Living/	Annual Min. Temp. (°C)	14.64 6.30am 21 July	13.55 6.30am 21 July	1.09	7
Dining	Annual Max. Temp. (°C)	30.54 1.30am 4 Jan	28.95 2.30am 4 Jan	1.59	5
	Average Annual Temp. (°C)	20.53	20.67	0.14	1
Bed 2	Annual Min. Temp. (°C)	17.30 5am 19 May	16.97 3.30 24 July	0.33	2
	Annual Max. Temp. (°C)	31.28 3.30pm 4 Feb	32.44 3.30pm 10 Jan	1.16	4
	Average Annual Temp. (°C)	20.95	21.10	0.15	1

Table 2 Historical Climate Results with Space Conditioning

\*Excluding garage.

However, the main surprise comes from the small change in internal temperatures that resulted in such significant energy consumption differences. Whilst the average annual temperature difference was only 1% for both rooms, the minimum and maximum temperatures are what appear to drive energy consumption. These figures are noticeably closer, with Bed 2 recording only a 2% and 4% difference the two houses for the minimum and maximum temperature, respectively. The KLD offered a slight anomaly, with Banksia House experiencing a 5% greater maximum temperature, whilst having a 7% higher minimum temperature. These similarities are illustrated in Figure 3 and Figure 4.

The higher maximum temperature in the KLD for Banksia House is likely attributable to the higher levels of thermal mass resulting from the reverse brick veneer external walls to the east, south, and west, and the internal brick walls to this room. This thermal mass stores and releases heat, evening out temperature variations throughout the day when temperatures rise and fall. However, after a number of consecutive hot days with limited overnight cooling, thermal mass can become a negative, inhibiting the ability of the house to passively cool itself by storing and radiating excess heat.



### WITHOUT SPACE CONDITIONING

Table 3 shows that, on average, Banksia House was warmer than BCA House when no space conditioning is used. This may be considered an advantage in winter but may equally be a disadvantage in summer, or even possibly a warming climate. Whilst the maximum temperatures are both separated by less than 1%, the minimum temperatures differ by 10% and 14% for the KLD and Bed 2, respectively. This leads to the assumption that Banksia House performs better when the heat flow direction is outwards, whereas when the direction is inwards the two designs are of virtually equal performance.

Room	Performance Metric	Banksia House	BCA House	Differ	ence
				Total	%
Kitchen/Living/	Annual Min. Temp. (°C)	10.44 7.30am 16 June	9.40 6.30am 21 July	1.04	10
Dining	Annual Max. Temp. (°C)	42.27 2.30pm 7 March	42.24 2.30pm 7 March	0.03	<1
	Average Annual Temp. (°C)	18.83	18.57	0.26	1
Bed 2	Annual Min. Temp. (°C)	11.12 6.30am 16 June	9.61 6.30am 21 July	1.51	14
	Annual Max. Temp. (°C)	42.16 2.30pm 7 March	42.14 2.30pm 7 March	0.02	<1
	Average Annual Temp. (°C)	18.54	17.85	0.69	4

Table 3 Historical Climate Results Without Space Conditioning

Figures 5 and 6 clearly illustrate the similarity in maximum temperatures, following an almost identical pattern. They also show the greater temperature ranges in BCA House depicted by the greater area of blue (Figure 6).



### FUTURE CLIMATE SCENARIO

### WITH SPACE CONDITIONING

Table 4 demonstrates the impact of a changing climate, in this example increasing the average annual internal temperatures in the KLD and Bed 2 by 1.34°C and 1.15°C in Banksia House, and 1.4°C and 1.10°C respectively in BCA House.

Whilst seemingly minor, these increases in temperature resulted in a projected increase in annual energy intensity of 11.22MWh (20%) and 19.57MWh (19%) for Banksia House and BCA House, respectively. This is even though the annual heating load for both designs dropped by 67% (Banksia House) and 68% (BCA House), clearly indicating a warming climate. Figures 7 and 8 demonstrate this shift in heating and cooling demand for the BCA House, seen by the increase in number and height of blue lines (cooling) and the flattening of the red lines (heating). This brings into question the current thought that Melbourne (climate zone 6) is a predominantly heating dominated climate.

Interestingly, despite these increases in annual energy intensity, the difference between Banksia House and BCA House regarding this metric was virtually unchanged (dropping from 47% to 46%). This may be cautiously interpreted that whilst a good design today may become a less good design in the future, a bad design today will likely only get worse.

Table 4 Future Climate Scenario Results with Space Heating

Performance Metric		Banksia House	BCA House	Difference	
				Total	%
Annual Energy In	tensity (kWh/m2)	55.64	103.00	47.36	46
Annual Heating L	oads (MWh)	1.95	2.77	0.82	30
Annual Cooling L	oads (MWh)	7.62	14.95	7.33	49
Peak Heating Loads (kW)		5.50 7.30am 16 Aug	10.41 7.30am 16 Aug	4.91	47
Peak Cooling Loa	ds (kW)	32.28 3.30pm 19 April	34.23 4.30pm 7 March	1.95	6
Kitchen/Living/	Annual Min. Temp. (°C)	15.49 6.30am 16 Aug	14.76 6.30am 16 Aug	0.73	5
Dining	Annual Max. Temp. (°C)	30.73 3.30pm 9 March	30.69 4.30pm 8 March	0.04	<1
	Average Annual Temp. (°C)	21.87	22.07	0.24	1
Bed 2	Annual Min. Temp. (°C)	17.62 3.30pm 27 June	17.23 8.00am 16 Aug	0.39	2
	Annual Max. Temp. (°C)	32.55 1.30pm 31 Dec	32.73 3.30pm 7 March	0.18	1
	Average Annual Temp. (°C)	22.10	22.20	0.10	<1

Another interesting change is that all maximum and minimum temperature dates moved to later in the year, barring the maximum annual temperature of Banksia Houses' Bed 2. This highlights another key design consideration for future buildings, with potential adjustments to current passive solar design strategies necessary for a changing climate.



### WITHOUT SPACE CONDITIONING

Without space conditioning the differences in internal temperatures between the two buildings became more obvious. Table 5 shows an increase in the temperature difference between each performance metric, except for the KLD annual maximum temperature which remained unchanged. This further reinforces the possibility that homes that are designed only to meet the minimum energy standards of today will be increasingly uncomfortable and energy intensive over their design life. It is also noteworthy that the maximum temperature for both rooms in both houses exceeded 45°C in this scenario.

Room	Performance Metric	Banksia House	BCA House	Difference	
				Total	%
Kitchen/Living/	Annual Min. Temp. (°C)	12.67 7.30am 28 June	17.79 11.30pm 17 June	5.12	29
Dining	Annual Max. Temp. (°C)	45.85 3.30pm 7 March	45.99 3.30pm 7 March	0.14	<1
	Average Annual Temp. (°C)	21.80	23.71	1.91	8
Bed 2	Annual Min. Temp. (°C)	13.11 8.30am 28 June	17.14 2.30am 27 Sept	4.03	24
	Annual Max. Temp. (°C)	46.10 3pm 7 March	46.41 3.30pm 7 March	0.31	1
	Average Annual Temp. (°C)	21.67	24.96	3.29	13

#### Table 5 Future Climate Scenario Results Without Space Heating

## OPTIMISED FUTURE BANKSIA HOUSE

#### **OPTIMISATION 1**

Increasing ceiling in this instance proved the most effective optimisation option, reducing overall energy intensity by 22% and seeing a reducing in both annual average and maximum temperatures for both rooms. This was achieved by effectively flipping the internal conditioning demands from predominantly cooling back to predominantly heating, with a 77% reduction in cooling demand and 66% increase in heating demand.

Figures 9 and 10 illustrate this change clearly. There is a clear reduction in the height and number of blue columns from Figure 9 to Figure 10, showing a reduction in cooling demand. Equally, there is a clear widening of the red lines in Figure 10, demonstrating an increase in heating demand in the warmer months. The red lines also appear higher in Figure 10 but when considering the y axis scale, this is not the case.

Table 6 Increased Bulk Ceiling Insulation to R6.0

Performance Metric		Banksia House	Optimisation 2	Difference	
				Total	%
Annual Energy In	tensity (kWh/m2)	55.64	43.60	12.40	22
Annual Heating L	oads (MWh)	1.95	5.78	3.83	66
Annual Cooling L	oads (MWh)	7.62	1.72	5.90	77
Peak Heating Loa	ids (kW)	5.50 (7.30am, 16 Aug)	6.19 (7.30am, 21 July)	0.69	11
Peak Cooling Loa	ds (kW)	32.28 (3.30pm, 19 April)	23.11 (4.30pm, 25 Jan)	9.17	28
Kitchen/Living/	Annual Min. Temp. (°C)	15.49 (6.30am, 16 Aug)	14.68 (6.30am, 21 July)	0.81	5
Dining	Annual Max. Temp. (°C)	30.73 (3.30pm, 9 March)	30.44 (1.30am, 4 Jan)	0.29	1
	Average Annual Temp. (°C)	21.87	20.54	1.33	6
Bed 2	Annual Min. Temp. (°C)	17.62 (3.30pm, 27 June)	17.35 (3.30pm, 24 July)	0.27	2
	Annual Max. Temp. (°C)	32.55 (1.30pm, 31 Dec)	31.28 (3.30pm, 4 Feb)	1.27	4
	Average Annual Temp. (°C)	22.10	20.96	1.14	5



Figure 9 Banksia House Heating & Cooling Loads

Figure 10 Optimisation 1 Heating & Cooling Loads

### **OPTIMISATION 2**

The best option for reducing internal temperatures is generally always going to be stopping the heat at its source. In this instance, the source are the windows. During winter they provide free passive solar gain, keeping the heating demands low. However, if not appropriately located and covered they can pose a significant risk for overheating in summer.

Performance Metric		Banksia House	Optimisation 3	Difference	
				Total	%
Annual Energy In	ntensity (kWh/m2)	55.64	43.37	12.27	22
Annual Heating	Loads (MWh)	1.95	5.85	3.90	67
Annual Cooling I	oads (MWh)	7.62	1.61	6.01	79
Peak Heating Lo	ads (kW)	5.50 (7.30am, 16 Aug)	6.10 (7.30am, 21 July)	0.60	10
Peak Cooling Loads (kW)		32.28 (3.30pm, 19 April)	20.96 (3.30pm, 25 Jan)	11.32	35
Kitchen/Living/	Annual Min. Temp. (°C)	15.49 (6.30am, 16 Aug)	14.75 (6.30am, 21 July)	0.74	5
Dining	Annual Max. Temp. (°C)	30.73 (3.30pm, 9 March)	29.58 (2.30am, 4 Jan)	1.15	4
	Average Annual Temp. (°C)	21.87	20.54	1.33	6
Bed 2	Annual Min. Temp. (°C)	17.62 (3.30pm, 27 June)	17.30 (3.30pm, 24 July )	0.32	2
	Annual Max. Temp. (°C)	32.55 (1.30pm, 31 Dec)	39.45 (2.30pm, 7 March)	6.90	17
	Average Annual Temp. (°C)	22.10	20.93	1.17	5

Table 6 Adjustable Shading to all Windows

In this instance, shutters were provided to all windows, with a resistance value of 1m<sup>2</sup>K/W (Appendix 14), and an operating profile of closing at indoor temperatures above 24°C between 8am and 8pm (Appendix 15). This resulted in a similar overall reduction in energy intensity (22%) and overall performance changes as Optimisation 1.

However, there were two notable differences. The annual maximum temperature unexpectedly rose by over 17% to a significant 39.45°C. It is not definitively understood why this was the case but is assumed to possibly be a result of reduced ventilation due to the drawn shutters. This is surprisingly coupled with an overall reduction in peak cooling loads, falling by 35% (27% for Optimisation 1). This is most clearly denoted by the change in y axis values from Figure 10 to 12, reducing from 24kWh to 21kWh.



### **OPTIMISATION 3**

Bulk insulation batts are now commonly available in 90mm thicknesses, allowing for the installation in standard 90mm stud frames. This increase from R2.5 to R2.7 was considered an easy optimisation to make and resulted in significant energy savings. The energy intensity fell by 21%, with a similar profile to that of Optimisation 1. The heating and cooling demand change is again depicted by a comparison with the original Banksia House in Figures 13 and 14.

Performance Metric		Banksia House	Optimisation 1	Difference	
				Total	%
Annual Energy In	tensity (kWh/m2)	55.64	44.01	11.63	21
Annual Heating L	oads (MWh)	1.95	5.84	3.89	67
Annual Cooling L	oads (MWh)	7.62	1.73	5.89	77
Peak Heating Loads (kW)		5.50 (7.30am, 16 Aug)	6.25 (7.30am, 21 July)	0.75	12
Peak Cooling Loads (kW)		32.28 (3.30pm, 19 April)	22.05 (4.30pm, 25 Jan)	10.23	32
Kitchen/Living/	Annual Min. Temp. (°C)	15.49 (6.30am, 16 Aug)	14.65 (7.30am, 21 July)	0.84	5
Dining	Annual Max. Temp. (°C)	30.73 (3.30pm, 9 March)	30.53 (1.30am, 4 Jan)	0.20	1
	Average Annual Temp. (°C)	21.87	20.54	1.33	6
Bed 2	Annual Min. Temp. (°C)	17.62 (3.30pm, 27 June)	17.32 (3.30pm 24 July)	0.30	2
	Annual Max. Temp. (°C)	32.55 (1.30pm, 31 Dec)	31.28 (3.30pm 4 Feb)	1.27	4
	Average Annual Temp. (°C)	22.10	20.96	1.14	5

 Table 7 Increased Wall Insulation to R2.7



### COMBINED OPTIMISATION'S

As with the modelling of any complex system, the combined outcome is not as simple as the sum of each of its parts. In this instance, a combined overall energy intensity reduction of 24% was achieved. Whilst this was slightly disappointing given the reductions of the individual optimisations, it still represents a significant energy saving and likely increase in occupant comfort.

Given more time, an analysis of how each option impacts on the other would be a pertinent exercise. Due to the time restrictions and excessive simulation times, this was not considered practical in this instance.

Performance Metric		Banksia House	Combined	Difference	
			Optimisations	Total	%
Annual Energy Ir	ntensity (kWh/m2)	55.64	42.27	13.37	24
Annual Heating	Loads (MWh)	1.95	5.68	3.73	66
Annual Cooling I	.oads (MWh)	7.62	1.59	5.63	74
Peak Heating Loads (kW)		5.50 (7.30am, 16 Aug)	5.96 (7.30am, 21 July)	0.46	8
Peak Cooling Loa	ads (kW)	32.28 (3.30pm, 19 April)	22.25 (3.30pm, 25 Jan)	10.03	31
Kitchen/Living/	Annual Min. Temp. (°C)	15.49 (6.30am, 16 Aug)	14.81 (6.30am, 21 July)	0.68	4
Dining	Annual Max. Temp. (°C)	30.73 (3.30pm, 9 March)	30.12 (1.30am, 4 Jan)	0.61	2
	Average Annual Temp. (°C)	21.87	20.56	1.31	6
Bed 2	Annual Min. Temp. (°C)	17.62 (3.30pm, 27 June)	17.38 (3.30pm, 24 July)	0.24	1
	Annual Max. Temp. (°C)	32.55 (1.30pm, 31 Dec)	28.71 (1.30pm, 24 Feb)	3.84	12
	Average Annual Temp. (°C)	22.10	20.95	1.15	5

 Table 7 Increased Wall Insulation to R2.7







## DISCUSSION

Considering the results and findings presented above, it appears appropriate at this point to reiterate that the ABCB (2015) defines the design life of the average residential building as 50 years. The future climate scenario used in this modelling was projected to 2050 – less than 30 years from today. Should these projected temperature increases continue linearly for another 20 years beyond 2050 then the performance of such buildings will likely deteriorate further.

Furthermore, with maximum temperatures in both rooms for both houses projected to exceed 45°C in the future climate scenario, consideration around resilience and safety of occupants in the event of power outages should be a vital design concern. Such considerations can already be seen in the example of the Climate Safe Rooms initiative by Geelong Sustainability (2021) which looks to retrofit one room in a house to ensure the safety of its occupants during extreme heat or cold weather events.

The outcomes of the simulations also show that creating such Climate Safe Rooms and the like via passive design principles may require a slight rethink. The future climate scenario illustrated a change in the timing of both maximum and minimum temperature dates, moving to later in the year. This impacts design considerations around the need for more operable shading devices in place of fixed shading due to more extreme temperatures outside of the summer and winter months.

Figure 17 demonstrates the practicalities of proper passive solar design in a stable climate. Banksia House is receiving significant sun penetration at 12pm on the winter solstice, which is ideal for standard passive design. However, should an overly warm day occur around this time of year, it can be clearly seen how easily the northern rooms would quickly overheat.



Figure 17 Banksia House 12pm Winter Solstice

Another issue demonstrated by the future climate scenario is a clear shift from a heating dominated climate to a potentially cooling dominated climate. The results show that buildings designed for the "current" climate will be unprepared should the future climate predictions eventuate.

# RECOMMENDATIONS

Whilst this report is not about specifying definitive design or specification changes, it is recommended that each of the three optimisation options be considered, with insulation prioritised over external blinds due to the ease of retrofitting these later compared to insulation.

However, what this report can certainly recommend is a holistic and long-term view of your home. Consider the possibilities of future climate scenarios and the costs and benefits of acting on these now as opposed to later. And consider how actively you (or your electronics) operate your home. Are you happy being a passive occupier or would you prefer the benefits of flexibility and connection that come with active use, such as opening and closing windows as the outdoor conditions change, operating external blinds throughout the day, or moving your rug around to cover and expose the thermal mass beneath your feet? These considerations are the recommendations of this report.

# CONCLUSION

Whilst it is not certain what climate we will all be living in by 2070, or even 2050, what is certain is that those that build and design homes today without these considerations may be locking themselves or their clients into not only inefficient but potentially harmful homes of the future. Analysing the outputs of the RMY and EFMY climate files has shown that our world is not static and that our homes, which we expect to last us for at least 50 years, are unlikely to exist in the same climate from which they were conceived.

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# APPENDICES

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PPENDIX 4         roject Construction (Opaque: External Wall)         iption:       Banksia Ext.RBV Wall         rmance:       ASHRAE         U-value:       0.3400         W/m <sup>2</sup> -K       Thickness:         127.500       mm         Total R-value:       2.7911         m*K/W       Mass:         Total R-value:       0.900         Resistance (m*K/W):       0.0299         Dutside       Emissivity:         Solar Absorptance:       0.700         mstruction Layers (Outside To Inside)       Sol         Material       Thickness       Conduc         Material       Thickness       Conduc         mm       9.0       0.16         avity       20.0       -	Thermal mass Cm e Emissivity: plar Absorptance: ctivity n K) Esso 650.0	: 6.6960 Very lightwei 0.900 0.550 Specific Heat Capacity J/(kg K) 1600.0	kJ/(m²-K) ght Resistance m²K/W 0.0545 0,1800	ID: WALL 1 istance (mªK/W) rstem Materials Vapour Resistivity GN's/kg·m) 200.000										
PPENDIX 4         Inoject Construction (Opaque: External Wall)         ription:       Banksia Ext.RBV Wall         urmance:       ASHRAE         U-value:       0.3400       W/m <sup>2</sup> ·K         Total R-value:       2.7911       m <sup>2</sup> K/W         Mass:       17.1375       kg/m <sup>2</sup> rfaces       Functional Settings       Regulations         Resistance (m <sup>2</sup> K/W):       0.0299       Default         Solar Absorptance:       0.700       Resistance (m <sup>2</sup> K/W):       0.0299         onstruction Layers (Outside To Inside)       Material       Thickness       Conduction Material         TMB TIMBER BOARD       9.0       0.16         Cavity       20.0       -         STD_MEM] Membrane       1.0       1.00	Thermal mass Cm e Emissivity: plar Absorptance: official definition for the second definition kg/m <sup>3</sup> for the second definition kg/m <sup>3</sup> for the second definition for the seco	: 6.6960 Very lightwei 0.900 0.550 Specific Heat Capacity J/(kg·K) 1600.0 - 1000.0	kJ/(m²-K) ght Resistance m³K/W 0.0545 0.1800 0.0010	ID: WALL 1 istance (m²K/W) rstem Materials Vapour Resistivity GN's/(kg·m) 200.000 - -	- [ External External . 0.1198 ☑ Def . Project Mater Category Timber - Asphalts & Other Rooi									
PPEENDIX 4         Project Construction (Opaque: External Wall)         ription:       Banksia Ext.RBV Wall         prmance:       ASHRAE         U-value:       0.3400         U-value:       0.3400         W/m <sup>2</sup> -K       Thickness:         Izoral R-value:       2.7911         m*K/W       Mass:         Total R-value:       2.7911         Inside       Inside         Cutside       Emissivity:       0.900         Emissivity:       0.900       Resistance (m²K/W):       0.0299         Solar Absorptance:       0.700       Sol         onstruction Layers (Outside To Inside)       Material       Thickness Conduc W/m         TMB] TIMBER BOARD       9.0       0.16         Cavity       20.0       -         STD_MEM] Membrane       1.0       1.00         GFSL] GLASS-FIBRE SLAB       87.5       0.03	Thermal mass Cm e Emissivity: plar Absorptance: ctivity kg/m <sup>3</sup> 650 650.0  000 1100.0 350 25.0	: 6.6960 Very lightwei 0.900 0.550 Specific Heat Capacity J/(kg·K) 1600.0 - 1000.0	kJ/(m²-K) ght Resistance m²K/W 0.0545 0.1800 0.0010 2.5000	ID: WALL1 istance (m²K/W) rstem Materials Vapour Resistivity GN's/(kg·m) 200.000 - - 6.000										

Project Construction (Opaque: External Wall)							- 🗆 ×			
Description: BCA House RBV External Wall						ID: WALL	External Internal			
Performance: ASHRAE V										
U-value: 0.3353 W/m <sup>2</sup> ·K Thickness: 241.000 m	n	Therma	al mass Crr	n: 7.9800	kJ/(m²∙K)					
Total R-value: 2.8330 m <sup>2</sup> K/W Mass: 219.2250 kg	1/m <sup>2</sup>			Verv lightwei	aht					
					-					
Surfaces Functional Settings Regulations RadianceIES										
Ground contact wall (not external wall)										
Construction Layers (Outside To Inside) Project Materials Project Materials										
Material	Thickness mm	Conductivity W/(m·K)	Density kg/m³	Specific Heat Capacity J/(kg·K)	Resistance m²K/W	Vapour Resistivity GN·s/(kg·m)	Category			
[REX] EXTERNAL RENDERING	15.0	0.5000	1300.0	1000.0	0.0300	50.000	Screeds & Renders			
[BRO] BRICKWORK (OUTER LEAF)	110.0	0.8400	1700.0	800.0	0.1310	58.000	Brick & Blockwork			
Cavity	20.0	-	-	-	0.1800	-	-			
[STD_MEM] Membrane	1.0	1.0000	1100.0	1000.0	0.0010	-	Asphalts & Other Roofing			
[GFSL] GLASS-FIBRE SLAB	85.0	0.0350	25.0	1000.0	2.4286	6.000	Insulating Materials			
[GPB] GYPSUM PLASTERBOARD	10.0	0.1600	950.0	840.0	0.0625	45.000	Plaster			
Copy Paste Cavity Insert Add Delete Flip										
Condensation Analysis Derived Parameters							OK Cancel			

Project Construction (Opaque: External Wall)							- 🗆 ×				
Description: Banksia Ext.Lighweight Wall						ID: WALL2	External Internal				
Performance: ASHRAE ~											
U-value: 0.3322 W/m²·K Thickness: 127.500 m	m	Therm	al mass Crr	: 3.3480	kJ/(m²∙K)						
Total R-value:         2.8605         m <sup>2</sup> K/W         Mass:         13.1375         kg	g/m²			Very lightwei	ght						
Surfaces Functional Settings Regulations RadianceIES											
Outside											
Emissivity: 0.900 Resistance (m <sup>2</sup> K/W): 0.0299 Default Emissivity: 0.900							): 0.1198 🔽 Default				
Solar Absorptance: 0.700		Solar Abs	orptance:	0.550							
Construction Layers (Outside To Inside)	_				S	ystem Materials.	Project Materials				
Material	Thickness mm	Conductivity W/(m·K)	Density kg/m³	Specific Heat Capacity J/(kg·K)	Resistance m²K/W	Vapour Resistivity GN•s/(kg•m)	Category				
[TMB] TIMBER BOARD	9.0	0.1650	650.0	1600.0	0.0545	200.000	Timber				
Cavity	20.0	-	-	-	0.1800	-	-				
[STD_MEM] Membrane	1.0	1.0000	1100.0	1000.0	0.0010	-	Asphalts & Other Roofing				
[GFSL] GLASS-FIBRE SLAB	87.5	0.0350	25.0	1000.0	2.5000	6.000	Insulating Materials				
[PPL] PERLITE PLASTERING	10.0	0.0800	400.0	837.0	0.1250	25.000	Plaster				
IPPLJ PERLITE PLASTERING         0.0800         400.0         837.0         0.1250         25.000         Plaster											
Copy Paste Cavity Insert Add Delete Flip											
Condensation Analysis Derived Parameters							OK Cancel				

Project Construction (Opaque: Ground/Exposed Floor) – 🗆 🗙														
escription: Banksia Floor (exposed concrete)						ID: FLOOR	External Internal							
erformance: ASHRAE V														
U-value: 0.7200 W/m²·K Thickness: 850.700	mm	Therm	ial mass Cr	n: 195.5000	kJ <b>/(</b> m²∙K)									
Total R-value:         0.6650         m¾/W         Mass:         1631.4900         kg/m²         Mediumweight														
Surfaces Eunctional Settings Regulations RadianceTES														
Outside		Inside												
Emissivity: 0.900 Resistance (m²K/W): 0.0299	🗸 Default	E	Emissivity:	0.900	Res	sistance (m²K/W)	): 0.1620 🔽 Default							
Solar Absorptance: 0.550		Solar Abs	orptance:	0.550										
Construction Layers (Outside To Inside)					S	ystem Materials.	Project Materials							
Material	Thickness mm	Conductivity W/(m·K)	Density kg/m³	Specific Heat Capacity J/(kg·K)	Resistance m²K/W	Vapour Resistivity GN·s/(kg·m)	Category							
[LNDN0000] London Clay	750.0	1.4100	1900.0	1000.0	0.5319	0.000	Sands, Stones and Soils							
[STD_PH1] Insulation	15.7	0.0250	700.0	1000.0	0.6280	-	Insulating Materials							
[STD_CC2] Reinforced Concrete	85.0	2.3000	2300.0	1000.0	0.0370	-	[STD_CC2] Reinforced Concrete         85.0         2.3000         1000.0         0.0370         -         Concretes							

Project Co	Project Construction (Opaque: Ground/Exposed Floor) – 🗆 🗙											
Description:	Banksia Floor (carpete	d)							ID: FLOOR1	External	Inte	ernal
erformance:	ASHRAE V											
	U-value: 0.6040	W/m²∙K	Thickness: 870.700 mr	n	Therma	al mass Cr	n: 191.9737	kJ <b>/(</b> m²∙K)				
Total	Total R-value:     0.9316     m <sup>2</sup> K/W     Mass:     1637.3530     kg/m <sup>2</sup> Mediumweight											
Surfaces Functional Settings Regulations RadianceIES												
Outside					Inside							
	Emissivity: 0.900	Resistanc	e (m²K/W): 0.0299	Default	-	miccivity	0.900	Dec	istance (m2K/M/	0 1620	Dofoult	
	Emissivity:			Juciaur	-	inissivity.	0.500	NC2	sistemee (m-row)	. 0.1020	Default	
Solar Ab	bsorptance: 0.550				Solar Abs	orptance:	0.550					
Construction	n Layers (Outside To Insid	de)						S	ystem Materials.	Project Ma	terials	
		Material		Thickness mm	Conductivity W/(m·K)	Density kg/m³	Specific Heat Capacity J/(kg·K)	Resistance m²K/W	Vapour Resistivity GN:s/(kg:m)	Category	y	
[LNDN0000]	] London Clay			750.0	1.4100	1900.0	1000.0	0.5319	0.000	Sands, Stones and	Soils	
[STD_PH1]	Insulation			15.7	0.0250	700.0	1000.0	0.6280	-	Insulating Materials	s	
[STD_CC2]	Reinforced Concrete	85.0	2.3000	2300.0	1000.0	0.0370	-	Concretes				
[CRUU] CEL	LULAR-RUBBER UNDERL	AY		10.0	0.1000	400.0	1360.0	0.1000	50000.000	Carpets		
[WCP] WILT	TON CARPET			10.0	0.0600	186.3	1360.0	0.1667	13.000	Carpets		

🖗 Project Construction (Opaque: Ground/Exposed Floor) X Description: Banksia Floor (tiled) ID: FLOOR11 External Internal Performance: ASHRAE  $\sim$ U-value: 0.7135 W/m<sup>2</sup>·K Thermal mass Cm: 219.9020 kJ/(m<sup>2·</sup>K) Thickness: 865.700 mm Total R-value: 0.6776 m²K/W Mass: 1662.9900 kg/m<sup>2</sup> Heavyweight Surfaces Functional Settings Regulations RadianceIES Outside Inside Resistance (m<sup>2</sup>K/W): 0.0299 Emissivity: 0.900 ✓ Default Emissivity: 0.900 Resistance (m²K/W): 0.1620 Default Solar Absorptance: 0.550 Solar Absorptance: 0.550 System Materials... Project Materials... Construction Layers (Outside To Inside) Specific Heat Vapour Thickness Conductivity Resistance Density Resistivity GN·s/(kg·m) Material Capacity Category mm W/(m·K) kg/m³ m²K/W J/(kg·K) [LNDN0000] London Clay 1000.0 0.5319 0.000 750.0 1.4100 1900.0 Sands, Stones and Soils [STD\_PH1] Insulation 0.0250 700.0 1000.0 0.6280 Insulating Materials 15.7 -[STD\_CC2] Reinforced Concrete 1000.0 0.0370 85.0 2.3000 2300.0 -Concretes [TB] TILE BEDDING 2100.0 650.0 0.0036 Gravels, Beddings, etc. 5.0 1.4000 45,000 Tiles [CT] CONCRETE TILES 10.0 1.1000 2100.0 837.0 0.0091 500.000

🚰 MacroFlo Op	ening Types					$\times$
MacroFlo Opening	Types					
XTRN0000 XTRN0001	Fixed Window Casement Window	Reference ID	XTRN0007			
XTRN0002 XTRN0003 XTRN0004	Casement Window (half) Casement Window (1/3) Awning Window (half)	Description	Internal Door	r		]
XTRN0005 XTRN0006	Sliding Window External Door	Exposure Type	05. 1:1 semi-e	exposed wall	~	±
XTRN0007	Internal Door	Opening Category	Custom / shar	rp edge orifice	~	·
		Openable A	rea %	90		
		Equivalent of Crack Flow Coeffic Crack Length Opening threshold Degree of Opening (Modulating Profile	rifice area ient )	90.000 1.300 I/(s·m·1 100 % of o 0.00 °C NatHERS Natural V	% of gross Pa^0.6) opening perimeter (entilation v ?	H
Add	Remove					
Include effects	of wind turbulence?		C	OK Cancel	Save	

	i (Giazed: Extern	ial Windo	ow)										-	
cription: Banksia	Window									I	D: EXTW		External	Intern
formance: ASHRAE	~													
Net U-value (includin	ig frame): 2.001	19 W	/m²·K	U-value (glas	s only):	1.6753 W	/m²∙K	Total sha	ding coefficie	nt: 0.4546		SHGC (o	enter-pane)	: 0.3955
Net	R-value: 0.596	i9 m <sup>3</sup>	²K/W	g-value (E	N 410):	0.4017		Visible light norma	al transmittan	ce: 0.76				
urfaces Frame Sha	ading Device Rar	dianceIES	S											
Outside														
Emissivity: 0.837 Resistance (mૠ/W): 0.0299 ☑ Default Emissivity: 0.837 Resistance (mૠ/W): 0.1198 ☑ Default														
Construction Layers (O	utside to Inside):									Sys	stem Materia	ls	Project Ma	terials
Material	Thi	ickness mm	Conductivity W/(m·K)	Angular Dependence	Gas	Convection Coefficient W/m²·K	Resistance m²K/W	Transmittance	Outside Reflectance	Inside Reflectance	Refractive Index	Outside Emissivity	Inside Emissivity	Visible Light Specified
[STD_EXW] Outer Par	ne 🛛	6.0	1.0600	Fresnel	-	-	0.0057	0.409	0.289	0.414	1.526	0.837	0.042	No
Cavity		12.0	-	-	Air	2.0800	0.4359	-	-	-	-	-	-	-
FCTD_TNIMI Tener Dan	•	6.0	1 0600	Engenel										

Apache Sy	rstems					_	
Default?	System Name	Name:	Banksia Hou	ise			
	New System 1	UK NCM type:	Central hea	ting using air distribution			UK NCM wizard
×	banksia House	Harting Cor		-teo Oslasharikan Amerikan Kasarah	Cost Costal		
		Heating Coo	Ming Hot wa	ater Solar heating Aux energy Air supply	Cost Control		
		Generator:		Cooling/ventilation mechanism	Air conditioning		~
				Nominal FED* kW/kW	Electricity: Meter	1	~
				Seasonal EER kW/kW			3.1250
				Delivery efficiency			1.0800
				SSEER kW/kW			2.0000
				Generator size kW			0.00
				Absorption chiller			
		Operation:		Changeover mixed mode free cooling*	Not a CMM system	1	~
		Heat rejecti	on:	Pump & fan power (% of rejected heat	:)		10.0
Add	Remove Duplicate	* - Applies to Uk	(NCM only			ОК	Cancel

Apache Sy	stems				-	- 🗆 X
Default?	System Name	Name:	Banksia House			
	New System 1	UK NCM type:	Central heating u	using air distribution		UK NCM wizard
	banksia nouse	Heating Co	alian Hatwater	Color booting Aux operate Air gues	ly Cast Castral	
		Generator:	ioling not water	Meter	Flockticky Motor 1	
		Generator.		Is it a beat numn*2	Electricity: Meter 1	
				Seasonal efficiency		2.0000
				Delivery efficiency		1.0669
				SCoP kW/kW		2.1339
				Generator size kW		0.00
		Heat recov	ery:	Vent. heat recovery effectiveness		0.0000
				Vent. heat recovery return air temp	°C	21.00
		CH(C)P:		Is this heat source used in conjuncti	on with CHP?	
				What ranking does this heat source	have after the CH(C)P plant?	1
Add	Remove Duplicate	* - Applies to U	K NCM only		ОК	Cancel

#### NatHERS Bedroom (latent)

E E	dit Proje	ct Daily Profile DAY_0025								
Prof Na	ile Name: tHERS Be	droom (latent)					ID: DAY	_0025	Modulating	Absolute
Cate	gories:					~				
	Time		Value					1.00		The second s
1	00:00				1.000		e	0.90		
2	08:00				1.000		val	0.80		
3	08:00				0.000		l.if	0.70		
4	23:00				0.000		Inlat	0.70		
5	23:00				1.000		Pop	0.60		
6	24:00				1.000		2	0.50		
								0.40		
								0.30		
								0.20		
								0.20		
								0.10		
								0.00	04 06 08 10 12 14	16 18 20 22 24
									Time o	of Day
÷	<b>1</b>	£ 🔾 🔥 🖻 💼		⊖ IP	No units			🗹 Grid		
									Help O	K Cancel

#### **NatHERS Bedroom (sensible)**



#### **NatHERS Daytime Zone (latent)**



#### NatHERS Daytime Zone (sensible)

P E	dit Proje	t Daily Profile DAY_0028					
Prof	ile Name: tHERS Da	vtime Zone (sensible)		ID: DAY_0028 Modulating			○ Absolute
Cate	egories:						Ū
	Time	Value	11		1.00		
1	00:00	0.000		e	0.90	÷	
2	08:00	0.000		Val	0.80	· · · · · · · · · · · · · · · · · · ·	
3	08:00	0.902		ing	0.70		
4	10:00	0.902		ulat	0.70		
5	10:00	0.275		Mod	0.60		
6	18:00	0.275		2	0.50		
7	18:00	1.000			0.40	÷	
8	23:00	1.000			0.30	····	
9	23:00	0.000			0.20		
10	24:00	0.000					
					0.10		
					0.00 00 02	04 06 08 10 12 14	16 18 20 22 24
						Time of	î Day
				_	_		
•	<b>山</b>	🕼 🤾 🎦 🖺 🔁 🔿 Metric 🖓 IP 💿 No units			🗹 Grid		
						Help OK	Cancel

#### NatHERS Kitchen/Living (latent)

6	Ed	lit Projec	t Daily Profile DAY_0024							
P	rofi	le Name:				ID:				
	Nat	HERS Kito	hen/Living (latent)			DA	Y_0024		Modulating	○ Absolute
c	ate	gories:			-					
I٢		Time	Value	4			1.00			
	1	00:00		0.000		le	0.90			
	2	08:00		0.000		<sup>ra</sup>	0.80 -			
	3	08:00		0.533		lin	0.70			
	4	09:00		0.533		nlat	0.70			
	5	09:00		0.266		Pop	0.60			
	6	10:00		0.266		2	0.50 -			
	7	10:00		0.133			0.40			
	8	18:00		0.133			0.30 -			
	9	18:00		0.200						
	10	19:00		0.200			0.20			
	11	19:00		1.000			0.10 -			
	12	20:00		1.000			0.00	02 04	06 08 10 12 14	
	13	20:00		0.200					Time of	f Day
	14	22.00		0 200						
	÷	<mark>أ</mark> ل ال	£ 🏹 🏠 🖺 🖺 🔿 Metric 🔿 IP 💿 No	units			Grid Grid			
									Help OK	Cancel

#### NatHERS Kitchen/Living (sensible)

2	Ec	lit Projec	t Daily Profile DAY_0023					
Pr	ofi	e Name:			ID:			
	Vat	HERS Kit	chen/Living (sensible)		DA	Y_0023	Modulating	○ Absolute
Ca	ate	gories:		~				
I٢		Time	Value			1.00		
	4	09:00	0.534		l e	0.90		
	5	09:00	0.348		Na l	0.80		
	6	10:00	0.348		lij	0.70		
	7	10:00	0.149		lula			
	8	18:00	0.149		19	0.60		
	9	18:00	0.379		12	0.50	·····	
	0	19:00	0.379			0.40		
1	1	19:00	1.000			0.30		
	2	20:00	1.000			0.20		
	13	20:00	0.472			0.10	· · · · · · · · · · · · · · · · · · ·	
	4	23:00	0.472					
	15	23:00	0.062			0.00 111111	04 06 08 10 12 14	16 18 20 22 24
P	16	24:00	0.062	Ŧ			Time of	Day
	₽		🐍 📝 👫 🖺 🕅 OMetric 🛛 IP 💿 No units	_		Grid Grid		
	-							
							Help OK	Cancel

External S	Shading Dev	ice											$\times$
Type of Con	<sup>F</sup> external sha trol	ding device:		○ None		<mark>ا ا</mark>	hutter	(	OLouvre				
Ope	ration profile	:		Externa	External Blinds ~								
	Continuously	variable											
c	Condition to lower device:				ii>3000.0 🗸 💿 Metric								
c	Condition to raise device:			ii<3000	ii<3000.0 ✓ ○ IP								
Nightt	Nighttime resistance:			1.000 m²K/W			Typically between 0.00 and 2.50						
Daytir	me resistance	:		1.000		m²K/W ☑ Calculate			Typically between 0.00 and 2.50				
Groun	id diffuse trar	nsmission facto	or:	0					Typically between 0 and 1				
Sky di	ffuse transmi	ssion factor:		0 Calculate				Typically between 0 and 1					
Trans	mission Facto	rs at 15 degre	e ind	rements	(values	in rar	ige 0.00 - 1	1.00	)				
	0° 15° 30°		30°	45*			60°		75* 90*				
	0.00	0.00	0.0	0	) 0.00		0.00		.00	0.00			
										ОК		Cancel	

Modulating formula profile creation

										Subject to proportion band of w	a ial idt
Controller is	s on if	Room air temperature (	(°C)	✓ is greate	er than	$\sim$	24		~	0	
AND	~	Room air temperature (	(°C)	✓ is greate	er than	~	Outside air t	emperature (°C	c) ~	0	
-	~	Room air temperature (	(°C)	✓ is greate	er than	$\sim$	Room air ten	nperature (°C)	~	0	
-	$\sim$	Room air temperature (	(°C)	✓ is greate	er than	$\sim$	Room air ten	nperature (ºC)	$\sim$	0	
-	$\sim$	Room air temperature (	(°C)	✓ is greate	er than	$\sim$	Room air ten	nperature (°C)	~	0	
ormula profile											
(la>24) &	formula f	(O-4)) from control conditions ( Create formula	Type formu     Check form	ula	Reset		Sa	ave formula	Rea	reate formu	ıla
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