Thermal Bridging Implementation in AccuRate

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Revised on 29 November 2022 and
changed default thermal break R-value from 0.25 to 0.20 m²·k/W

Revised on 8 March 2023 and
changed the timber frame dimensions from fixed default values to the same as those for steel frame. Removed the “Thermal resistance of a small air gap” section since air capsulation outside the steel frame is not considered.

Revised on 3 April 2023 and
Added a comparison between the fixed default value approach and the new approach with the frame dimensions as the steel frame.

BACKGROUND

The existing NatHERS software currently does not take thermal bridging into account in its regulatory mode. To better align the NatHERS compliance pathway with the other compliance pathways in the National Construction Code (NCC), CSIRO was commissioned by DISER to develop a set of thermal bridging default parameters and to provide a draft modelling guidance on how to apply these defaults for NatHERS rating. In this document, the implementation of thermal bridging in AccuRate Home is described in detail. This includes the implementation of thermal bridging calculation and the automatic adjustment of the insulation thickness due to thermal bridging with metal frames.

THERMAL BRIDGING CALCULATION

The thermal bridging calculation method is based on Chen and Ambrose (2020) except the reference timber frame dimensions.

Non-metal frame thermal bridge calculation

For a non-metal frame, the thermal bridging effect is calculated based on the New Zealand Standard ‘NZS 4214:2006 Methods of Determining the total Thermal Resistance of Parts of Buildings’. Thermal bridging according to NZS 4214:2006 is determined by the isothermal plane method. Figure 1 illustrates a bridged layer *i* with insulation material 1 and bridging materials 2 and 3 (the trial version of

AccuRate only included material 2 and material 3 is not currently considered). The thermal resistance of layer *i*, i.e., $R_{i,bridged}$ is calculated using Eq. (1).

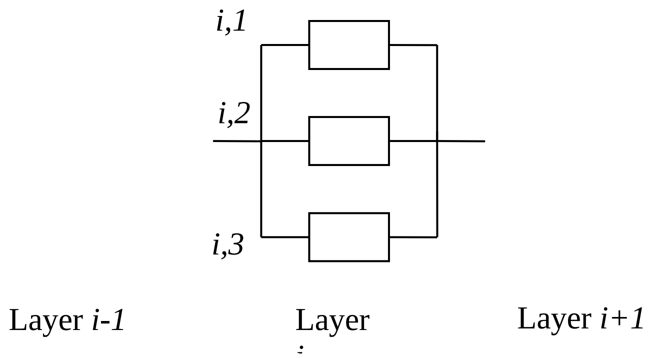

Figure 1. Illustration of a thermal bridged layer *i* with two bridge material *i,2* and *i,3*.

$$R_{i,bridged} = \frac{1}{\frac{f_{i,1}}{r_{i,1}} + \frac{f_{i,2}}{r_{i,2}} + \frac{f_{i,3}}{r_{i,3}}} \quad (1)$$

Here, $f_{i,1}$, $f_{i,2}$, $f_{i,3}$ are the fractional areas of material 1, 2 and 3 within layer *i*. $r_{i,1}$, $r_{i,2}$, $r_{i,3}$ are the thermal resistances of the material 1, 2 and 3 within layer *i*. ***If a material has both R heat-up and R heat-down, e.g a reflective air gap, the average of R heat-up and R heat-down is used for $R_{i,bridged}$ calculation***. For a construction with *n* bridged layers and *m* not-bridged layer, the total thermal resistance of the construction is calculated by Equation (2):

$$R_{total,bridged} = R_{es} + \sum_{i=1}^{n} R_{i,bridged} + \sum_{j=1}^{m} R_{j,notbridged} + R_{is} \quad (2)$$

Here, $R_{i,bridged}$ is the R-value for a thermally bridged layer and $R_{j,notbridged}$ is the R-value for a layer j which is not thermally bridged. R_{es} and R_{is} are the external side thermal resistance and internal side air film thermal resistance respectively. The isothermal planes method Equations (1) and (2) used for non-metal thermal bridge calculation is equivalent to the lower limit resistance R_{lower} calculation specified by ISO 6946:2017.

When we consider timber framed constructions, the insulation loss due to thermal bridging can be expressed by Eq. (3):

$$\begin{aligned}\Delta R_{timber} &= R_{total,withoutbridge} - R_{total,bridged} \\ &= \sum_{i=1}^{n} R_{i,withoutbridge} - \sum_{i=1}^{n} R_{i,bridged}\end{aligned} \quad (3)$$

Here, $R_{i,withoutbridge}$ is the R-value of a timber frame thermal bridged layer i when thermal bridging is not considered. $R_{total,withoutbridge}$ is the R-value of the entire construction if thermal bridging is not considered.

It should be noted that for timber frame thermal bridging calculation, the thermal conductivity used for timber is 0.12 W/m·k (or R-value of 8.333 m^2·k/W at 1m thickness) for the $R_{i,bridged}$ calculation, which is different from the value in the material library, i.e. 0.10 W/m·k. This is only used for timber frame thermal bridging calculation. Timber thermal conductivity for all the other NatHERS calculations is not changed.

Metal frame thermal bridge calculation

In NZS 4214:2006, the metal frame section is replaced by a notional enclosing equivalent rectangular as shown in Figure 2(c). The thermal resistance of the metal frame section is calculated using Eq. (4):

$$r_{i,2} = \frac{a \times l}{d \times k_m} + R_{c1} + R_{c2} \tag{4}$$

where a is the flange width (mm); l is the thickness or depth of the metal frame (mm); d is the base metal thickness; k_m is the thermal conductivity of the metal which is 50 $W/m·k$; R_{c1} and R_{c2} are the contact resistances between metal frame and facing (both assumed to be 0.03 m^2·K/W).

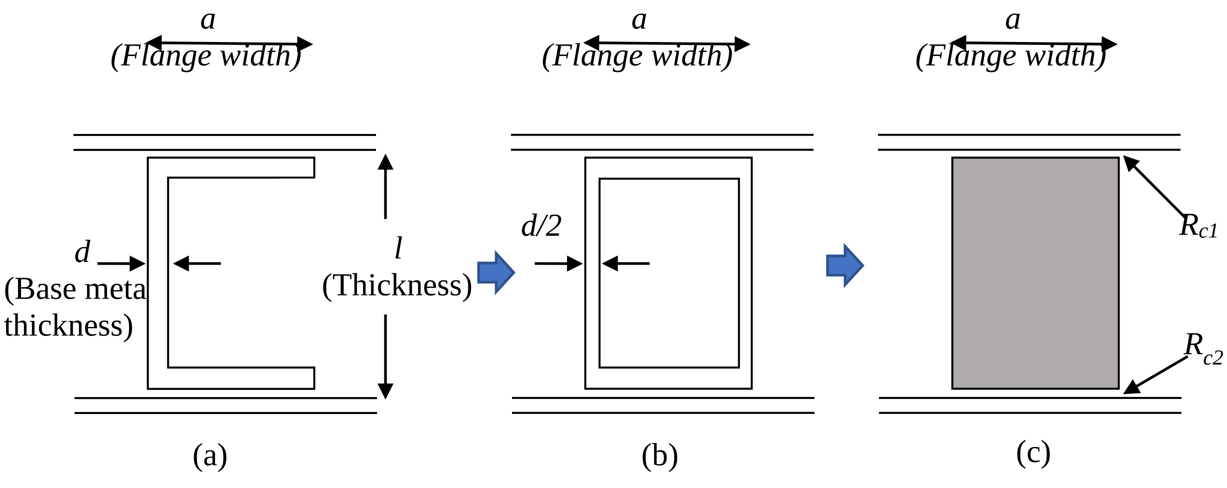

Figure 2. Transformation method for metal frame sections (NZS 4214:2006)

The thermal resistance of the bridged layer as well as the total thermal resistance of the construction are then calculated using exactly the same method as for the timber frame, i.e. Equations (1) and (2).

It is noted that according to NZS 4214:2006, a bridged layer is never bounded by an air space. Therefore, an adjacent air gap and the bridged layer is considered as one layer. This means when writing out the construction layers in the scratch file, the air gap will be missing. This raises difficulties in the current simulation of reflective air gaps since the Chenath engine calculates the air gap resistance based on gap surface temperatures for ceiling, floor and roof constructions. In this implementation, we used an approximation method by adding the thermal resistance of the metal frame section with R0.16, which is the unventilated non-reflective 40 mm vertical air gap thermal resistance, ***while leaves the air gap itself as an independent layer*** as described in Eq. (5):

$$r_{i,2} = \frac{a \times l}{d \times k_m} + R_{c1} + R_{c2} + R_{airgap} \tag{5}$$

Here the airgap thermal resistance R_{airgap} is fixed at 0.16 m^2·k/W for the thermal resistance calculation for the steel frame thermally bridged layer. With this method, the effect of the airgap on the metal frame section thermal bridging is considered approximation, while avoiding the issue in the Chenath simulation for air gap.

It should be noted that for timber frame, we do not add this air gap resistance in the timber frame section resistance since the air gap will still appear in the construction layer in the scratch file.

If there is a thermal break used for the metal frame, then, the thermal resistance of the metal frame section becomes

$$r_{i,2} = \frac{a \times l}{d \times k_m} + R_{c1} + R_{c2} + R_{airgap} + R_{thermalBreak} \tag{6}$$

Here, $R_{thermalbreak}$ is defaulted to be 0.20 m^2·k/W.

Again, for a construction with *n* bridged layers and *m* not-bridged layers, the thermal resistance of the bridged layer as well as the total thermal resistance of the construction are calculated by Equations (1) and (2).

METAL FRAME THERMAL BRIDGE CALCULATION ADJUSTMENT

Metal frame thermal bridge calculation adjustment

According to the proposed approach of thermal bridging calculation in NCC 2022, the effect of a metal framed construction on insulation loss should be adjusted by its related timber framed construction insulation loss. So, the adjusted R-value for a metal framed construction can be expressed by Equation (7):

$$R_{total,bridged,adjusted} = R_{es} + \sum_{i=1}^{n} R_{i,bridged} + \sum_{j=1}^{m} R_{j,notbridged} + R_{is} + \Delta R_{timber} \quad (7)$$

The related timber frame construction

In previous recommendations, the parameters for the reference timber framed constructions were based on the timber frame defaults reported in Chen and Ambrose (2020) as show in Table 1. Based on Table 1, the following fixed value parameters were recommended for the thermal bridging calculation for the reference timber framed constructions.

For roof constructions:
RafterDepth = 140;
RafterWidth = 45;
RafterSpacing = 600;

For wall constructions:
StudDepth = 90;
StudWidth =45;
StudSpacing = 450;
NoggingDepth = 90;
NoggingWidth = 45;
NoggingSpacing = 600;

For floor constructions:
JoistDepth = 140;
JoistWidth = 45;
JoistSpacing = 450;

For ceiling constructions:
CeilingJoistDepth = 140;
CeilingJoistWidth = 45;
CeilingJoistSpacing = 600;

Timber frame fractions:
WallFraction = 0.1675;
CeilingFraction = 0.075;
FloorFraction = 0.10;
RoofFraction = 0.075;

Timber resistance (1m)
TimResistanceUp = 8.33333;
TimResistanceDown = 8.33333;

However, it was found later that this fixed value parameter approach for the thermal bridging calculation for the reference timber framed constructions have several issues. One of the main issues is that when assessors enter the insulation with single-layer or two-layer approaches in NatHERS accredited software tools, the adjusted R-values for the bridged construction could be different. Table 2 shows an example of this R-value discrepancy with a ceiling construction.

It is noted that the default timber frame dimension approach is an approximation and the thermal conductivity for timber could vary with different types of timbers as well. In order to avoid the R-value discrepancy issue with the default timber frame dimension approach, a new approach was recommended by Energy Inspections and agreed among all the NatHERS software developers. With the new approach, the dimensions of the timber frame are assumed to be exactly the same as the steel frame. With this new approach, the example in Table 2 becomes that in Table 3 which gives the same adjusted R-values for the construction with single-layer and two-layer approaches.

Table 1 Defaults for information not contained in building plans (Chen and Ambrose, 2020)

Element		Wood (both soft and hard wood)	Steel frame
Roof elements – raftered roofs with concealed rafters or horizontal ceilings **Dependent on the design, thermal bridging may not need to be considered for roof elements. The dimensions listed are the defaults if thermal bridging exists.**	Rafter dimensions	140 x 45 mm	200 x 75 mm
	rafter spacing	600 mm	900 mm
	Base Metal Thickness	N/A	1.5
	Flange width	N/A	75 mm
	batten dimensions	N/R	N/R
	batten spacing	N/R	N/R
Walls	Stud dimensions	90 x 45 mm	90 x 40 mm
	Stud spacing	450 mm	600 mm
	Flange width	N/A	40 mm
	Base Metal Thickness	N/A	0.75 mm
	Nogging dimensions	90 x 45 mm	90 x 40 mm
	Nogging spacing	600 mm	1200 mm
Floors	Joist dimensions	140 x 45 mm	100 x 50 mm
	Joist spacing	450 mm	450 mm
	Flange width	N/A	50 mm
	Base Metal Thickness	N/A	1.5 mm
	Nogging dimensions	N/A	N/A
	Nogging spacing	N/A	N/A
Horizontal Ceiling	Ceiling joist dimensions	140 x 45 mm	90 x 40 mm
	Ceiling joist spacing	600 mm	900 mm
	Flange width	N/A	40 mm
	Base Metal Thickness	N/A	0.75 mm
	Nogging dimensions	N/A	N/A
	Nogging spacing	N/A	N/A

Notes: **Consistent to NZS 4214:2006, the thermal bridging effect of the ties or nails are not considered.**

N/R: not required.

Table 2 An example of the single-layer and two-layer approaches for thermal bridging effect calculation using fixed reference timber frame dimensions

Layer No.	Single-layer approach	Two-layer approach
1	220 mm glass fibre insulation thermally bridged by 0.75 mm steel frame with 90 mm (depth) X 40 mm (width) X 900 mm (spacing)	130 mm glass fibre insulation not thermally bridged
2	10 mm plasterboard	90 mm glass fibre insulation thermally bridged by 0.75 mm steel frame with 90 mm (depth) X 40 mm (width) X 900 mm (spacing)
3	-	10 mm plasterboard
Adjusted total R-value	4.87	4.61

Other issues with the fixed timber frame dimension approach are

1. When custom steel frames are used for particular structure reasons, the reference timber frame does not change to represent the changes in steel frames;
2. If we force assessors to enter single-layer insulation only, designs could have difficulties to be assessment when additional insulation layer(s) are actually needed in reality.

Table 3 An example of the single-layer and two-layer approaches for thermal bridging effect calculation using the new proposed approach

Layer No.	Single-layer approach	Two-layer approach
1	220 mm glass fibre insulation thermally bridged by 0.75 mm steel frame with 90 mm (depth) X 40 mm (width) X 900 mm (spacing)	130 mm glass fibre insulation not thermally bridged
2	10 mm plasterboard	90 mm glass fibre insulation thermally bridged by 0.75 mm steel frame with 90 mm (depth) X 40 mm (width) X 900 mm (spacing)
3	-	10 mm plasterboard
Adjusted total R-value	4.65	4.65

Scratch file

For the constructions in the scratch file, the thermal bridging calculation in the current implementation only impacts on the thickness of those bridged insulation layers, while these insulation layers which are not bridged should have no impact.

If there is only one bridged layer, its thickness can be adjusted directly by Equation (8).

$$Thickness_{i,adjusted} = Thickness_i \times \frac{R_{i,bridged}}{R_{i,withoutbridge}} \quad (8)$$

Here, $Thickness_i$ is the original insulation layer thickness when thermal bridging is not considered. $Thickness_{i,adjusted}$ is the adjusted thickness of the bridged insulation layer written in the scratch file after considering the thermal bridging.

When there are multiple bridged layers, the adjusted thickness of the bridged layer is calculated by Equation (9).

$$Thickness_{i,adjusted} = Thickness_i \times \frac{\sum_{i=1}^{n} R_{i,bridged}}{\sum_{i=1}^{n} R_{i,withoutbridge}} \quad (9)$$

The reason that Equation (9) is used rather than using Equation (8) is due to the historical implementation in AccuRate when different thermal bridging calculation methods were adopted such as the ISO 6946: 1996 approach. With the ISO 6946: 1996 approach, the R value for each bridged insulation layer could not be determined, e.g. the R_{max} for the ISO approach can only be determined for the entire construction, not for a single layer. So, Equation (9) is a pro-rata method if there are more than one bridged insulation layers.

ENERGY RATINGS USING DIFFERENT TIMBER DIMENSION APPROACHES

The differences in energy requirement and in energy star rating by using the default timber frame dimension approach and the new approach, i.e. the same dimensions as the steel frame are demonstrated for the sample house (with different variations) and the sample apartment (with ground and top floor variations) used in Chen and Ambrose (2020) for the eight capital cities in Tables 4-7. The star rating differences between the new approach and the previous recommended default timber frame dimension approach are also listed in the last columns in Table 4 and Table 6 for the houses and apartments respectively.

It was found that the new approach gives slightly lower star ratings in comparison with the default timber frame dimension approach. For the house with different construction types, the new approach gives an average of 0.075 less stars and a maximum of 0.2 less star in comparison with the default timber frame dimension approach. For the apartment, the new approach gives an average of 0.015 less stars and a maximum of 0.1 less star in comparison with the default timber frame dimension approach. This is due to that the frame fraction for default timber frame is generally larger than that for the corresponding steel frame. Similarly, the new approach gives a slightly higher energy requirement with a 1.7% increase in average and a 2.8% maximum increase in comparison with the default timber frame dimension approach.

It should be noted that the 0.2 star difference for the two cases in Table 4 is partially caused by the rounding method used in NatHERS star rating, i.e. the star rating never rounds up to a half or a full star. The differences in the total heating and cooling energy requirement for the two cases are 1.7% and 2.0% respectively which should result in a 0.1 star difference (considering that energy difference is approximately 20% for a full star rating difference). However, the star rating with the new approach is 6.9 star and 5.9 star respectively, which causes the star rating difference to be 0.2 stars rather than 0.1 star.

REFERENCES

Chen D and Ambrose M (2020) Thermal Bridging for Residential Building Energy Rating – Updated with NZS4214. CSIRO, Australia.

ISO 6946: 1996. Building components and building elements—thermal resistance and thermal transmittance—calculation method, Switzerland, ISO 1996.

ISO 6946: 2017. Building components and building elements—thermal resistance and thermal transmittance—calculation method, Switzerland, ISO 2017.

New Zealand Standard NZS4214: 2006: Methods of Determining the total Thermal Resistance of Parts of Buildings.

Table 4 AccuBatch modelling results for the house for capital cities using the new timber frame dimension approach

Climate Name	Build Type	Variation	Frame	Thermal Bridge	Approach	Heating MJ/m²	Sensible Cooling MJ/m²	Latent Cooling MJ/m²	Adjusted Heating MJ/m²	Adjusted SCooling MJ/m²	Adjusted LCooling MJ/m²	Adjusted Cooling MJ/m²	Adjusted Energy MJ/m²	Area m²	Stars	Star Diff.
Darwin	House	BV	MF	TB	New	0.0	212.7	111.0	0.0	203.8	106.3	310.2	310.2	148.5	6.7	-0.1
Brisbane	House	BV	MF	TB	New	5.9	28.2	17.0	5.5	26.7	16.1	42.8	48.3	148.5	6.4	-0.1
Perth	House	BV	MF	TB	New	29.5	33.3	3.5	27.2	30.7	3.3	34.0	61.1	148.5	6.9	-0.2
Adelaide	House	BV	MF	TB	New	46.2	30.2	2.1	42.5	27.7	2.0	29.7	72.2	148.5	6.6	-0.1
Sydney	House	BV	MF	TB	New	23.0	8.9	3.9	21.0	8.1	3.5	11.7	32.7	148.5	6.7	-0.1
Melbourne	House	BV	MF	TB	New	60.4	15.5	2.0	54.9	14.1	1.8	15.9	70.8	148.5	6.5	-0.1
Canberra	House	BV	MF	TB	New	150.4	12.6	1.3	137.3	11.5	1.2	12.7	150.0	148.5	6.3	0
Hobart	House	BV	MF	TB	New	155.8	1.3	0.2	141.0	1.2	0.2	1.3	142.3	148.5	6.3	0
Darwin	House	LC	MF	TB	New	0.0	219.3	108.5	0.0	210.1	103.9	314.0	314.0	148.5	6.6	-0.1
Brisbane	House	LC	MF	TB	New	7.2	29.9	16.1	6.8	28.3	15.2	43.5	50.3	148.5	6.3	0
Perth	House	LC	MF	TB	New	33.1	38.0	3.5	30.5	35.0	3.2	38.3	68.7	148.5	6.6	-0.1
Adelaide	House	LC	MF	TB	New	50.8	33.6	2.1	46.7	30.9	1.9	32.8	79.5	148.5	6.2	-0.1
Sydney	House	LC	MF	TB	New	25.5	10.5	3.6	23.3	9.6	3.3	12.8	36.1	148.5	6.4	0
Melbourne	House	LC	MF	TB	New	65.3	17.9	2.0	59.4	16.3	1.8	18.1	77.6	148.5	6.2	-0.1
Canberra	House	LC	MF	TB	New	160.3	15.4	1.3	146.3	14.0	1.2	15.3	161.6	148.5	5.9	-0.2
Hobart	House	LC	MF	TB	New	165.0	1.4	0.2	149.3	1.3	0.1	1.4	150.7	148.5	6	-0.1
Darwin	House	MCSF	MF	TB	New	0.0	209.6	94.8	0.0	200.8	90.8	291.6	291.6	148.5	7.2	0
Brisbane	House	MCSF	MF	TB	New	13.5	29.4	14.6	12.8	27.8	13.8	41.7	54.4	148.5	5.9	-0.1
Perth	House	MCSF	MF	TB	New	41.3	40.4	3.6	38.0	37.2	3.3	40.5	78.5	148.5	6	-0.1
Adelaide	House	MCSF	MF	TB	New	54.0	36.4	2.2	49.7	33.5	2.0	35.5	85.2	148.5	5.9	-0.1
Sydney	House	MCSF	MF	TB	New	29.6	11.3	3.2	27.0	10.3	2.9	13.2	40.2	148.5	5.9	0
Melbourne	House	MCSF	MF	TB	New	65.4	19.4	2.0	59.5	17.7	1.8	19.4	78.9	148.5	6.1	-0.1
Canberra	House	MCSF	MF	TB	New	150.2	17.3	1.5	137.1	15.8	1.3	17.2	154.3	148.5	6.2	0
Hobart	House	MCSF	MF	TB	New	150.3	2.4	0.3	136.0	2.2	0.2	2.4	138.4	148.5	6.4	0

Table 5 AccuBatch modelling results for the house for capital cities using the default timber frame dimension approach

Climate Name	Build Type	Variation	Frame	Thermal Bridge	Approach	Heating MJ/m²	Sensible Cooling MJ/m²	Latent Cooling MJ/m²	Adjusted Heating MJ/m²	Adjusted SCooling MJ/m²	Adjusted LCooling MJ/m²	Adjusted Cooling MJ/m²	Adjusted Energy MJ/m²	Area m²	Stars
Darwin	House	BV	MF	TB	Dft	0.0	211.3	110.6	0.0	202.4	105.9	308.3	308.3	148.5	6.8
Brisbane	House	BV	MF	TB	Dft	5.7	28.1	16.9	5.4	26.5	16.0	42.6	47.9	148.5	6.5
Perth	House	BV	MF	TB	Dft	28.8	33.0	3.5	26.5	30.4	3.2	33.6	60.1	148.5	7.1
Adelaide	House	BV	MF	TB	Dft	45.3	29.7	2.1	41.6	27.3	2.0	29.3	70.9	148.5	6.7
Sydney	House	BV	MF	TB	Dft	22.5	8.8	3.9	20.5	8.1	3.6	11.6	32.2	148.5	6.8
Melbourne	House	BV	MF	TB	Dft	59.3	15.4	2.0	53.9	14.0	1.8	15.8	69.8	148.5	6.6
Canberra	House	BV	MF	TB	Dft	148.1	12.4	1.3	135.1	11.3	1.2	12.4	147.6	148.5	6.3
Hobart	House	BV	MF	TB	Dft	153.5	1.3	0.2	138.9	1.2	0.2	1.3	140.2	148.5	6.3
Darwin	House	LC	MF	TB	Dft	0.0	217.1	108.3	0.0	208.0	103.7	311.7	311.7	148.5	6.7
Brisbane	House	LC	MF	TB	Dft	6.9	29.5	16.0	6.5	27.9	15.1	43.0	49.5	148.5	6.3
Perth	House	LC	MF	TB	Dft	31.9	37.3	3.5	29.4	34.4	3.2	37.6	67.0	148.5	6.7
Adelaide	House	LC	MF	TB	Dft	49.3	33.0	2.1	45.3	30.4	1.9	32.3	77.7	148.5	6.3
Sydney	House	LC	MF	TB	Dft	24.7	10.3	3.6	22.6	9.4	3.3	12.6	35.2	148.5	6.4
Melbourne	House	LC	MF	TB	Dft	63.6	17.6	2.0	57.8	16.0	1.8	17.8	75.6	148.5	6.3
Canberra	House	LC	MF	TB	Dft	156.9	15.3	1.4	143.2	13.9	1.3	15.2	158.4	148.5	6.1
Hobart	House	LC	MF	TB	Dft	161.5	1.3	0.1	146.2	1.2	0.1	1.3	147.5	148.5	6.1
Darwin	House	MCSF	MF	TB	Dft	0.0	207.4	94.6	0.0	198.7	90.6	289.3	289.3	148.5	7.2
Brisbane	House	MCSF	MF	TB	Dft	12.9	28.7	14.4	12.2	27.2	13.6	40.8	53.0	148.5	6
Perth	House	MCSF	MF	TB	Dft	40.5	39.6	3.6	37.3	36.5	3.3	39.8	77.1	148.5	6.1
Adelaide	House	MCSF	MF	TB	Dft	53.2	35.1	2.2	48.9	32.3	2.0	34.3	83.3	148.5	6
Sydney	House	MCSF	MF	TB	Dft	28.9	10.9	3.1	26.4	10.0	2.8	12.8	39.2	148.5	5.9
Melbourne	House	MCSF	MF	TB	Dft	64.8	18.7	1.9	59.0	17.0	1.8	18.8	77.7	148.5	6.2
Canberra	House	MCSF	MF	TB	Dft	149.6	16.6	1.4	136.5	15.1	1.3	16.4	153.0	148.5	6.2
Hobart	House	MCSF	MF	TB	Dft	150.4	2.2	0.2	136.1	2.0	0.2	2.2	138.4	148.5	6.4

Table 6 AccuBatch modelling results for the apartment for capital cities using the new timber frame dimension approach

Climate Name	Build Type	Variation	Frame	Thermal Bridge	Approach	Heating MJ/m²	Sensible Cooling MJ/m²	Latent Cooling MJ/m²	Adjusted Heating MJ/m²	Adjusted SCooling MJ/m²	Adjusted LCooling MJ/m²	Adjusted Cooling MJ/m²	Adjusted Energy MJ/m²	Area m²	Stars	Star Diff.
Darwin	Apt	Ground	MF	TB	New	0.0	207.7	110.9	0.0	193.3	103.2	296.5	296.5	92.5	7	0
Brisbane	Apt	Ground	MF	TB	New	1.8	19.4	13.6	1.7	17.7	12.4	30.1	31.8	92.5	8.4	0
Perth	Apt	Ground	MF	TB	New	20.4	34.1	3.1	18.3	30.7	2.8	33.5	51.8	92.5	7.6	0
Adelaide	Apt	Ground	MF	TB	New	36.8	37.8	2.1	33.2	34.1	1.9	36.0	69.1	92.5	6.7	-0.1
Sydney	Apt	Ground	MF	TB	New	15.5	7.1	3.4	13.9	6.3	3.0	9.3	23.3	92.5	7.8	-0.1
Melbourne	Apt	Ground	MF	TB	New	46.2	17.7	2.1	41.3	15.9	1.9	17.7	59.0	92.5	7.2	0
Canberra	Apt	Ground	MF	TB	New	128.9	10.5	1.1	115.6	9.4	1.0	10.4	126.1	92.5	6.9	0
Hobart	Apt	Ground	MF	TB	New	149.9	1.0	0.1	133.9	0.9	0.1	1.0	134.9	92.5	6.4	0
Darwin	Apt	Top	MF	TB	New	0.0	180.4	97.7	0.0	168.0	91.0	258.9	258.9	92.5	7.9	0
Brisbane	Apt	Top	MF	TB	New	9.6	12.9	8.1	8.7	11.8	7.4	19.2	27.9	92.5	8.9	0
Perth	Apt	Top	MF	TB	New	31.5	51.5	3.3	28.4	46.4	2.9	49.3	77.7	92.5	6.1	0
Adelaide	Apt	Top	MF	TB	New	39.1	50.1	2.4	35.2	45.2	2.2	47.3	82.6	92.5	6.1	0
Sydney	Apt	Top	MF	TB	New	21.3	11.7	2.7	19.1	10.5	2.4	12.9	32.0	92.5	6.8	0
Melbourne	Apt	Top	MF	TB	New	45.3	24.1	2.2	40.5	21.6	2.0	23.5	64.0	92.5	6.9	0
Canberra	Apt	Top	MF	TB	New	108.6	23.9	1.5	97.4	21.4	1.3	22.7	120.1	92.5	7.1	0
Hobart	Apt	Top	MF	TB	New	116.2	2.8	0.3	103.8	2.5	0.2	2.7	106.5	92.5	7.3	0

Table 7 AccuBatch modelling results for the apartment for capital cities using the default timber frame dimension approach

Climate Name	Build Type	Variation	Frame	Thermal Bridge	Approach	Heating MJ/m²	Sensible Cooling MJ/m²	Latent Cooling MJ/m²	Adjusted Heating MJ/m²	Adjusted SCooling MJ/m²	Adjusted LCooling MJ/m²	Adjusted Cooling MJ/m²	Adjusted Energy MJ/m²	Area m²	Stars
Darwin	Apt	Ground	MF	TB	Dft	0.0	207.5	111.0	0.0	193.2	103.3	296.5	296.5	92.5	7
Brisbane	Apt	Ground	MF	TB	Dft	1.8	19.4	13.6	1.6	17.7	12.4	30.1	31.7	92.5	8.4
Perth	Apt	Ground	MF	TB	Dft	20.1	34.0	3.1	18.1	30.6	2.8	33.4	51.5	92.5	7.6
Adelaide	Apt	Ground	MF	TB	Dft	36.4	37.7	2.1	32.8	33.9	1.9	35.8	68.6	92.5	6.8
Sydney	Apt	Ground	MF	TB	Dft	15.4	7.0	3.4	13.8	6.3	3.0	9.3	23.1	92.5	7.9
Melbourne	Apt	Ground	MF	TB	Dft	45.8	17.7	2.1	40.9	15.8	1.9	17.7	58.6	92.5	7.2
Canberra	Apt	Ground	MF	TB	Dft	128.0	10.4	1.1	114.8	9.4	1.0	10.4	125.2	92.5	6.9
Hobart	Apt	Ground	MF	TB	Dft	149.1	1.0	0.1	133.1	0.9	0.1	1.0	134.1	92.5	6.4
Darwin	Apt	Top	MF	TB	Dft	0.0	180.4	97.7	0.0	168.0	91.0	259.0	259.0	92.5	7.9
Brisbane	Apt	Top	MF	TB	Dft	9.5	12.9	8.1	8.7	11.8	7.4	19.2	27.9	92.5	8.9
Perth	Apt	Top	MF	TB	Dft	31.4	51.6	3.3	28.3	46.4	2.9	49.4	77.6	92.5	6.1
Adelaide	Apt	Top	MF	TB	Dft	39.0	50.1	2.4	35.1	45.1	2.2	47.3	82.4	92.5	6.1
Sydney	Apt	Top	MF	TB	Dft	21.3	11.5	2.7	19.1	10.4	2.4	12.8	31.8	92.5	6.8
Melbourne	Apt	Top	MF	TB	Dft	45.1	24.1	2.2	40.3	21.6	2.0	23.5	63.9	92.5	6.9
Canberra	Apt	Top	MF	TB	Dft	108.2	23.8	1.5	97.0	21.4	1.3	22.7	119.7	92.5	7.1
Hobart	Apt	Top	MF	TB	Dft	115.9	2.8	0.3	103.4	2.5	0.2	2.7	106.2	92.5	7.3

Note: The “Dft”.

BV brick veneer

Dft default, the default timber dimension approach

Ground ground floor

LC Lightweight cladding (eg fibre cement) on a waffle pod slab

MCSF	metal cladding with suspended floor
MF	metal frame
NA	thermal bridging not applied
NB	no thermal break
New	the new approach using the same dimensions as the steel frame
TB	with thermal break
TF	timber frame
Top	top floor