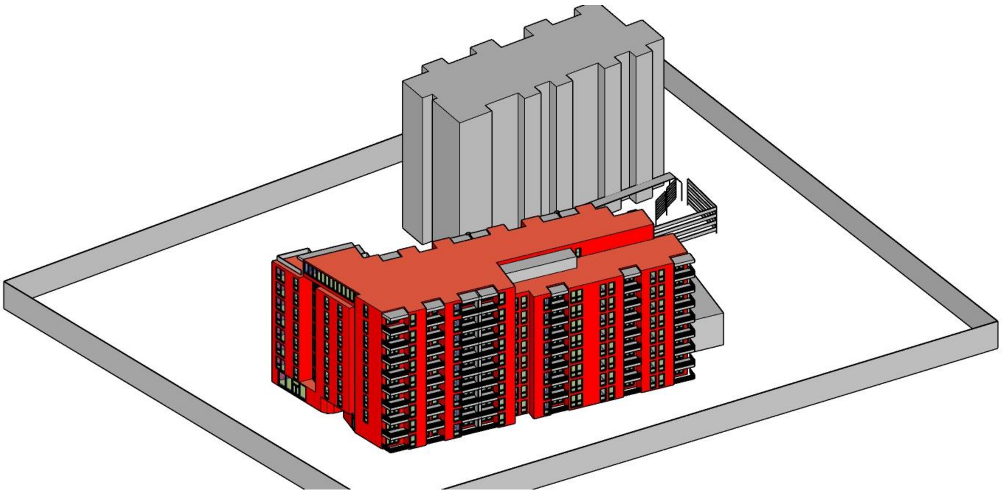
Stellar Apartments - Mauranui

Initial Passive House Design



29 April 2022

Sustainable Engineering Ltd

Purpose

We have prepared an initial design review analysing the building's performance as currently specified and options to reach Passive House standard. We have provided recommendations to achieve each performance level. This report is intended to show *what* needs to be done for this specific design and site to meet various performance goals. This advice is specific to the named project and based on the drawings and specifications supplied by the client.

Summary

The buildings are very large with a slightly high glazing ratio compared to a Passive House design. Maranui and GSR have a very low form factor of 1.2 and 1.3 respectively (form factor is surface area divided by the useful floor area). A design with a form factor of below 3 indicates an efficient floor plan and we typically see form factors of over 4. The form factor of this design is driven by the large apartment blocks. As you can see on the graphs on the following page, this kind of design produces Passive House like performance with code levels of insulation. The spec design has a lower heating requirement than code but this may not be necessary as the building is already so highly performing.

We have modelled design variants of four different solutions with varying levels of performance. Code insulation R-values already meet Passive House performance levels so additional insulation levels of insulation may not be necessary.

If you were to use a Passive House certified MVHR and window frames that are known to pass the surface temperature requirements, then certifying the buildings would be achievable.

This building has a moderate glazing ratio for a Passive House with the window area being 23% of the usable floor area. Low solar heat gain glass is essential for both projects.

The energy savings between code and variant 3 are 85,333 kWh/a. Assuming a heat pump system with an efficiency of 3:1 and an electricity unit rate of 19.5c/kWh (excluding lines charges) this equates to a cost saving of $5,547 p.a. The net present value of this saving over 50 years of operation, assuming a 2% discount rate, is $ 174,294. At a0% discount rate (assuming parity between electricity price rises and interest rate increases it would be $277,331.

Possibly of more interest is the efficiency gains of opting for a heat pump domestic hot water system. Switching from a business-as-usual electric resistance hot water cylinder in each dwelling to a heat pump hot water cylinder would save 6,090 kWh/a. Amalgamated storage and efficient hot water loops would add further to those savings. This is an annual saving of $31,240 with a NPV of $982,000 using a 2% discount rate. Further savings would likely be possible thanks to reducing the size of the electrical connection required for the building.

Recommendations

- The balcony details may cause substantial heat loss, especially if concrete is continued out from the inside of the thermal envelope to the outdoor air. We can go over better practice options for these during detailed design.
- The carpark column details may also cause heat loss. This is another detail that we can review in detailed design. We've not allowed margin for this heat loss.
- Brick lintels & brick ties need to be carefully considered to minimise thermal bridging through the PIR layer. These details ought to be reviewed for potential internal moisture issues.
- We would recommend considering a lighter weight cladding system such as the clay tile system being used by Nga Kainga Anamata.
- Check overheating of critical apartments with TM59 calcs. Our results are averaged across the building as a whole and sunny corner apartments could see substantially more overheating.
- If you opt for a MVHR system that is Passive House certified and window frames that we know will meet the surface temperature criteria then you have met all the main components for certification.
- Certifying the buildings is one way to demonstrate that you meet the healthy housing standards without installing an oversized heating system.
- Localised overheating may occur in some apartments, particularly those with more solar heat gain or high internal loads. Hotter summers will also increase the likelihood of this being a problem.
- Consider the pros and cons between a centralised vs decentralised MVHR system. Centralised systems can make maintenance simpler overall and help balance heating/cooling loads around the building, but the fire separation requirements can be challenging. Units in every apartment avoid many penetrations through fire walls and allow for more individual control but there is more maintenance required, especially labour changing filters. Some building managers like the justification for 6 monthly maintenance visits. Either way we would advise that maintenance of the mechanical systems is carried out by the landlord to ensure it is done regularly and the equipment is well cared for.
- Domestic hot water cylinders and circulation loops that are not sufficiently insulated may contribute unwanted internal heat gains and cause overheating issues. With standalone hot water systems, the heat losses from these could easily be double the heating demand (they would effectively be your heating system). International best practice would be heat pump water heaters with very compact tube in tube circulation loops to vertical stacks of apartments.
- Internal loads have been assumed to be 2.79W/m2 (conservative for a heating case). Variant 6 assumes 2.79 W/m2 for heating and 5.36 W/m2 for cooling. This represents around 3 occupants per apartment, a hot water cylinder and some additional plug-loads. Research into modelling assumptions by BRANZ (Carbon Challenge Seminar parametric energy simulation) indicated load assumptions of 2.43 to 6.38 W/m2 for a 150m2 dwelling which will have a lower density of energy using appliances than an approximately 70m2 2 bedroom apartment.
- Both buildings will have a higher heating load for the ground floor. GSR for the commercial which is on a slab on grade and Mauranui for the residential which is over the carpark or a slab on grade. This is estimated at 17W/m2 (assuming edge insulation only).
- All slab on grade occupied space should have edge insulation for energy efficiency and to prevent mould issues.

Table 1: Heat Pump Sizes

Variant	Name	Heating Load W/m²	Cooling Load W/m²	Frequency of overheating (> 25 °C)	HP Heating Capacity kW	HP Cooling capacity kW
1	NZ Code	16.4	10.1	6%	262	128
2	Spec	5.9	10.4	16%	94	132
3	APL windows - Low G glass	5.3	6.0	3%	84	76
4	Reduce Insulation	5.7	6.0	3%	92	77
5	Certified MVHR	5.1	6.0	3%	81	77
6	3 with higher internal loads	5.6	8.5	17%	89	109

Airtightness

The building durability and performance is dependent on the air/vapour control layer being continuous, & without leaks, for the life of the building. The key to this airtightness performance is to specify the control layer installation (i.e. design it properly) and then test it (air leakage testing) to make certain it was built properly. In practice, this typically means that the internal linings will be mounted on battens creating a service cavity and installed after the air leakage testing so that any defects in the air/vapour control layer can be easily located and repaired during testing. The installation of the internal lining can then be done such that the air/vapour control layer is not damaged. Additionally, having a service cavity between the internal lining and the air/vapour control layer protects the control layer from damage from hanging paintings/signs, retrofit wiring, etc. The air/vapour control layer is not to be penetrated by services except where necessary and these penetrations should be carefully sealed.

Variants

For the initial design process, we have modelled the building thermal envelope (the external shell) along with the site shading provided (see Figure 1). We then model several variants (using Passive House Planning Package or PHPP) to determine the building's overall heating/cooling energy usage (Figure 1). We start with the NZ Building Code legal minimum as a reference point, then assess the performance of the specified design and finally move up in performance in economic steps until we reach the Passive House performance level.

1. NZ Code

   Code based on the schedule R-values. Extract only ventilation.
2. Spec

   Specified performance, good low E argon filled double glazing in thermally broken aluminum frames, Lossnay MVHR. 100mm EPS insulation to suspended slabs to achieve min R2.5. 140mm stud walls with 140mm batt insulation ~R3.2. 120mm PIR to all roof types.
3. APL windows with Low G glass

   Window frames that would meet the Passive House surface temperature requirements and low solar heat gain glass to reduce overheating.
4. Reduce insulation

   90mm stud walls, still with 40mm external insulation. 100mm PIR to the roof and roof decks. 50mm insulation to the suspended slabs.
5. Certified MVHR

   Option 4 with a passive house certified MVHR. Zehender used as an example, Stiebel Eltron or Woolf would have similar performance.
6. 3 with higher internal loads

   Assuming 3 occupants per apartment and some additional plug loads for a more conservative cooling case. No natural ventilation.

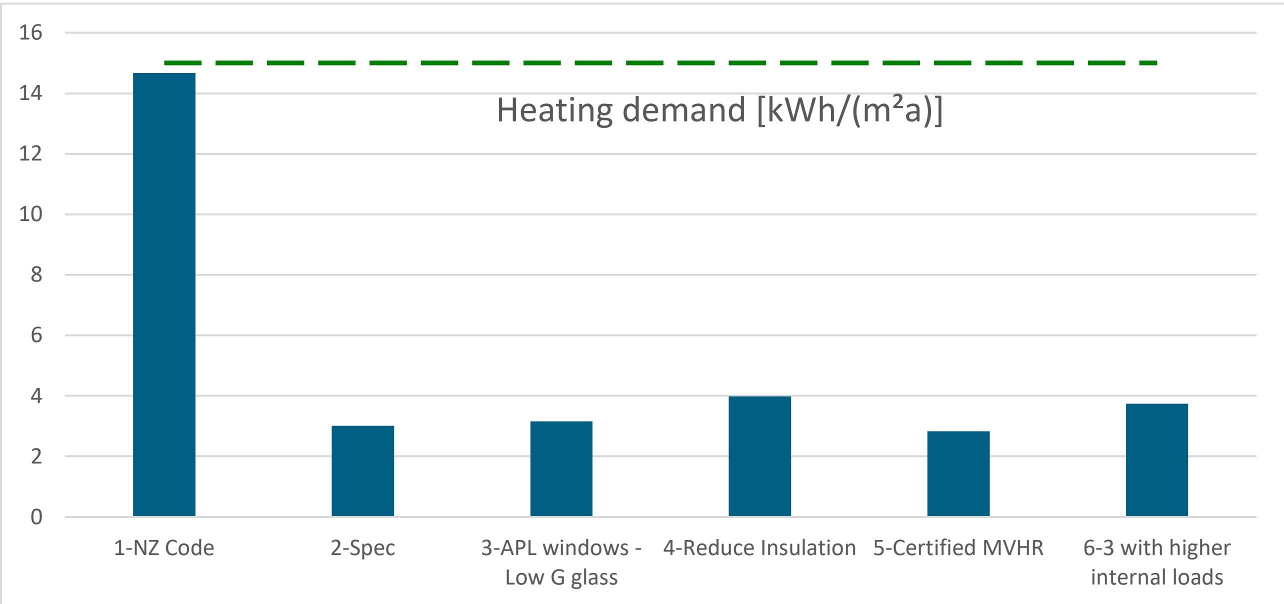


Figure 1: Variants according to heating demand

Thermal Comfort

Winter thermal comfort is assured in the Passive House variant. This would be ‘A’ grade space per ISO7730 and means that you can occupy the full space in the winter. This is straightforward to calculate as the design condition is a cold clear night. The Low Energy Building variants do not always offer the same assurance of winter thermal comfort as the windows can fail to meet the thermal comfort criteria – so the rest of the building would be fine but you might get cold if you sit right up against the windows.

Summer thermal comfort is not assured in the same way. Passive House design and even certification doesn’t guarantee summer comfort. This is because Passive House Certification allows up to 10% overheating which means by definition, there will be hours of *dis-comfort*. Additionally, the standard permits the flexibility of using night or additional windows ventilation and operable shading. But, if the occupants keep all the windows closed because they like it nice and quiet, or don’t close the blinds because they like the view, the building will overheat even more than expected. To allow the flexibility for the occupant who lives in the countryside to have the windows open or shading deployed the overheating percentage is dependent on occupant behaviour.

Frequency of overheating (>25˚C)

One of the ways we work to understand overheating in this building is to run what we call a stress-test. To perform the stress-test, we remove any window/night ventilation, set the operable shading to minimum and set the MVHR to standard rate on summer bypass (or leave on the continuous extract fan). Then if the building is below 5% overheating, we’ve got a building that’s *easy to keep cool*. If it’s over 5% overheating, and almost all buildings are, then it is *likely to overheat*. Put in a heat pump for cooling or at the absolute least put in the wiring/ducting to add one easily later. This stress-test gives us a consistent measure to compare between buildings so you know how this building might work if you wanted to keep it closed for noise or security reasons.

When we run the stress test on this building the overheating ranges from 1,530-280 hours of overheating a year (17-3%). There is a reasonable risk of overheating with this design.

Table 2: Stress test with no operable shading or windows opened

	NZ Code	Spec	APL windows - Low G glass	Reduce Insulation	Certified MVHR	3 with higher internal loads
	1	2	3	4	5	6
Stress Test – no natural ventilation or operable shading						
Frequency of overheating (> 25 °C)	6%	16%	3%	3%	3%	17%
Annual hours of overheating	521	1433	289	280	280	1525

Initial Carbon Estimate

The built environment (of which buildings are a large part) makes a surprisingly large contribution to greenhouse gas emissions: fully 20% of New Zealand's emissions when measured from the point of view of consumption. There are a range of tools and strategies available for reducing both the embodied and operational carbon emissions associated with new buildings.

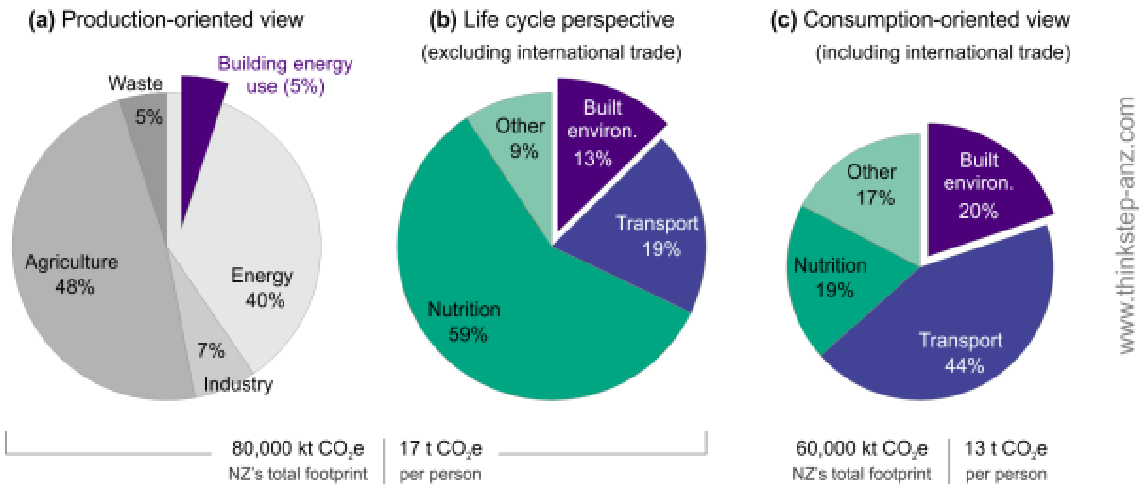


Figure 2: Hotspot or not? The carbon footprint of NZ's built environment. Report by thinkstep-anz

Estimating embodied and operational carbon emissions is very useful at this early stage of design. It can guide decision-making between alternative design concepts and indicates how the building's carbon footprint can be reduced.

The carbon calculator we have developed takes into account embodied carbon up until the time the building is completed (ie it does not include emissions associated with disposal of products at the end of their life). Our calculations are based on the standard LCA 90-year lifespan for a new building (although we note that in many other parts of the world, homes and other buildings are habited for hundreds of years).

This is a design stage assessment that provides fast, affordable and indicative comparisons between building elements and variants, to support good design choices at an early stage of design. The following limitations should be noted.

- Only the thermal envelope area is included in the analysis: the materials from the cladding to the interior of the wall, floor and roof. For the sake of clarity, internal walls, midfloors and attached garages are not included.
- Cladding and roofing are assumed to be painted weatherboards and long run steel roofing respectively.
- Carpet or other flooring coverings and internal fit-out are not included. (In the case of a solid wood floor laid on joists, the analysis includes the plywood subfloor, not the flooring.)
- Element carbon values from the High-Performance Construction Details Handbook were used. This includes stages A1-A5 for embodied carbon.

- The environmental impact of the grid is factored in across the 90-year life span (even electricity generated from 100% renewable sources still has a carbon impact due to the grid infrastructure). We have calculated this impact based on the BRANZ data.
- The aggregated carbon for a specific building should be based on a full LCA analysis for that particular project.

Reducing carbon emissions

The following strategies are useful 'low-hanging fruit' that will reduce the carbon emissions of any building.

- If a concrete slab is unavoidable, consider the use of additives that reduce carbon emissions.
- Increase R-value of walls and roof by improving insulation and minimising or eliminating thermal bridges.
- Reduce or eliminate the use of steel.
- Specify locally-grown timber. Consider the use of engineered timber products such as cross-laminated beams for structural purposes.
- Specify timber windows instead of aluminum.
- Long-lasting timber products for cladding.
- All-electric heating instead of using gas for cooking or water or space heating.
- Use heat pump hot water heaters for the most energy-efficient hot water heating.

Specific recommendations for Stellar Apartments

We can calculate the embodied carbon for this design as part of the detailed design if desired. It would require a few specialist assemblies for the unique constructions to this building. The concrete shear walls and midfloor will be the main driver of the embodied CO_2 for a design like this, however it could be interesting to find out if the outstanding efficiency of the envelope makes up for the higher embodied carbon needed for the structure.

With the thermal efficiency of these apartments, hot water, lighting and appliance use will be the main driver of each unit's operational CO_2 emissions. In the graph below variants 1, 2 and 3 have heat pump heating, cooling and domestic hot water systems. Variants 4, 5 and 6 have electric resistance heating and domestic hot water.

Note that the appliance assumed in the graphs below are modern and efficient. If tenants were to supply their own (i.e. old inefficient fridges) then these emissions could be higher.

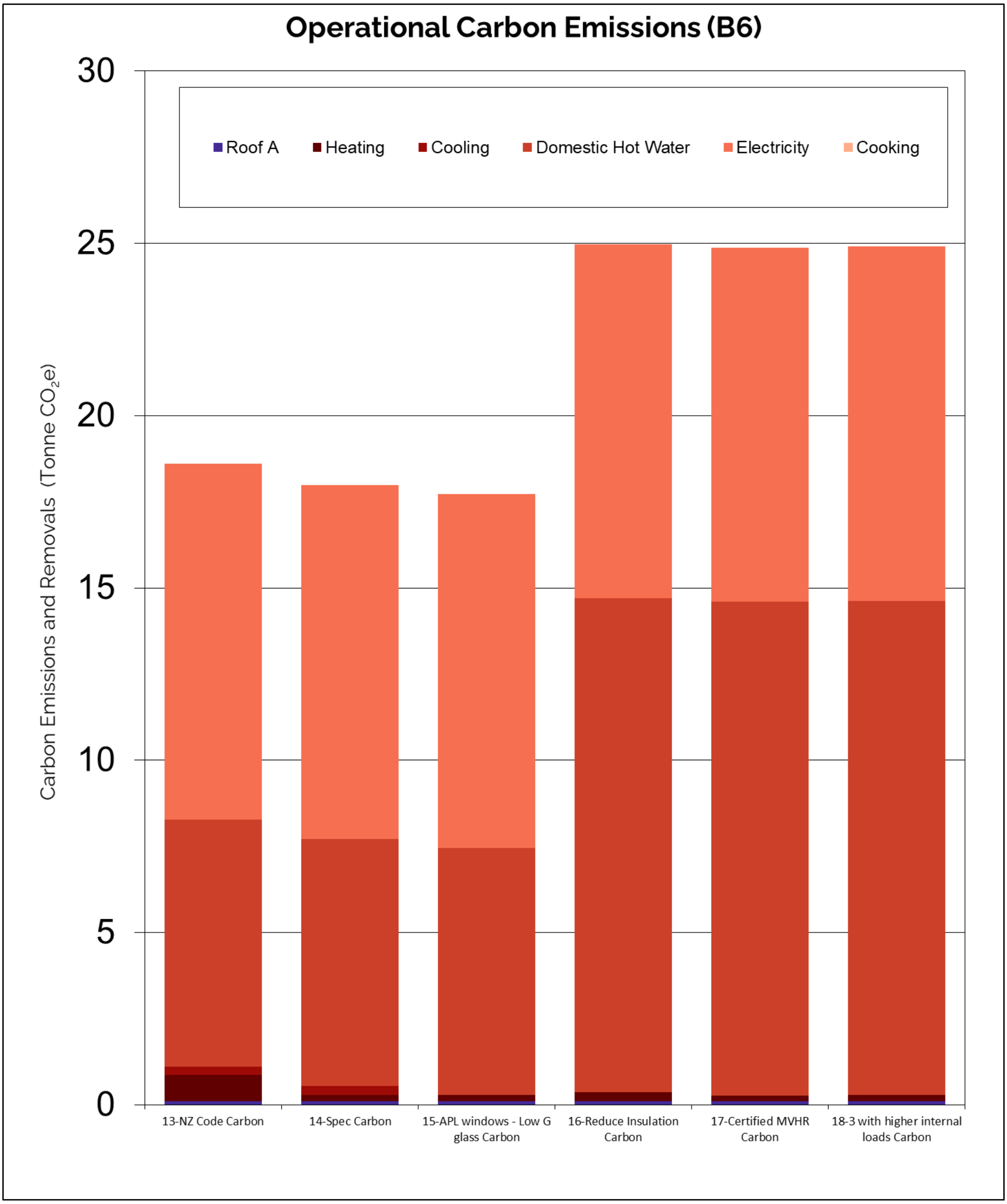


Figure 3: Carbon calculation for six initial design variants

Next step

This completes the **Initial Design Phase** of our process. The next step is to discuss what you want to build and move into the Detail Design Phase so that we can work out how it is to be built. Following our process ensures that this project proceeds in a timely way and delivers the result you want. This Initial Design report describes what you need (in terms of walls, glazing, floor etc) to reach your desired level of performance. The Detail Design Phase works out *how* to do it:

We provide your designer/architect with the highly specific details to reach the required performance level so that they do not need to generate these themselves by trial and error. Our advice focuses on the junctions and details that typically cause issues during construction and quality assurance testing.

We review the designer's drawings adding constructability information and call outs to reduce construction questions and building time.

We give recommendations about the best suppliers and products to suit your particular project.

Providing correct details for the 'fiddly bits' unique to high-performance construction can save time, the need to rework drawings and the cost of fixing mistakes once constructed. This is particularly important if your designer and/or builder do not have a lot of experience in designing and constructing Passive Houses.

Reviewing drawings will fix mistakes and clarify ambiguities at the drawing board stage, not on the building site.

Some clients hire us for the Detailed Design Phase solely to access our independent advice about the best and most suitable components to use and which suppliers to work with. We are in an unique position as New Zealand's sole Passive House certifier: every Passive House project in New Zealand (and some in Australia) come across our desk. We make it our business to know the intricate detail of every component available for use in a certified Passive House. Without any financial or other type of tie to any one supplier, we can identify the best options for your specific project. Good performance windows and doors can account for 20+% of a project; our advice on vendors to consider alone could save you far more than the cost of our fee.

After the detail design phase, we can offer **Construction Support**. Note that we generally do not provide construction advice unless we have also done the Detailed Design or fully reviewed the design drawings. We can't (from an ethical or liability standpoint) provide support to designers and builders during the construction for detailed design we have not been involved with.

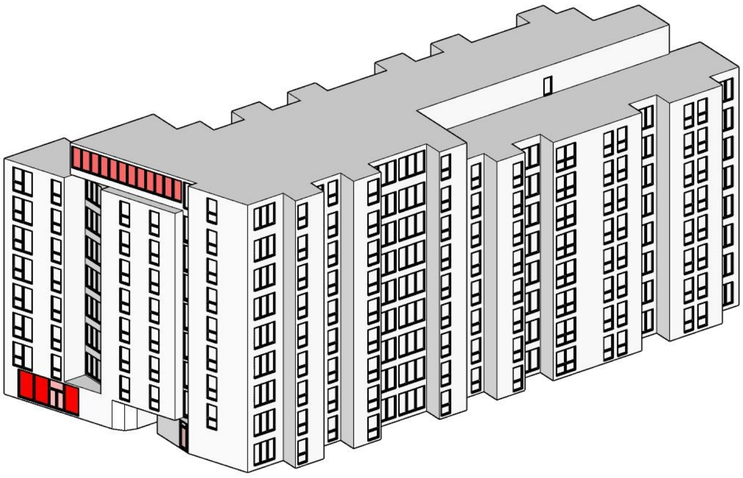
For the highest performance designs, we can also offer to submit them for **Passive House Certification** and provide the required information to the third-party Passive House Certifier. This independent review provides market assurance that the building is designed and built to surpass the stringent Passive House Certification criteria. A Certified Passive House rating should increase resale/rent if the local market acts similarly to California, where property values have been found to increase 9% with 3rd party green labelling.

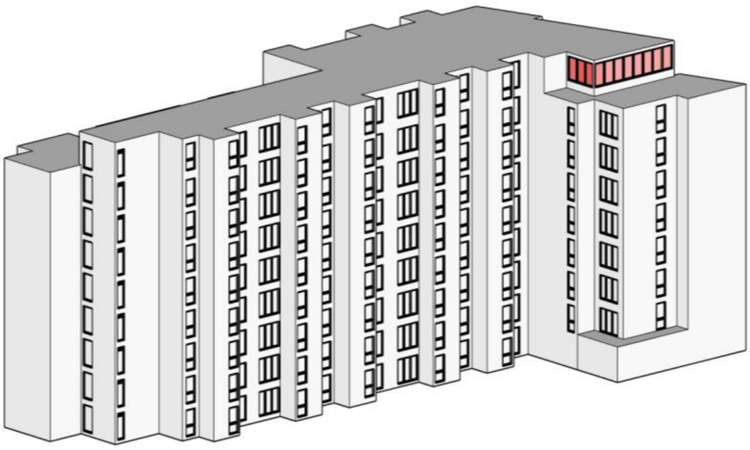
Appendices

Window Analysis

In our process we have generated a graphic showing the window heat gains per square meter from high to low (or losses) from red to blue. This is to illustrate how each window contributes to the building heating or heat losses in the winter and overheating and cooling in the summer.

Two example illustrations are provided below. Typically, we can colourise all the windows in these to provide an idea of where the solar heat gains are coming from. Unfortunately, due to the sheet number of windows our software did not work as usual. We will investigate what is happening with these and produce a memo with one floor with the windows coloured by their solar heat gain.





Energy Balance Graphs

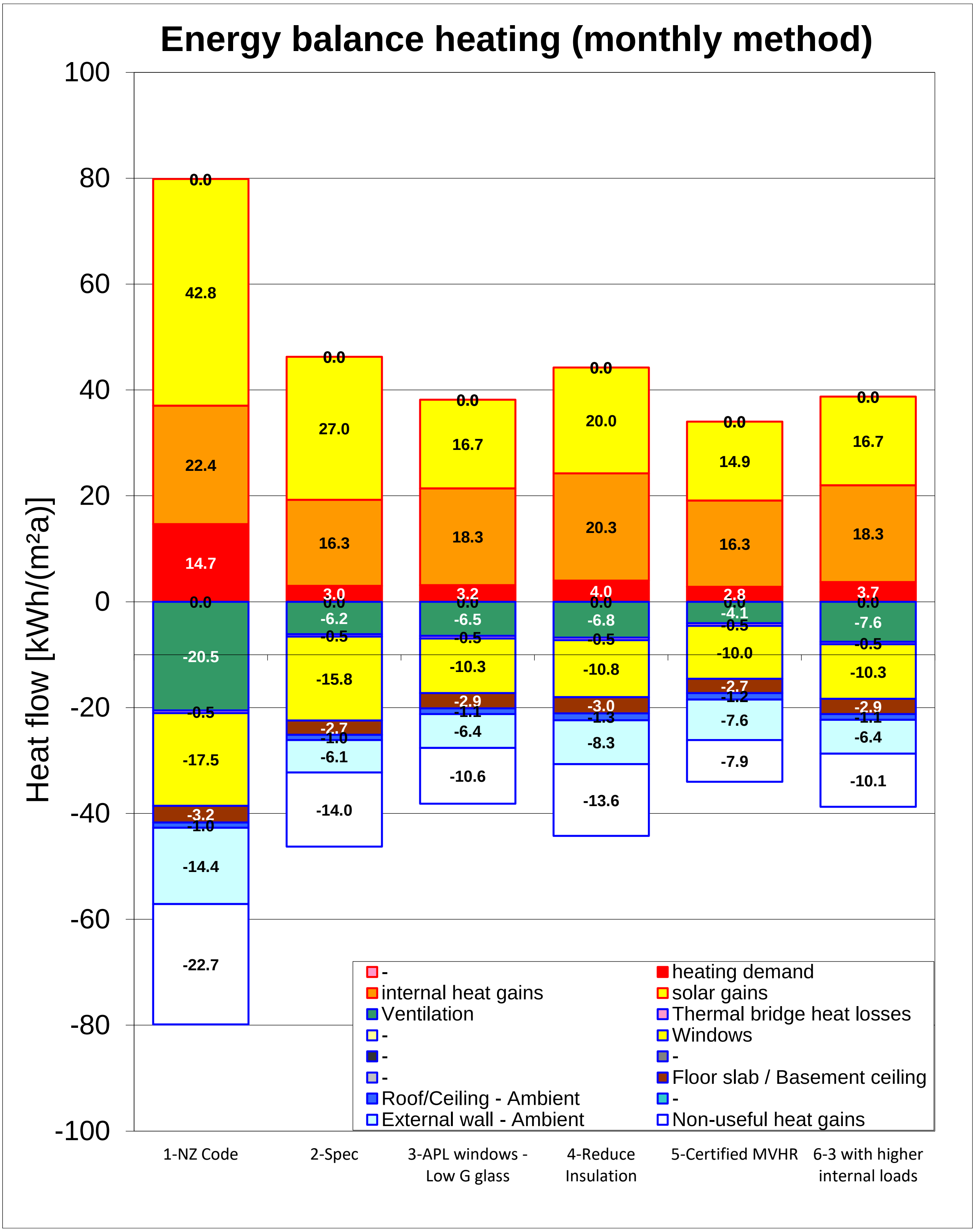


Figure 4: All variants heating demand energy balance

Variant calculation

Passive House with PHPP Version 9.6a

Stellar Appartments - Mauranui / Climate: Auckland / TFA: 7975 m² / Heating: 3.7 kWh/(m²a) / Cooling: 10.1 kWh/(m²a) / PER: 95.9 kWh/(m²a)

		NZ Code	Spec	APL windows - Low G glass	Reduce Insulation	Certified MVHR	3 with higher internal loads
Results	**Units**	**1**	**2**	**3**	**4**	**5**	**6**
Heating demand	kWh/(m²a)	14.7	3.0	3.2	4.0	2.8	3.7
Heating load	W/m²	16.4	5.9	5.3	5.7	5.1	5.6
Cooling & dehum. demand	kWh/(m²a)	4.0	6.1	1.4	1.5	1.5	10.1
Cooling load	W/m²	10.1	10.4	6.0	6.0	6.0	8.5
Frequency of overheating (> 25 °C)	%						
PER demand	kWh/(m²a)	77.5	66.9	65.3	66.3	65.0	95.9
Passive House Classic?	yes / no	no	no	no	no	no	no
User determined results		-	-	-	-	-	-
Whole of Wall R-value	m²K/W	2.1	4.4	4.4	3.6	3.6	4.4
Whole of Roof R-value	m²K/W	6.7	5.8	5.8	4.9	4.9	5.8
Effective Slab R-value (accounts for ground)	m²K/W	2.9	2.9	2.9	2.9	2.9	2.9
Windows R-value	m²K/W	0.6	0.6	0.9	0.9	0.9	0.9
Glass	type	03ud-Double low-E glazing 4/16Argon90%/4 Epsilon=0.1	03ud-Double low-E glazing 4/16Argon90%/4 Epsilon=0.1	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)
Windows Ug	W/(m²K)	1.3	1.3	1.1	1.1	1.1	1.1
Windows g-value	fraction	0.6	0.6	0.4	0.4	0.4	0.4
Frame	type	03ud-NZ thermal broken alum	03ud-NZ thermal broken alum	39ud-APL opening	39ud-APL opening	39ud-APL opening	39ud-APL opening
Frame Uf	W/(m²K)	3.0	3.0	0.8	0.8	0.8	0.8
Ventilation	type	2-Extract air unit	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR
MVHR Selected	model		02ud-Allowance for Mitsuibishi HRV unit	02ud-Allowance for Mitsuibishi HRV unit	02ud-Allowance for Mitsuibishi HRV unit	03ud-Zehnder - ComfoAir 180	02ud-Allowance for Mitsuibishi HRV unit
Overall MVHR Eff	%		0.6	0.6	0.6	0.8	0.6
Air Tightness	ACH_n50	6.0	1.0	1.0	1.0	1.0	1.0
Window ventilation rate	ACH	0.3	0.3	0.3	0.3	0.3	0.0
Night Ventilation Rate	ACH	0.3	0.3	0.3	0.3	0.3	0.0
Summer Daily Temp Stroke	degrees C	4.6	4.2	2.6	2.7	2.7	2.2
Cooling load (if active cooling)	W/m²	10.1	10.4	6.0	6.0	6.0	8.5
Frequency of overheating (> 25 °C)	%	0.1	0.2	0.0	0.0	0.0	0.2
Annual hours of overheating (> 25 °C)	hours	521.0	1433.0	289.0	280.0	280.0	1525.0
0.000	hours	0.0	0.0	0.0	0.0	0.0	0.0
0.000	hours	0.0	0.0	0.0	0.0	0.0	0.0

	Input variables	Units	1	2	3	4	5	6
▼	Building assembly layers	U-Value						
a	Wall Stud Insulation	W/(mK)	0.034	0.044	0.044	0.044	0.044	0.044
		mm	90	140	140	90	90	140
b	Wall Outside Insulation	W/(mK)	0.033	0.024	0.024	0.024	0.024	0.024
		mm	0	40	40	40	40	40
c	Roof Insulation	W/(mK)	0.022	0.022	0.022	0.022	0.022	0.022
		mm	140	120	120	100	100	120
d	Roof Deck Insulation	W/(mK)	0.022	0.022	0.022	0.022	0.022	0.022
		mm	140	120	120	100	100	120
e	Slab Insulation	W/(mK)	0.040	0.040	0.040	0.040	0.040	0.040
		mm	0	0	0	0	0	0
f	Suspended slab insulation	W/(mK)	0.040	0.040	0.040	0.040	0.040	0.040
		mm	50	100	100	50	50	100
▼	Windows and shading	Windows						
a	Windows	Glazing list						
	Active variant: g-Value:0.53 U-Value: 1.12 W/(m²K)	Glazing	03ud-Double low-E glazing 4/16Argon90%/4 Epsilon=0.1	03ud-Double low-E glazing 4/16Argon90%/4 Epsilon=0.1	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)	14ud-Metro - Xtreme (5:/16/4 90% Ar)
	U-Value [W/(m²K]: left: 3 right: 3 bottom: 3 top: 3 Width [m]: left: 0.06 right: 0.06 bottom: 0.06 top: 0.06	Frame	03ud-NZ thermal broken alum	03ud-NZ thermal broken alum	39ud-APL opening	39ud-APL opening	39ud-APL opening	39ud-APL opening
	Window reveal depth	m	0.025	0.025	0.025	0.025	0.025	0.025
	Distance from glazing edge to reveal	m	0	0	0	0	0	0
b	Doors	Glazing list						
		Glazing						
		Frame						
	Window reveal depth	m						
	Distance from glazing edge to reveal	m						
▼	Ventilation	Ventilation						
	Ventilation type	select	2-Extract air unit	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR
	Air change rate at pressurisation test (n50)	1/h	6	1	1	1	1	1
	Design air flow rate (maximum)	m³/h	9900	9900	9900	9900	9900	9900
	Installation site ventilation unit	Inside / Outside	1-Inside thermal envelope	1-Inside thermal envelope	1-Inside thermal envelope	1-Inside thermal envelope	1-Inside thermal envelope	1-Inside thermal envelope
	Ventilation unit selection	select	0	02ud-Allowance for Mitsuibishi HRV unit	02ud-Allowance for Mitsuibishi HRV unit	02ud-Allowance for Mitsuibishi HRV unit	03ud-Zehnder - ComfoAir 180	02ud-Allowance for Mitsuibishi HRV unit
▼	User determined parameters							
1	Timber Fraction in Outer Stud w	%	22%	22%	22%	22%	22%	22%
2	Perimeter Thermal Bridges		0.000	0.250	0.250	0.250	0.250	0.250
3	Occupancy		207.300	207.300	207.300	207.300	207.300	330.000
4	Extra IHG		0.000	0.000	0.000	0.000	0.000	1.000