BETTER APARTMENTS DISCUSSION PAPER

APARTMENT ENERGY METRICS

FOR

DEPARTMENT OF ENVIRONMENT, LAND, WATER AND PLANNING

22 July 2016

File 1025A

In conjunction with Tony Isaacs Consulting Pty Ltd

CONTENTS

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1. Introduction

1.1. Nature of the problem

This project seeks to develop additional performance metrics for apartment buildings in order to improve minimum standards for summer performance specifically and overall performance in general.

There is anecdotal evidence of poor summer performance in apartment buildings constructed to the minimum requirements of the NCC. This is supported by theoretical analysis. Apartments have large areas of shared walls, floors and ceilings which have minimal heat loss in winter. Apartments therefore have significant lower heating loads than detached houses. Because the NatHERS rating is based on the sum of heating and cooling loads, this inherent advantage in winter could mean that apartments have significantly higher cooling loads than detached houses.

The nature of NCC minimum performance requirements for apartments is different to that for houses. While all houses must meet a minimum of 6 stars, apartment ratings are averaged over the whole building. No apartment may have a rating lower than 5 stars, while the average rating for the building must be a minimum of 6 stars. This averaging allows significantly greater variation in the performance of apartments than in houses and this could further exacerbate issues with summer performance.

1.2. Buildings used to examine the issue

Three apartment buildings were used for this analysis to represent high rise, medium rise and low rise apartment buildings.

Table 1 The 3 apartment buildings used in this study

Building Type	Code used in this report	Number of Storeys	Number of Apartments
High rise	690 E	18	147
Medium Rise	2-6 R	9	115
Low Rise	216 C	5	31

Plans for typical floors and elevations are shown in the Appendix.

1.3. Alternative metrics used

This project has proposed the use of two alternative metrics to address the performance issues with apartments:

- Increase the minimum rating to 5.5 stars

  Apartments with larger exposed surface areas e.g. top floor with exposed roof, lower floor with floors above car parks or corner units, may also have poor winter performance. 5.5 stars was proposed to ensure that apartments which also have poor performance in winter are also captured.

- Impose a limit on the size of simulated cooling loads (‘cooling cap’): 30 MJ/m2 has been suggested from a number of sources. (This applies to the Melbourne Central Climate, Moorabbin and Tullamarine may require different cooling caps)

  Communication with Sustainability Victoria -who have a database of rating energy loads for all dwellings submitted for building permit in the last 12 months - confirmed 30 MJ/m^2 would capture the worst performing apartments. This metric directly addresses the perceived issue with poor summer performance.

1.4. Albedo

Lowering the Albedo of roofs i.e. using a lighter colour will reduce the effective external temperature and therefore the heat flows through the roof in hot conditions. This measure was not comprehensively reviewed for this project for five reasons:

- In multi-storey buildings the roof colour only affects the top floor. In the three apartment buildings evaluated for this project this represents only 8% of the units,
- Top floor apartments often have higher glazing areas to capture views. This is the reason that these roof level apartments perform poorly so adjusting the albedo will not address the key design issue.
- Roofs are always well insulated so whilst the reduction in the effective temperature of the roof during the day through using lighter colours may be significant, the insulation has already significantly reduced heat flows so the overall effect is low,
- The most commonly used NatHERS tools (FirstRate5 and BERS Pro) only have roof colour options of light, medium and dark so the ability to fine tune the albedo is not great, and;
- Using a lighter coloured roof increases heating energy requirements. This increase is often larger than the decrease in cooling requirements e.g. in one of the top floor units in the 690 E building changing the roof colour to a light colour from the default medium only reduced cooling from 33.2 to 32.4 MJ/m2, while heating was increased from 95.6 to 98.0.

1.5. Assessing apartment performance

The impacts of the two proposed metrics are assessed using three measures:

- **Expected average energy loads for heating and cooling.** The NatHERS occupancy pattern assumes that occupants are home all day, and that heating or cooling is available whenever the dwelling is uncomfortable. In addition, lower thermostats are used in bedrooms for heating and a high cooling thermostat is used to provide easier compliance for dwellings designed for passive cooling. A new occupancy pattern and thermostat settings were used to better approximate average use: 11 hours per day occupancy (excluding overnight), 20 degree heating thermostat in both living areas and bedrooms and a 23 degree cooling thermostat.
- **Average number of hours of discomfort.** To undertake this analysis, heating and cooling was turned off, and temperatures allowed to float. The average number of hours which exceed 27 degrees was assessed for each apartment to provide an indication of discomfort. The number of hours was averaged across all rooms in each apartment.

  Twenty seven (27) degrees was used as this broadly correlates with the Discomfort Index (Morshed 2015). The Discomfort Index (DI) = 0.5 * Wet Bulb temperature + 0.5 * dry bulb temperature. When the DI is greater than 28 there is a high probability of heat stress. Note that NatHERS tools output internal environmental temperature which takes into account both the radiant temperature of surfaces and the air temperature. It is a better measure of comfort than air temperature alone.
- **Peak Loads**. Peak loads occur when the dwelling has been closed up all day, unable to ventilate and occupants arrive home after work. The occupancy pattern was adjusted to close the house during the day. Peak loads affect the capacity of the grid to supply electricity and the size (and therefore cost) of the cooling appliance/plant.

  Note that the increasing use of time-of-use electricity tariffs will mean one unit of cooling will be more expensive than heating because cooling loads are highest during the daytime peak period.

  Where time-of-use tariffs are applied containing peak loads will therefore result in a greater level of cost saving.

These performance measures are not available using NatHERS tools. A special utility has been designed for use with NatHERS tools to allow more in depth assessment. This tool is called AccuBatch. It was originally designed by Tony Isaacs and is now owned and supported by CSIRO. Note that NatHERS assessors will not need to use AccuBatch to determine whether units meet the cooling cap or 5.5 star minimum. AccuBatch was only used by this project to determine free running temperatures and peak loads.

1.6. Climates assessed

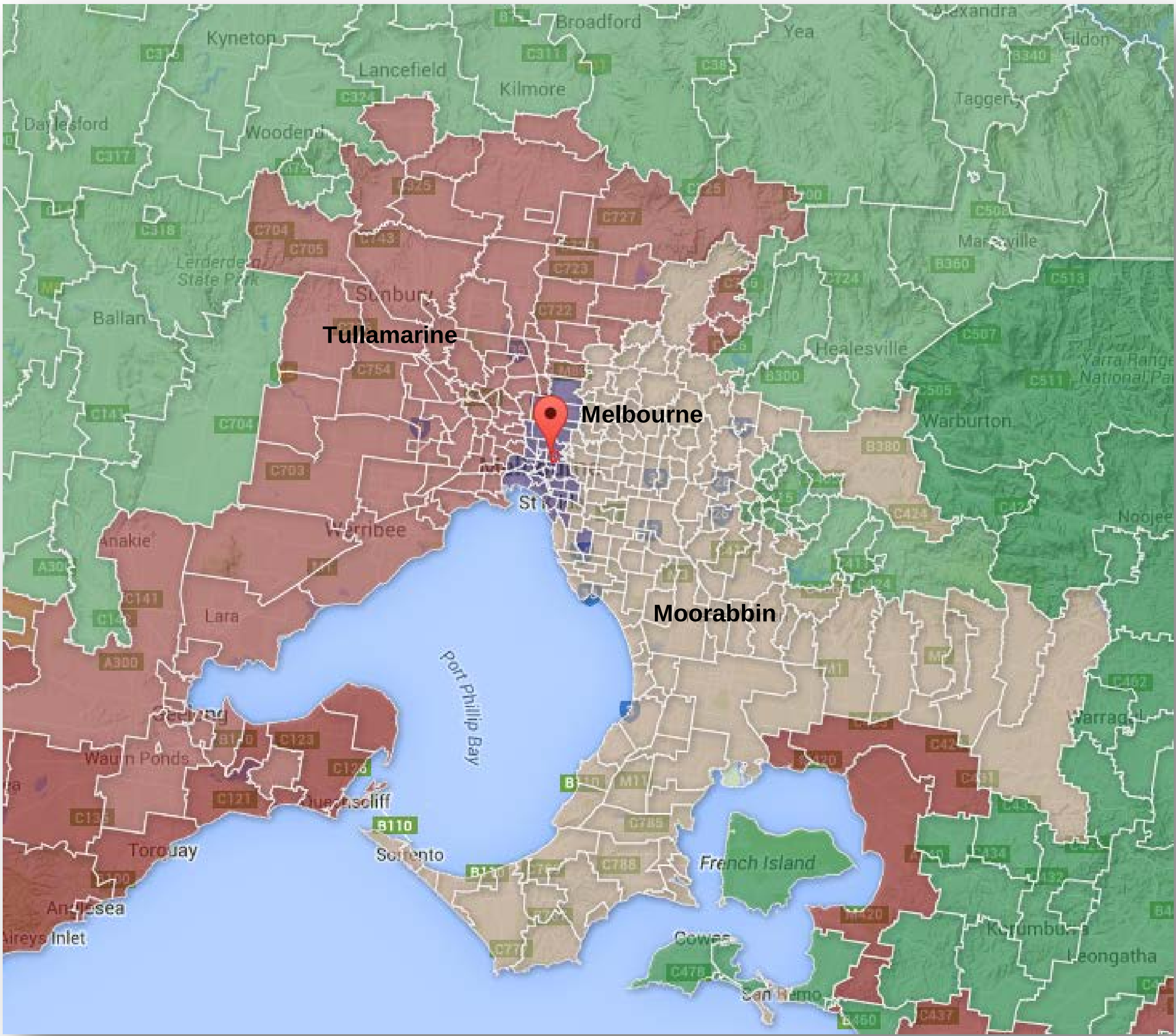
The majority of apartment construction in Victoria occurs within the Melbourne area. There are three main climates in the Melbourne area:

- Melbourne Central Climate Zone: this climate is warmer than suburban climates due to the heat island effect,
- Moorabbin Climate Zone: suburban areas south and east of Melbourne are based on this climate, and
- Tullamarine Climate Zone suburban areas north and west of Melbourne are based on this climate.

The map below is taken from the NatHERS website and shows the extent of these climates in Melbourne

(See http://apps.nowwhere.com.au/DCCEE/climatezonemaps):

Figure 1: Map of Melbourne Climate zones



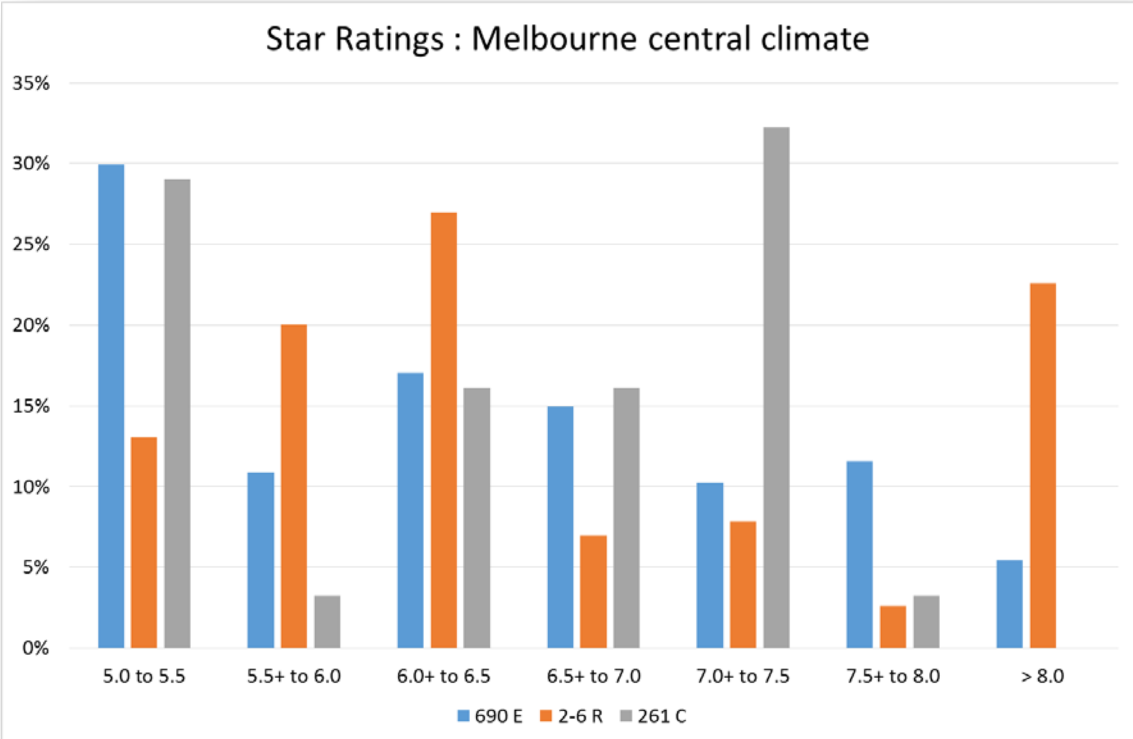
2. Apartment Performance

The three apartment buildings selected are existing projects which have already met the minimum requirements of the NCC. These requirements state that the average rating over all apartments must be 6 stars and no apartment can be less than 5 stars. This has led to a wide range in performance of apartments and there is often little information presented to the consumer on the performance of the unit they wish to buy. Results are shown below for the Melbourne climate. Moorabbin and Tullamarine show a similar range of performance.

2.1. Range of Star Ratings

The diversity in the performance of apartments can be seen in the range of star ratings they achieve. The figure below shows the range of ratings obtained in the three buildings in the Melbourne climate zone:

Figure 2: Range of ratings in 3 buildings (Melbourne climate)



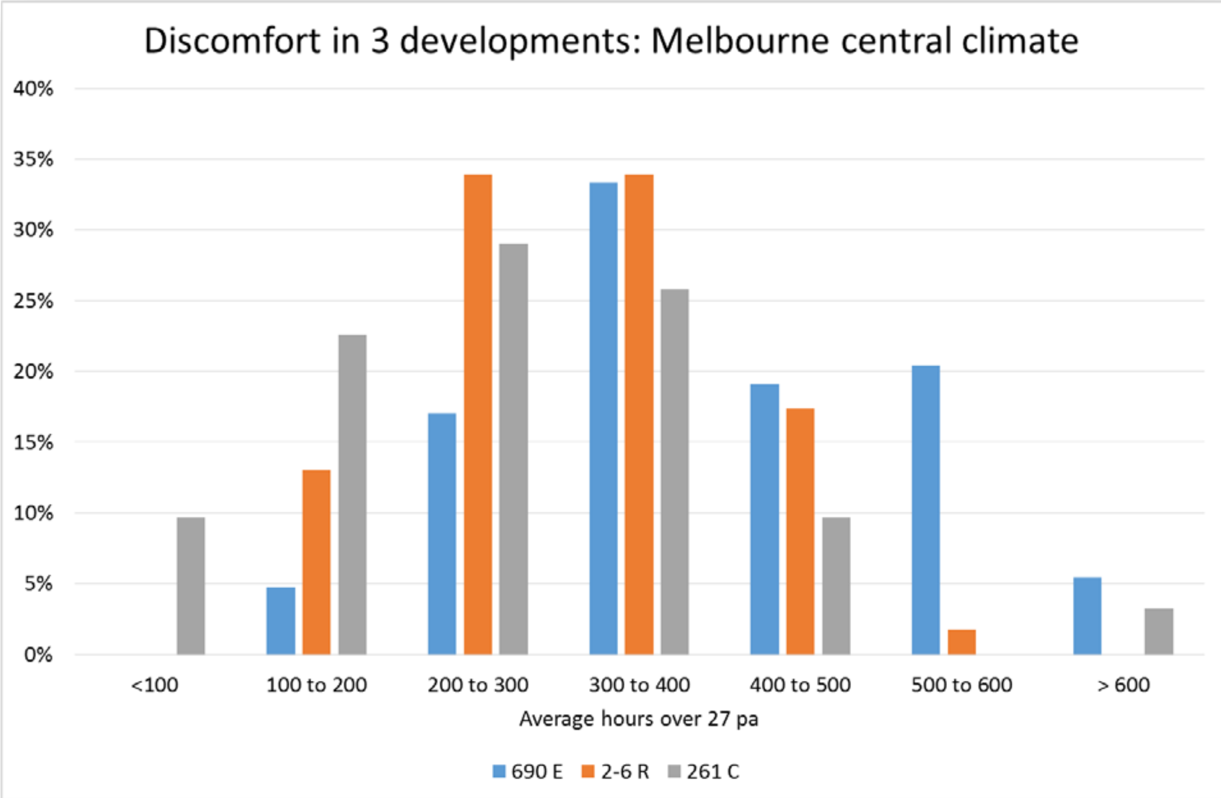
In the three apartment buildings studied, ratings for individual apartments showed that around one third of the apartments obtain a rating below 6 stars. Ratings range up to 8.5 stars. This results in a substantial diversity of performance across all the units in a building.

Star Ratings are an abstract measure of performance that can be difficult for both consumers and policy makers to relate to. To provide further information the buildings have been analysed to determine the extent of summer discomfort, the peak load and the average heating and cooling energy use so that the implications of the range of star ratings can be better understood.

2.2. Range of Summer Discomfort

The figure below shows how summer discomfort varies across the three buildings in the Melbourne climate zone. Summer discomfort was modelled by turning off all heating and cooling and assessing the resultant hourly temperatures over a year of average weather data.

Figure 3: Summer Discomfort (>27) in the three buildings



The diversity in ratings is reflected in an enormous variation in discomfort. In the three buildings studied some apartments had less than 100 hours a year of uncomfortable conditions in the absence of cooling, while others had over 600 hours per year. Some apartments are six times more uncomfortable than others. These buildings have passed a minimum energy efficiency standard, but the application of the standard in apartments has led to very poor summer performance for some apartments.

2.3. Range of Peak Loads

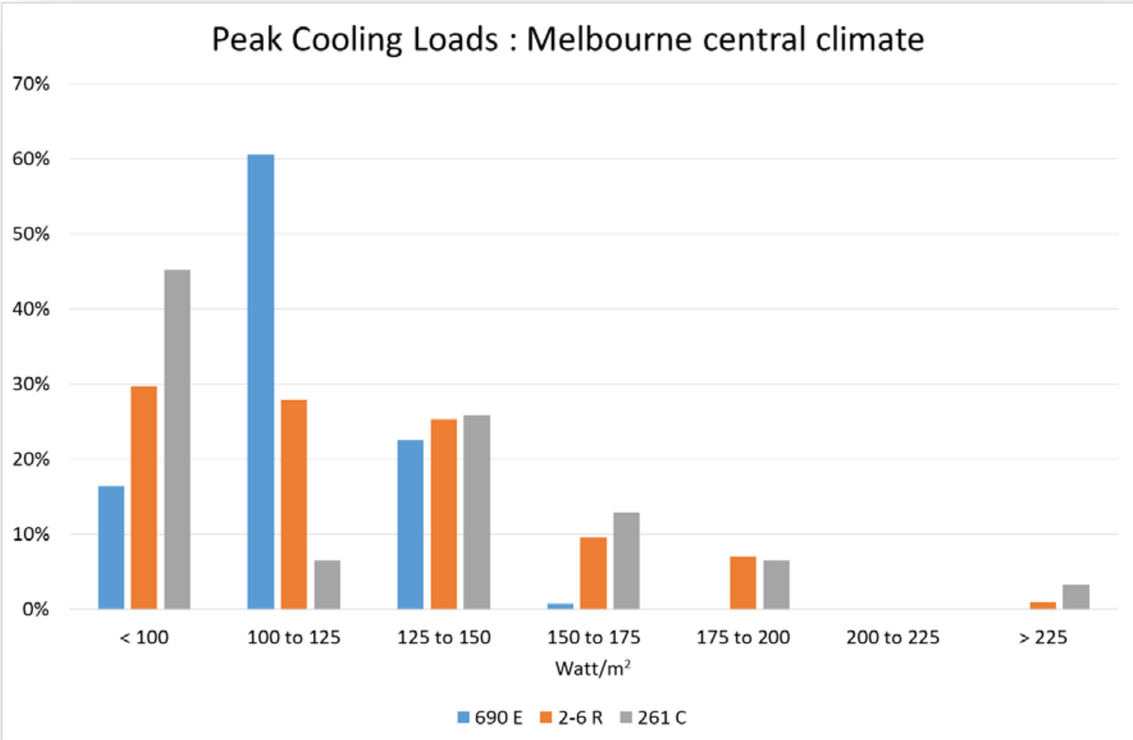
Peak cooling loads (i.e. the highest required cooling load to maintain temperatures within the comfort band) typically occur when the building has been closed all day and occupants arrive home after work and turn on the air conditioner. The higher the peak load of an apartment the more electricity infrastructure is needed to service these requirements. Peak loads also determine the size of air conditioner required. Lower peak loads mean lower costs for air conditioners and help relieve the strain on the electricity grid which lowers energy prices.

Peak loads cannot be assessed with NatHERS tools because the occupancy pattern is fixed. For this project peak loads were assessed by using the AccuBatch utility to modify the occupant cooling regime so that windows were closed from 9am to 5pm and air-conditioning was turned on at 6pm.

Peak loads also depend on the area cooled. All other factors being equal a larger apartment will have a bigger peak load than a smaller apartment. To eliminate area variations from the peak load evaluation the peak loads have been calculated in terms of Watts per square metre (W/m^2). Peak Loads are reported without allowing for the efficiency of the air-conditioner.

The figure below shows the range of peak loads found in the three buildings in the Melbourne climate:

Figure 4: Range of Peak Loads in the 3 buildings - Melbourne climate



Peak loads in the worst apartments are more than double those in the best. This means that some apartments will need an air conditioner with twice the cooling capacity of others. It is doubtful that air-conditioner sizing is as sophisticated as this analysis. Consequently, some of the worst apartments may end up with undersized air-conditioners that are not capable of achieving comfort under peak conditions. The phenomenon of ongoing climate change will mean that these peak conditions are likely to occur more frequently in the future.

2.4. Range of Heating and Cooling energy use

The NatHERS star rating is determined by adding together the heating and cooling loads of a dwelling and dividing by the area. As a result, NatHERS does not necessarily deliver energy savings for both heating and cooling because designers may focus on improvements for one season only.

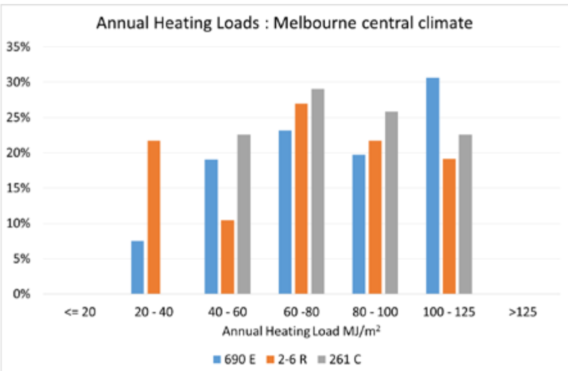
It is generally cheaper to lower heating loads than cooling loads because the shading systems needed to reduce cooling loads are more expensive than alternative design strategies which reduce heating loads. Further, in apartment buildings, designing for good cross flow ventilation to reduce cooling loads is not possible for many units so this strategy is not available. This can lead to very poor summer performance in some apartments as indicated by the results above.

While summer performance may suffer through the lack of specific controls over cooling loads, in those apartments with high cooling loads the NatHERS rating at least means that in those apartments will at least have low heating loads.

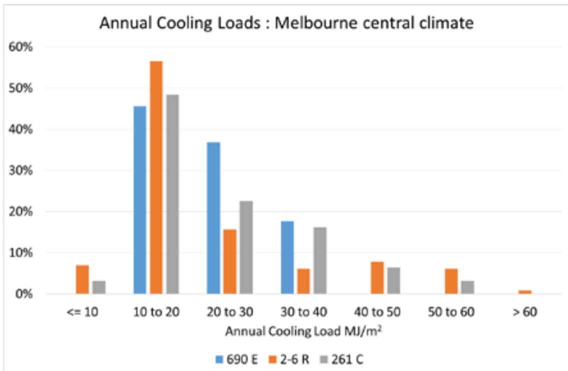
The figure below shows that heating loads and cooling loads also vary widely across the buildings in Melbourne, however, where cooling loads are high, heating loads are low and vice versa.

Figure 5: Range of heating and cooling loads per square metre in Melbourne climate

Heating Loads



Cooling Loads



The substantial range of heating and cooling loads mean that in the 2-6 R building cooling loads vary from being 87% less than heating load to only 20% less. This provides a stark example of the range of performance units in an apartment building.

2.5. Discussion

The range of individual unit performance allowed by NatHERS ratings under the building regulations helps to explain the concerns regarding apartment performance. While some apartments perform very well, others will be ‘hot boxes’ in summer. This diversity has come about through two factors:

- The averaging of performance over the building. Some apartments will have inherently low energy use because they have so little exposed external envelope and a favourable window orientation. The high rating of these apartments allows developers to achieve quite low performance for many units. In the three examples studied, approximately one third attain a rating less than the 6 stars required for houses.
- The NatHERS rating is based on the sum of heating and cooling and does not specify minimum requirements for heating and cooling. Consequently, in low rating apartments which also have inherently low heating loads, cooling loads can be very high and still meet minimum NCC requirements. This will cause discomfort and result in high cooling energy costs for occupants of these apartments.

The diversity of performance clearly shows that the current NCC standards result in a highly variable outcome in terms of comfort and energy consumption. Additional controls in the form of a higher minimum rating or a cap on cooling loads are needed to address the poor performance of some units in apartment developments.

On average the apartment buildings evaluated for this project exceed the performance of new houses. The average rating for these buildings in all climates is around 6.5 stars. Just under one third of the apartments have ratings over 7 stars. The poor performance of around a third of the apartments evaluated is justification for additional controls; however, it is clear that these controls only need to address the worst performing apartments.

3. Impact of proposed alternative metrics on apartment performance

There are two proposed methods of addressing poor performance in apartment building: a cooling load cap and raising the minimum rating. The method selected should be the technique which best captures poor performing units and results in the greatest improvements to performance indicators.

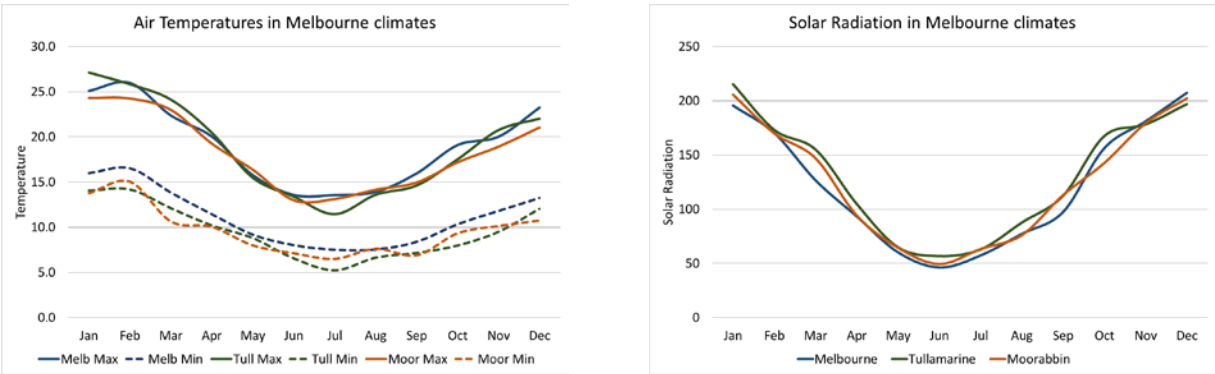
Before reporting the results, however, the issue of the Cooling Cap needs further consideration. A 5.5 star minimum is an administratively simple measure and takes account of climatic differences because star bands are set to an appropriate level for each climate. A Cooling Cap is requires slightly more effort because Assessors, Planners and Building Surveyors are more used to only dealing with the headline star rating. In NSW, however, BASIX imposes both a heating and a cooling cap. The use of a cooling cap in Victoria is not asking any more from the NatHERS assessor industry than they already provide in NSW. Because all climates are based on the greater Melbourne area a single cap may represent similar performance in terms of discomfort, energy use and peak load across all climate zones in the Melbourne metropolitan area. The following section explains whether a single or climate specific cooling cap is required.

3.1. Cooling load cap: single measure or climate specific?

The three climates under consideration are broadly similar. The figure below compares average monthly climate data for air temperature and solar radiation for the three climate zones:

Figure 6: Average monthly climate data for three Melbourne climates

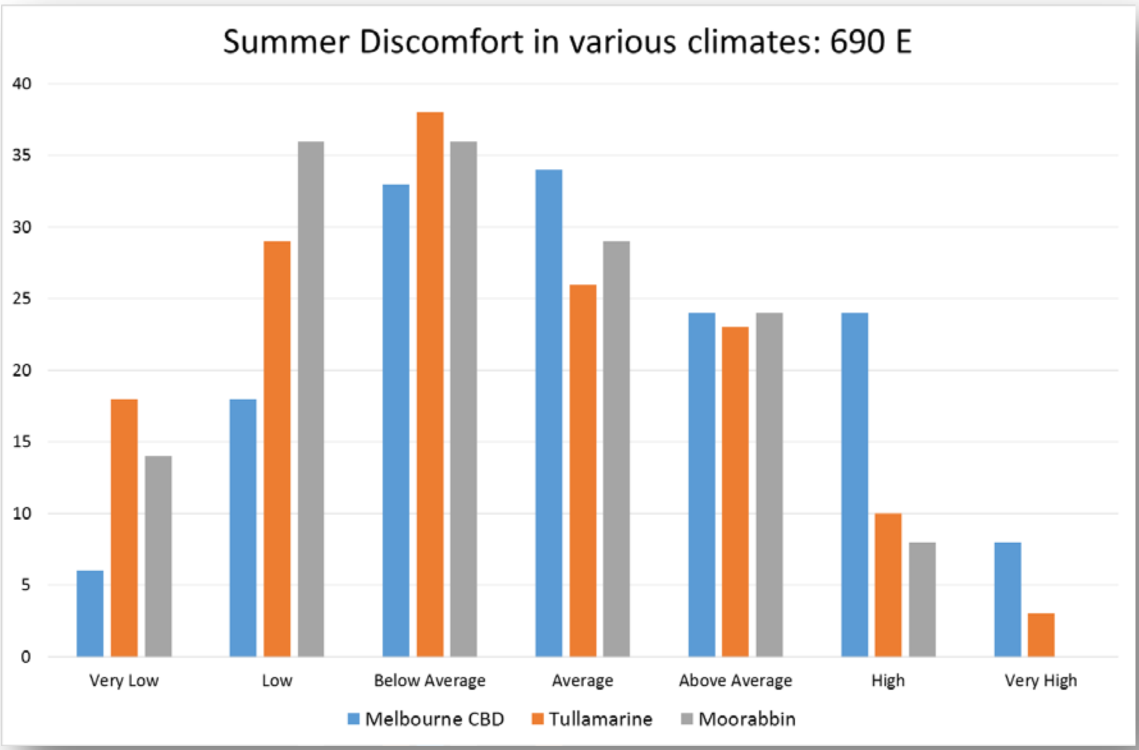
Air Temperature: Maximum & Minimum Solar Radiation



While the climate parameters are quite similar, whether this means that the same Cooling Load represents similar performance with respect to the performance indicators is not straightforward. To investigate this, the performance of the 690E building was compared across all three climates.

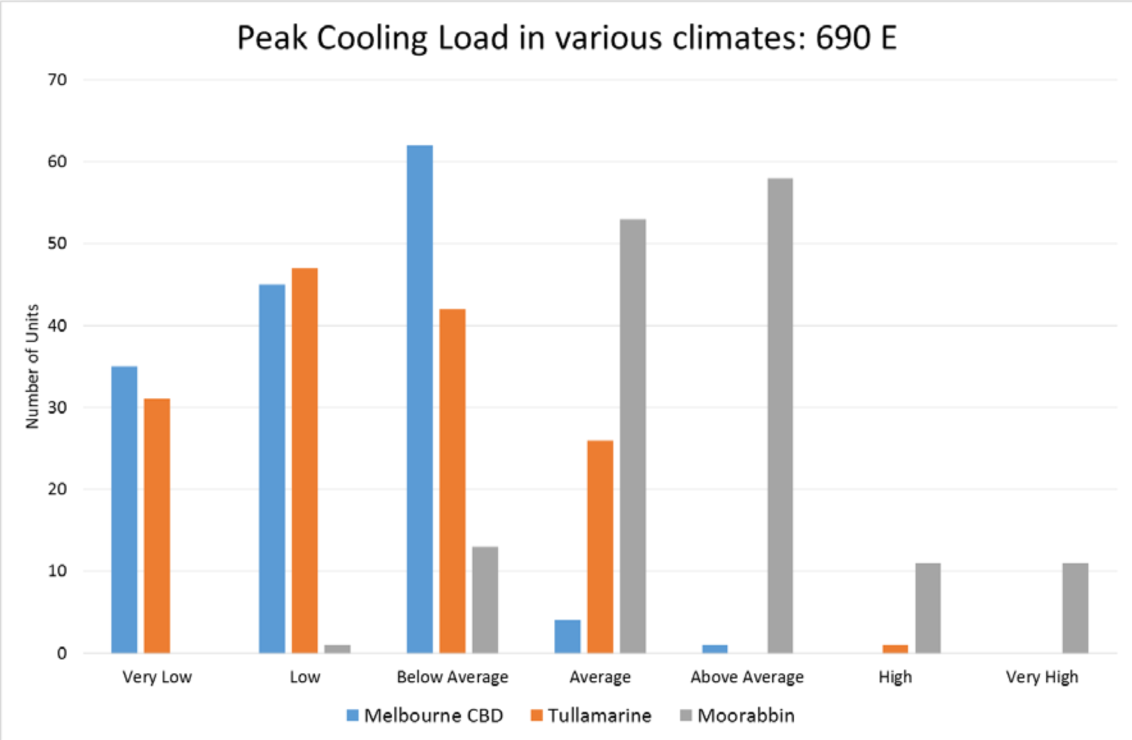
The figure below shows the variation in summer discomfort in all three climates:

Figure 7: Summer discomfort in 690 E building in three climates



Discomfort is highest in the warmer Melbourne climate as expected. Melbourne is slightly warmer due to the heat island effect. Moorabbin has the least discomfort because it has slightly lower temperatures in summer than the other two climates. However, Moorabbin has significantly higher Peak Loads than either Tullamarine or Melbourne central as shown in the figure below:

Figure 8: Peak cooling loads in three Melbourne climates



The Moorabbin climate has higher solar radiation when temperatures are high in summer and this leads to higher peak loads. So while the discomfort analysis may have suggested that a single Cooling Cap may represent the same performance across climates, the Peak Loads do not.

The distribution of cooling loads in the 690 E building were examined in each climate to see whether a single cooling cap would capture poor performing units in each climate. This proved to be problematics as shown in the figure below:

Table 2: Number of units captured by various cooling load caps

690 Elizabeth Street	No < 5.5 stars	No > 30 MJ/m2 cooling	No > 22 MJ/m2 cooling	No > 21 MJ/m2 cooling
Melbourne	44	26	70	76
Tullamarine	38	2	26	27
Moorabbin	42	0	10	24

The table above shows that if 30 MJ was used in all climate that virtually none of the poor performing units in Tullamarine or Moorabbin would be affected by the use of a cooling load cap. The use of a cooling load cap of 22 in Tullamarine and 21 in Moorabbin would capture roughly the same number of poor performing units in each climate. These caps will be used for this report along with the 30 MJ/m^2 cap for Melbourne central area.

3.2. Which metric works best: Cooling Cap or a 5.5 star minimum?

3.2.1. Performance Improvements

All of the apartments which did not meet the required performance levels for the two proposed metrics were modified to comply with the minimum requirements. The changes to design and specification were recorded. The rating files were then run through AccuBatch to examine how their heating and cooling loads, summer discomfort and peak loads changed.

The improvement to each metric due to the application of the proposed additional controls was evaluated for each unit. The table below shows the average improvement against each of the four performance indicators for each building in the Melbourne central climate:

Table 3: Change to performance indicators in Melbourne central climate

Performance Indicator	%age improvement in performance indicator for affected apartments					
	Minimum 5.5 stars			Maximum 30 MJ		
	690 E	2-6 R	261 C	690 E	2-6 R	261 C
Cooling Load (MJ)	15%	19%	9%	10%	30%	26%
Heating Load (MJ)	7%	3%	4%	9%	6%	13%
Peak Cooling Load (MJ)	5%	10%	7%	8%	18%	20%
Comfort (hours over 27 pa)	57%	39%	18%	39%	45%	27%

The table shows that the 30 MJ/m^2 cooling cap delivers greater improvements over all performance indicators in the 2-6 R and 261 C building and for heating loads and peak cooling loads in the 690E building. The apartments in the 690E building did not show as great a range of performance as the other two buildings. In particular, the building does not have as many units with high cooling loads as the other two buildings.

Note that the application of the 30 MJ/m^2 cooling cap has also led to reductions in the amount of energy required for cooling. This is due to the design changes made to achieve the cooling cap. In the majority of cases the simplest and most cost effective way to reduce cooling loads is to reduce window area in less favourable orientations. A smaller window area facing east or west will result in lower heat losses in winter as well as lower heat gains in summer. Window size reduction is not the only design modification used to achieve the cap, but it does explain why heating loads also improve.

Use of smaller windows is not the only way in which the cooling cap could be met. Windows with low solar heat gain glazing could be used or external shading devices installed to reduce summer heat gains as well. External shading is relatively expensive and adjustable external shades may not be able to be used at high level except on balconies. In addition, use of low solar heat gain windows[1] will increase heating requirements which may mean that further improvements to winter performance are required. This means that a slight reduction to glazing areas, particularly those with the highest solar heat gain on the west and east, is the most rational way to meet the cooling cap. Consequently for the purposes of this study we have assumed window glazing reductions will be adopted by developers.

[1] Low solar heat gain glazing includes tinted and/or Low E coated glass with a maximum solar heat gain co-efficient of 04.

The table below shows the average improvement against each of the four performance indicators for each building in the Tullamarine climate:

Table 4: Change to performance indicators in Tullamarine climate

Performance Indicator	%age improvement in performance indicator for affected apartments					
	Minimum 5.5 stars			Maximum 22 MJ		
	690 E	2-6 R	261 C	690 E	2-6 R	261 C
Cooling Load (MJ)	18%	21%	20%	12%	33%	29%
Heating Load (MJ)	8%	4%	6%	8%	6%	12%
Peak Cooling Load (MJ)	8%	8%	12%	11%	19%	20%
Comfort (hours over 27 pa)	67%	39%	25%	45%	49%	32%

The table above shows a similar picture in to the Melbourne climate. The cooling cap achieves the greatest improvement across all performance indicators except for cooling loads and comfort in building 690E.

Finally, the table below shows the average improvement against each of the four performance indicators for each building in the Moorabbin climate:

Table 5: Change to performance indicators in Moorabbin climate

Performance Indicator	%age improvement in performance indicator for affected apartments					
	Minimum 5.5 stars			Maximum 21 MJ		
	690 E	2-6 R	261 C	690 E	2-6 R	261 C
Cooling Load (MJ)	13%	16%	14%	9%	28%	27%
Heating Load (MJ)	8%	3%	5%	-4%	-6%	1%
Peak Cooling Load (MJ)	6%	5%	6%	8%	11%	14%
Comfort (hours over 27 pa)	65%	47%	23%	51%	61%	35%

Once more the results paint a similar picture to the other climates. The cooling cap provides a greater level of improvement in almost every case. Note that in Moorabbin meeting the cooling cap does lead to a modest increase in heating loads in two of the buildings and a lower reduction in loads than the 5.5 star minimum in all. This is presumably because Moorabbin has the highest heating loads of the three climates and the reduction in glazing area, even on the less favourable east and west orientations leads to a small increase in heating loads.

The improvement in the performance of the apartments due to the cooling cap is very significant, particularly in the reduction of hours over 27 degrees and cooling loads (and therefore cooling bills. The small increase in heating in some climates would be more than compensated for by the reduction in cooling.

3.2.2. Additional Costs

The brief for this project did not include detailed costing of design changes required to comply with the new measures. Nevertheless, some conclusion can be drawn on the expected cost impact:

- As explained above, we assumed that developers would choose to use slightly lower glass areas in order to achieve the cooling cap. In general terms this will lower the cost of the building because windows are more expensive than walls.

- If developers choose not to reduce glazing areas, additional costs of external shades or high performance glazing[2]can be significant for those units which do not meet the cooling cap: around 20% of the units in the three examples. If developers choose this higher cost option, they are making a value judgement about the costs they believe the market can bear.
- In a number of cases ceiling fans were also used to achieve the cooling cap. These were mainly installed in living areas. NatHERS tools model the additional air movement provided by ceiling fans and their impact on comfort. This helps the occupant at least delay the onset of cooling on hot days or avoid cooling altogether on milder days. Ceiling fans are relatively inexpensive, and help to avoid heat stress.
- The impact of complying with a cooling cap or a higher minimum rating will increase the average rating of the building, and the regulation is based on the average rating. In the 690 E building in Melbourne a 5.5 star minimum increased the average rating from 6.40 to 6.69 and the cooling cap increased the average rating to 6.53. Developers may choose to use this improvement to the average to lower the rating of other units in order to compensate for the additional costs of improving the performance of the worst units.
- The cooling cap delivers significant reductions in peak load. This has potential to save costs for developers by reducing the size (cooling capacity) of air conditioners needed for the project. It may also reduce the size of the electricity infrastructure needed for the project although this would require a more thorough estimate of loads than is currently typically undertaken by building services engineers. Even if cost savings are not achieved, the reduction in peak load will at least mean that air conditioners have sufficient capacity to adequately cool apartments at least save some money in terms of post occupancy call backs.

These factors suggest that the additional costs of meeting a cooling cap requirement to meeting a cooling cap will be modest. Note that Appendix B includes the list of changes units affected by the cooling cap and the 5.5star minimum.

3.2.1. Impact on Internal Daylight Levels

The introduction of a cooling cap does have the potential to adversely affect internal daylight levels within habitable rooms if the design response is simply to reduce the glazing area significantly without consideration of the consequences for internal amenity. However, in practice, we don't believe this will occur for the following reasons:

- The issue of maximum cooling demand will be considered by designers during the schematic design process when sufficient flexibility exists to provide an integrated design response which considers internal amenity.
- High cooling loads are associated with significant areas of glazing and these apartments are unlikely to have internal daylighting constraints.
- High cooling loads may also be reduced by adopting other design strategies which do not result in a net reduction in glazing area. For example: shifting the area of glazing from the west to the north façade; providing adjustable external shading devices.
- The Better Apartments Design Guide will also include design measures aimed at achieving reasonable daylight access into habitable rooms.

[2] i.e. Low E coated double glazed units.

3.2.2. Conclusion

The Cooling Cap produces better performance improvements in the affected units than raising the minimum allowable rating to 5.5 stars. Further, Table 2 shows that the Cooling Cap is less intrusive: it affects fewer units. It is therefore recommended that the Cooling Cap be adopted.

The following cooling caps are recommended:

NatHERS climate zone	Cooling load cap MJ/m^2 pa
21 Melbourne	30
60 Tullamarine	22
62 Moorabbin	21

The cooling cap does solve some performance issues with apartments, but it is not a 'silver bullet'. The imposition of a cap will eliminate the worst performing units, but that does not mean that all units in every apartment building will have excellent performance. The averaging of apartment ratings also leads to a very high range of performance across an apartment building. Even better outcomes may be achieved through a combination of measures like raising the minimum allowed AND a cooling cap.

It is therefore recommended that the Government continues to monitor the issue of apartment building performance and in particular, whether occupants of buildings which meet the cooling cap report better outcomes. This will be possible with existing buildings if the NatHERS predicted cooling loads are known by contrasting the occupant experience of comfort and cooling energy bills in apartments with loads above and below the cooling cap.

While the majority of apartments are constructed in and around Melbourne the use of apartments in regional centres is becoming more popular. Any class 2 building, no matter where it is built, is allowed to average ratings. This is a major source of the variability in apartment performance found in this report. It is therefore recommended that further investigation be undertaken into the broader use of cooling caps across all Victorian climates.

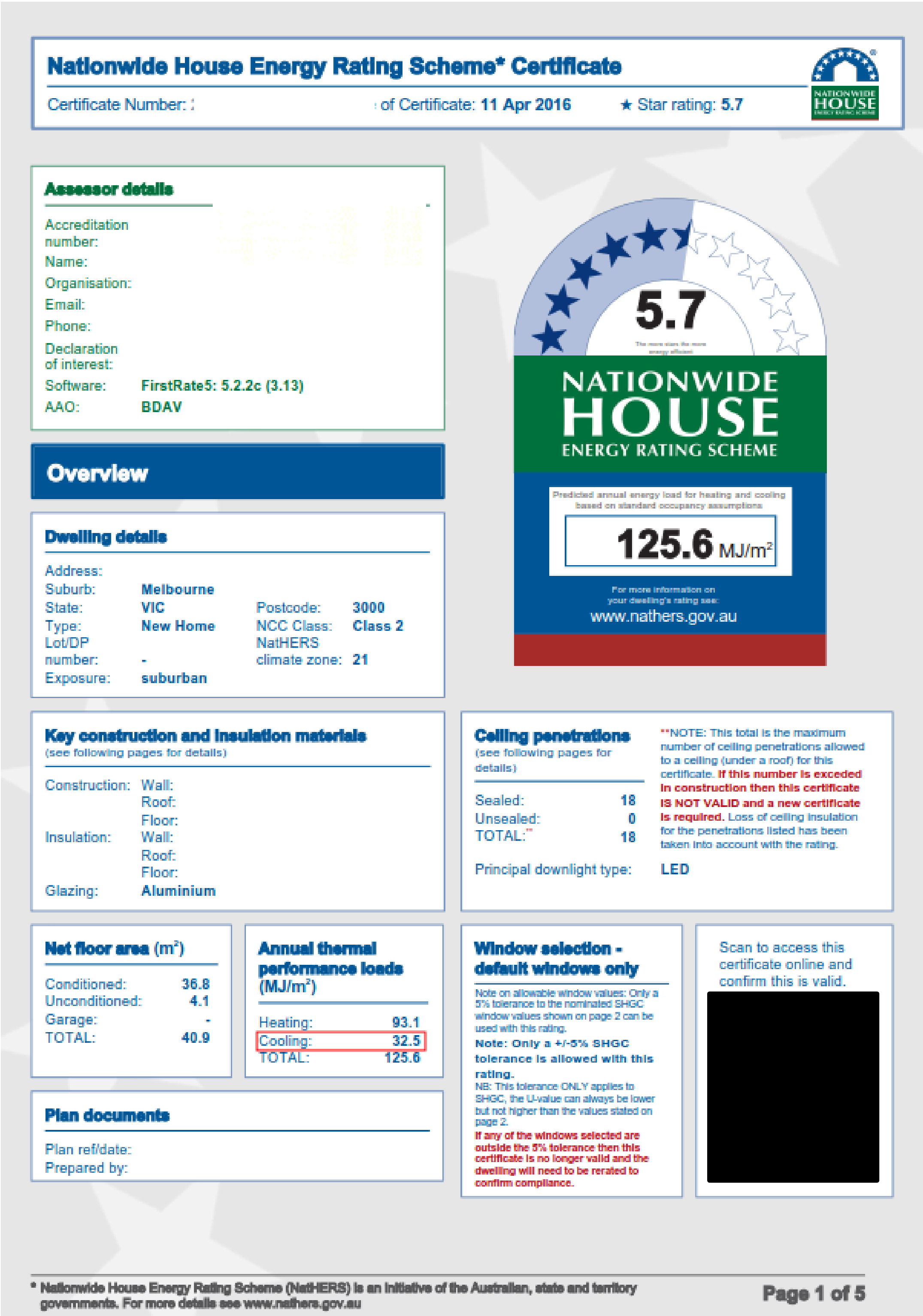
The vast range of outcomes observed in this project from the application of a minimum building regulation is a concerning issue. The minimum standard does not provide a minimum level of performance for every unit. While the application of minimum ratings to houses also leads to variable outcomes in terms of the size of cooling loads, it is nowhere near as significant as in apartments. The application of a cooling cap will help to eliminate the worst performing units, however the variability of outcomes will still be large. This suggests that it may be appropriate to undertake a more thorough review of how minimum building fabric performance regulations are applied to class 2 buildings.

3.2.3. Application of the cooling load cap

All NatHERS tools (AccuRate, FirstRate and BERSPro) produce a certificate with a common format which shows the NatHERS predicted cooling load. It is therefore relatively easy to enforce a cooling load cap because this information is routinely reported. Extracts from individual apartment and group (whole of development) certificates showing the cooling loads are provided in Figures 9 & 10 below.

The cooling load is shown highlighted in red. These certificates are a standard format for all NatHERS tools. An additional requirement to keep the cooling load below a cap is therefore easy for all NatHERS assessors to follow.

Figure 9: First Rate 5 Certificate with cooling load highlighted



Nationwide House Energy Rating Scheme* Certificate

Certificate Number: : of Certificate: **11 Apr 2016** ★ Star rating: **5.7**

Assessor details

Accreditation number:
Name:
Organisation:
Email:
Phone:
Declaration of interest:
Software: **FirstRate5: 5.2.2c (3.13)**
AAO: **BDAV**

5.7

NATIONWIDE HOUSE ENERGY RATING SCHEME

Predicted annual energy load for heating and cooling based on standard occupancy assumptions

125.6 MJ/m²

For more information on your dwelling's rating see: www.nathers.gov.au

Overview

Dwelling details

Address:
Suburb: **Melbourne**
State: **VIC** Postcode: **3000**
Type: **New Home** NCC Class: **Class 2**
Lot/DP number: **-** NatHERS climate zone: **21**
Exposure: **suburban**

Key construction and insulation materials
(see following pages for details)

Construction: Wall:
Roof:
Floor:
Insulation: Wall:
Roof:
Floor:
Glazing: **Aluminium**

Ceiling penetrations
(see following pages for details)

Sealed: **18**
Unsealed: **0**
TOTAL:** **18**

Principal downlight type: **LED**

NOTE: This total is the maximum number of ceiling penetrations allowed to a ceiling (under a roof) for this certificate. **If this number is exceeded in construction then this certificate is NOT VALID and a new certificate is required. Loss of ceiling insulation for the penetrations listed has been taken into account with the rating.

Net floor area (m²)

Conditioned:	36.8
Unconditioned:	4.1
Garage:	-
TOTAL:	40.9

Annual thermal performance loads (MJ/m²)

Heating:	93.1
Cooling:	32.5
TOTAL:	125.6

Window selection - default windows only

Note on allowable window values: Only a 5% tolerance to the nominated SHGC window values shown on page 2 can be used with this rating.
Note: Only a +/-5% SHGC tolerance is allowed with this rating.
NB: This tolerance ONLY applies to SHGC, the U-value can always be lower but not higher than the values stated on page 2.
If any of the windows selected are outside the 5% tolerance then this certificate is no longer valid and the dwelling will need to be rerated to confirm compliance.

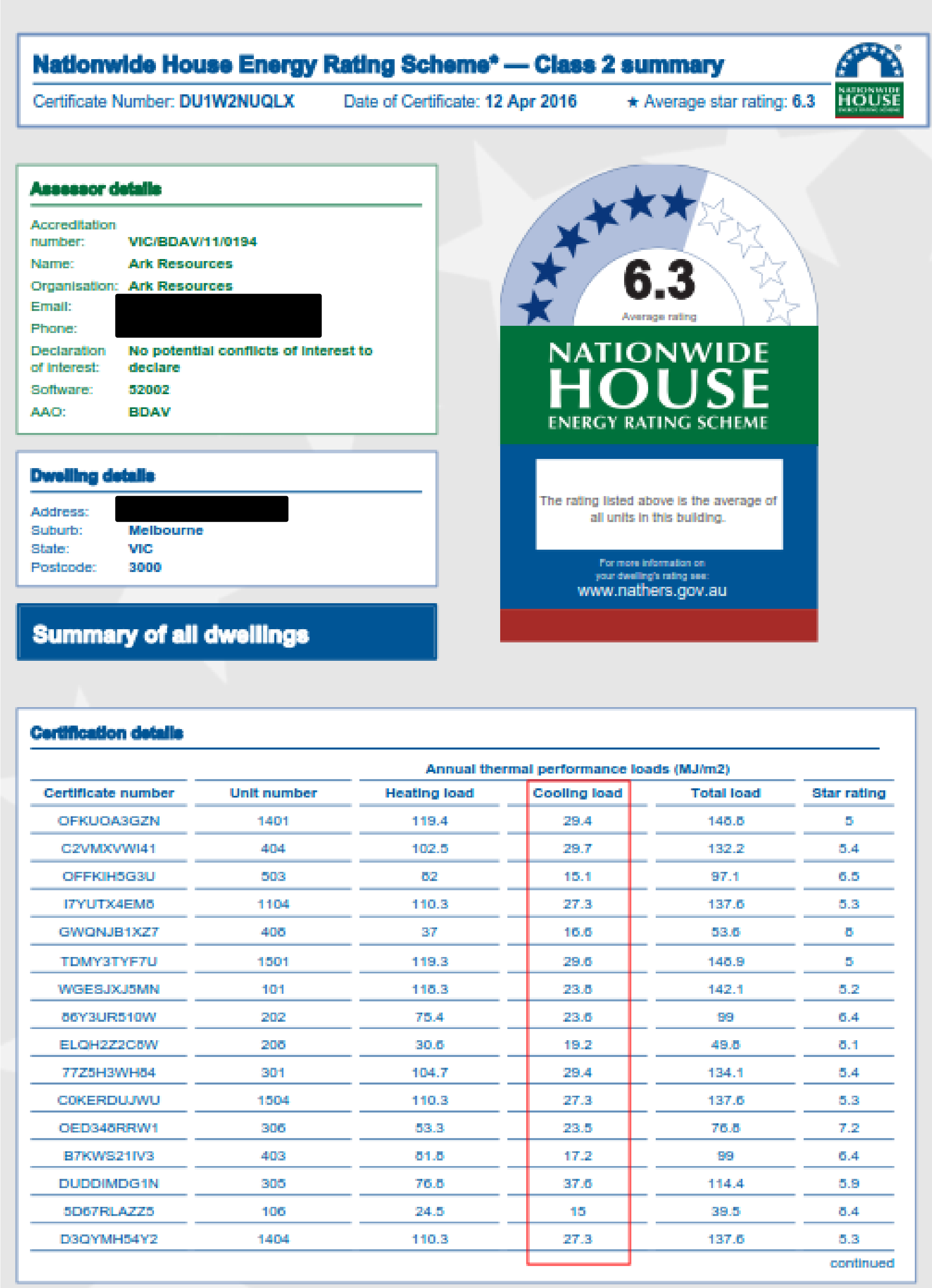
Scan to access this certificate online and confirm this is valid.

[redacted]

* Nationwide House Energy Rating Scheme (NatHERS) is an initiative of the Australian, state and territory governments. For more details see www.nathers.gov.au

Page 1 of 5

Figure 10: First Rate 5 Group Certificate with cooling load highlighted



Nationwide House Energy Rating Scheme* — Class 2 summary

Certificate Number: **DU1W2NUQLX** Date of Certificate: **12 Apr 2016** ★ Average star rating: **6.3**

Assessor details

Accreditation number: VIC/BDAV/11/0194
Name: Ark Resources
Organisation: Ark Resources
Email: [redacted]
Phone:
Declaration of interest: No potential conflicts of interest to declare
Software: 52002
AAO: BDAV

Dwelling details

Address: [redacted]
Suburb: Melbourne
State: VIC
Postcode: 3000

6.3
Average rating

NATIONWIDE HOUSE ENERGY RATING SCHEME

The rating listed above is the average of all units in this building.

For more information on your dwelling's rating see: www.nathers.gov.au

Summary of all dwellings

Certification details

Certificate number	Unit number	Annual thermal performance loads (MJ/m2) Heating load	Cooling load	Total load	Star rating
OFKUOA3GZN	1401	119.4	29.4	148.8	5
C2VMXVWI41	404	102.5	29.7	132.2	5.4
OFFKIH5G3U	503	82	15.1	97.1	6.5
I7YUTX4EM6	1104	110.3	27.3	137.6	5.3
GWQNJB1XZ7	406	37	16.6	53.6	8
TDMY3TYF7U	1501	119.3	29.6	148.9	5
WGESJXJ5MN	101	118.3	23.8	142.1	5.2
66Y3UR510W	202	75.4	23.6	99	6.4
ELQH2Z2C6W	206	30.6	19.2	49.8	8.1
77Z5H3WH64	301	104.7	29.4	134.1	5.4
COKERDUJWU	1504	110.3	27.3	137.6	5.3
OED346RRW1	306	53.3	23.5	76.8	7.2
B7KWS21IV3	403	81.8	17.2	99	6.4
DUDDIMDG1N	305	76.8	37.6	114.4	5.9
5D67RLAZZ5	106	24.5	15	39.5	8.4
D3QYMH54Y2	1404	110.3	27.3	137.6	5.3

continued

Importantly, the application of the cooling cap fits within current design and energy rating processes for apartment buildings. It utilises the current energy rating tools and their standard outputs. The only difference is the extent of design advice given by assessors. Without the cooling cap, designers of apartment buildings effectively have little restriction on the area of glass facing high summer solar heat gain east or west windows. The application of a cooling cap will help to ensure that there is at least a modest reduction in the use of glass facing east and west compared to current practice. The cooling cap may even help to increase the extent of north facing glass in corner units where designers seek to maximise overall window areas.

Many Victorian NatHERS assessors undertake ratings in NSW where BASIX already requires both heating and cooling caps. Many more assessors are familiar with BASIX through their recently completed Certificate IV in NatHERS assessment. The introduction of a cooling cap in Melbourne climates should therefore be straightforward for Victorian thermal performance assessors.

There are a number of other ways in which the introduction of the cooling caps can be made easier for the property development industry such as:

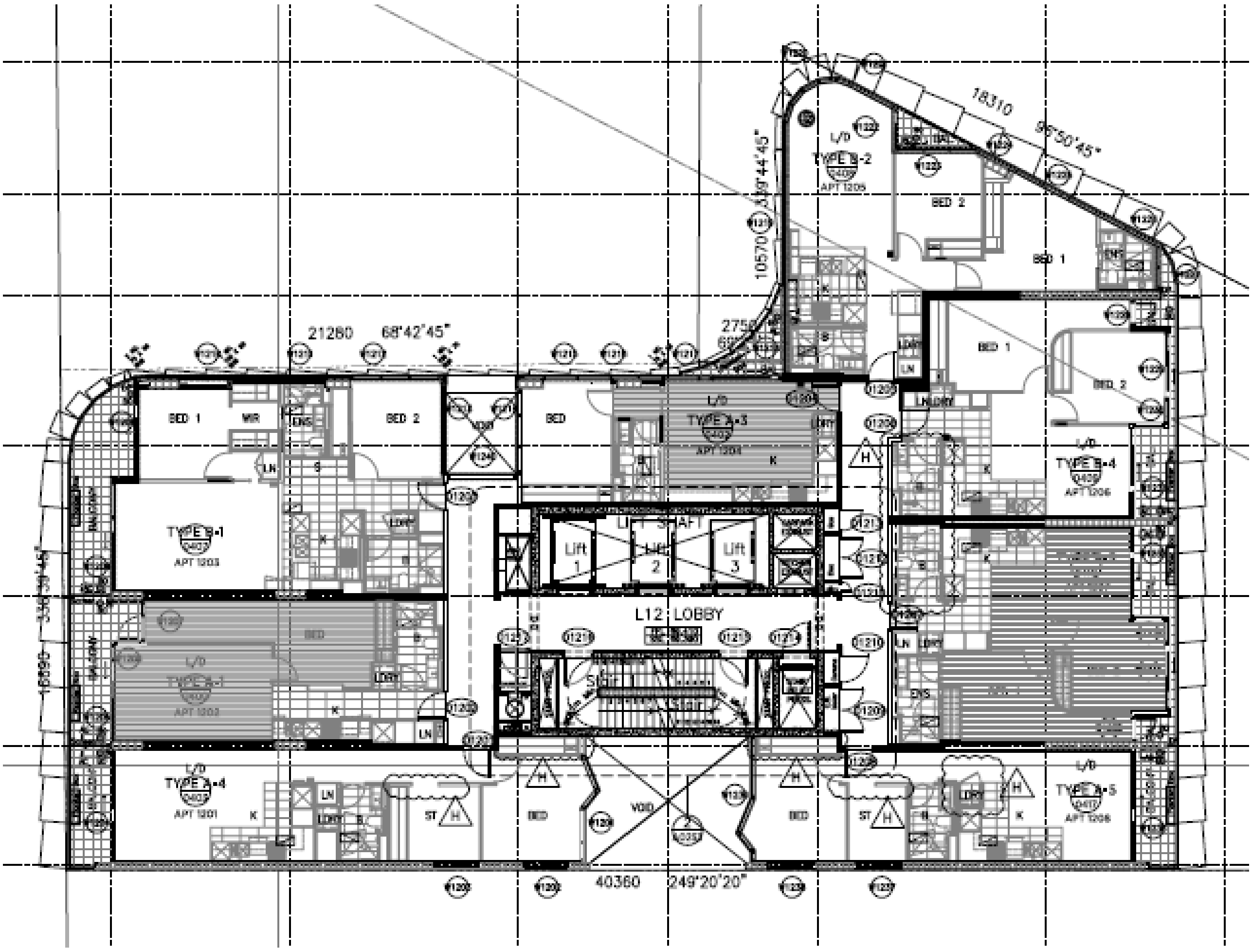
- Including information about the requirement in the Victorian Building Authority's Practice Note PN55 Residential Sustainability Measures
- Integration into the Built Environment Sustainability Scorecard (BESS) planning tool,
- Modifying NatHERS tools Group Certificates to ensure that the cooling load is shown for each unit to make it easier for regulatory authorities to check compliance with the cap.
- Provision of information and/or webinars to NatHERS Assessor Accrediting Organisations BDAV and ABSA,
- Development of Case Study material for the development industry, and
- Training and CPD for NatHERS assessors, planners and building surveyors on the new requirement and how to determine compliance.

4. References

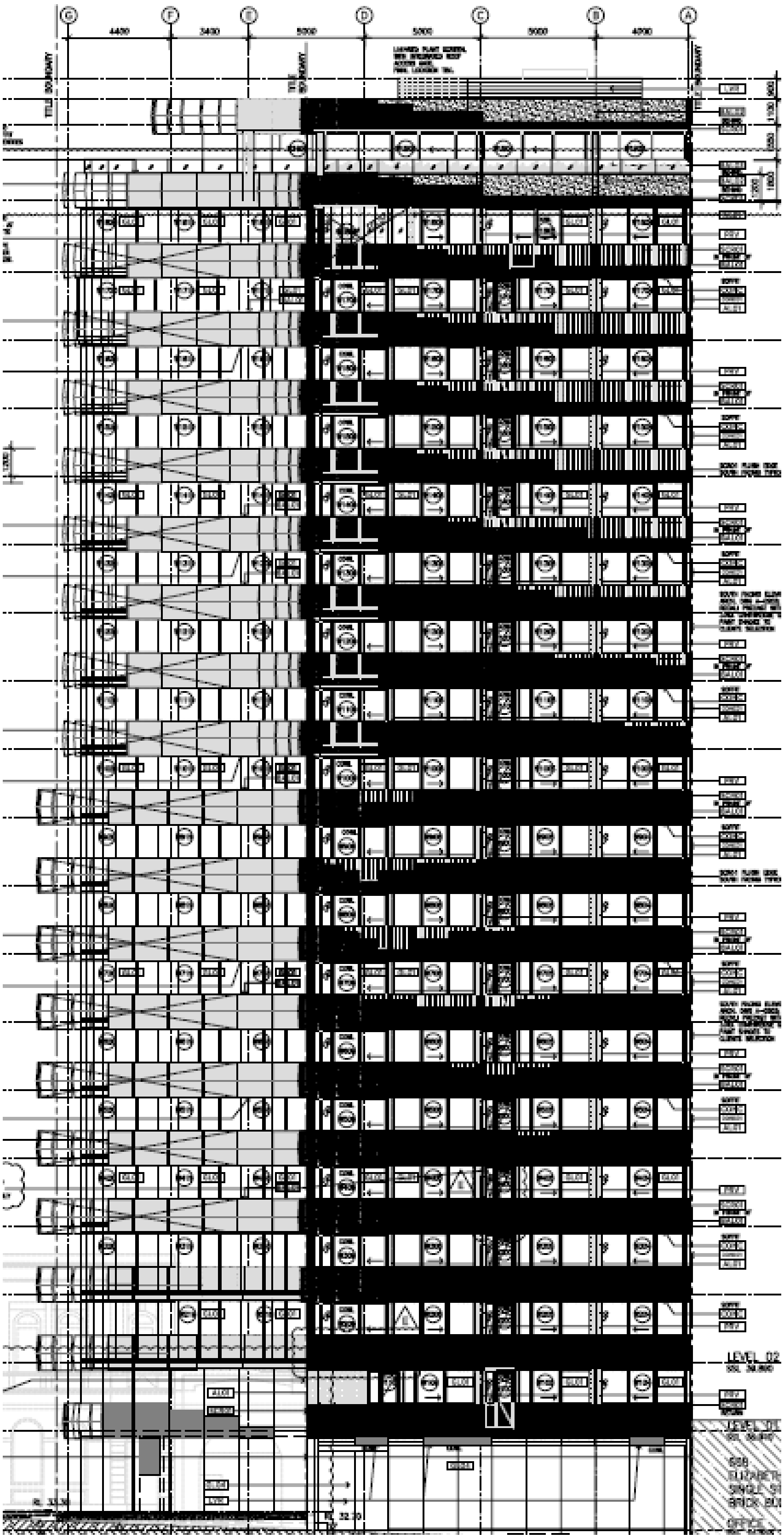
Morshed A 2015, *Probability of heat wave impact on the occupants of different star rated houses and the benefits of upgrading house star ratings to 6 star: A case study for Victoria*, paper by Morshed Alam, Pathmanathan Rajeev, Jay Sanjayan, Mark Stewart and John Wilson presented at SENG 2015 National Conference, 9 & 10 Sept 2015, Adelaide Convention Centre, Paper 34

5. Appendix A Plans of buildings used in this study

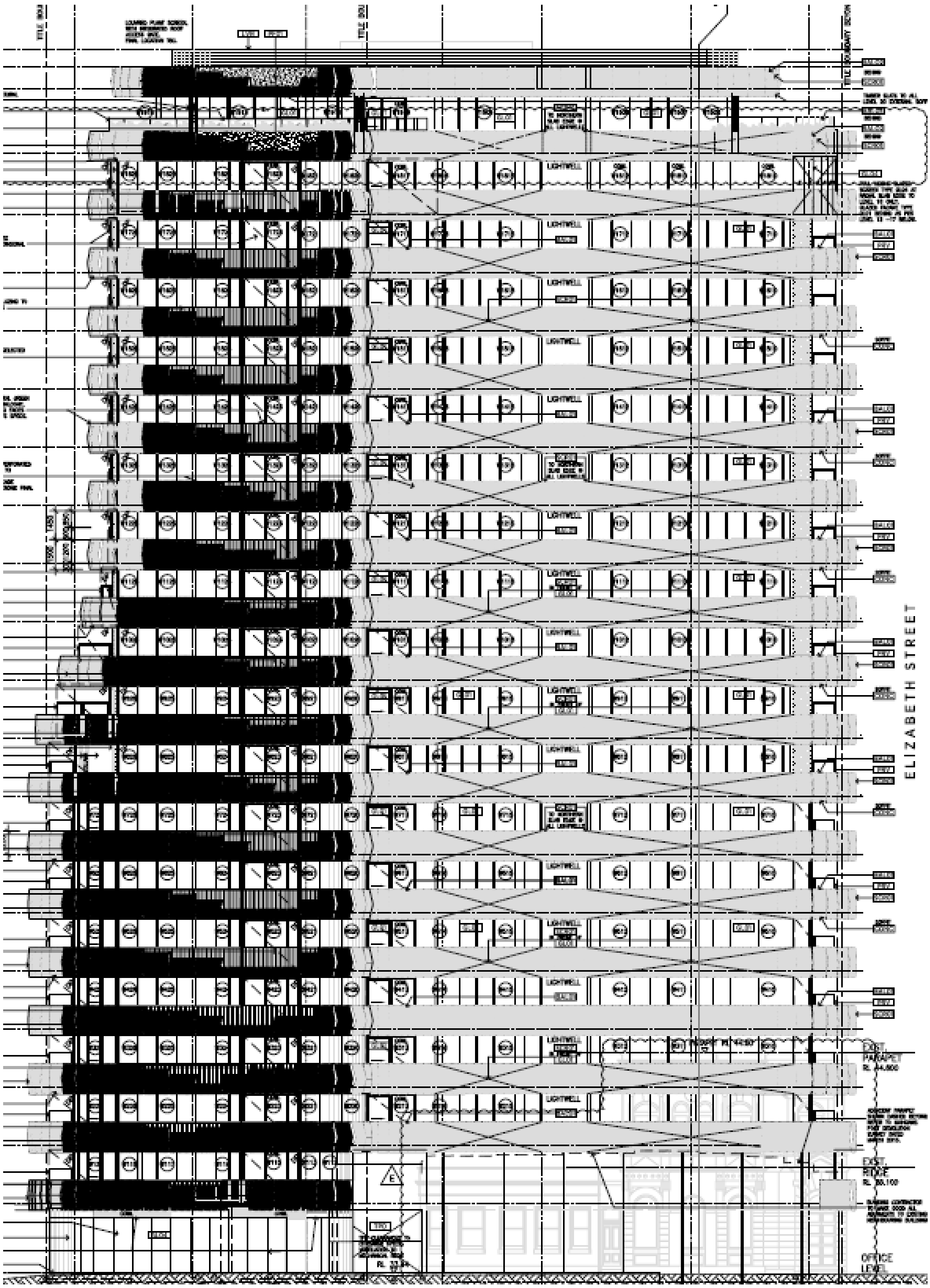
Typical floor plate for 690 E



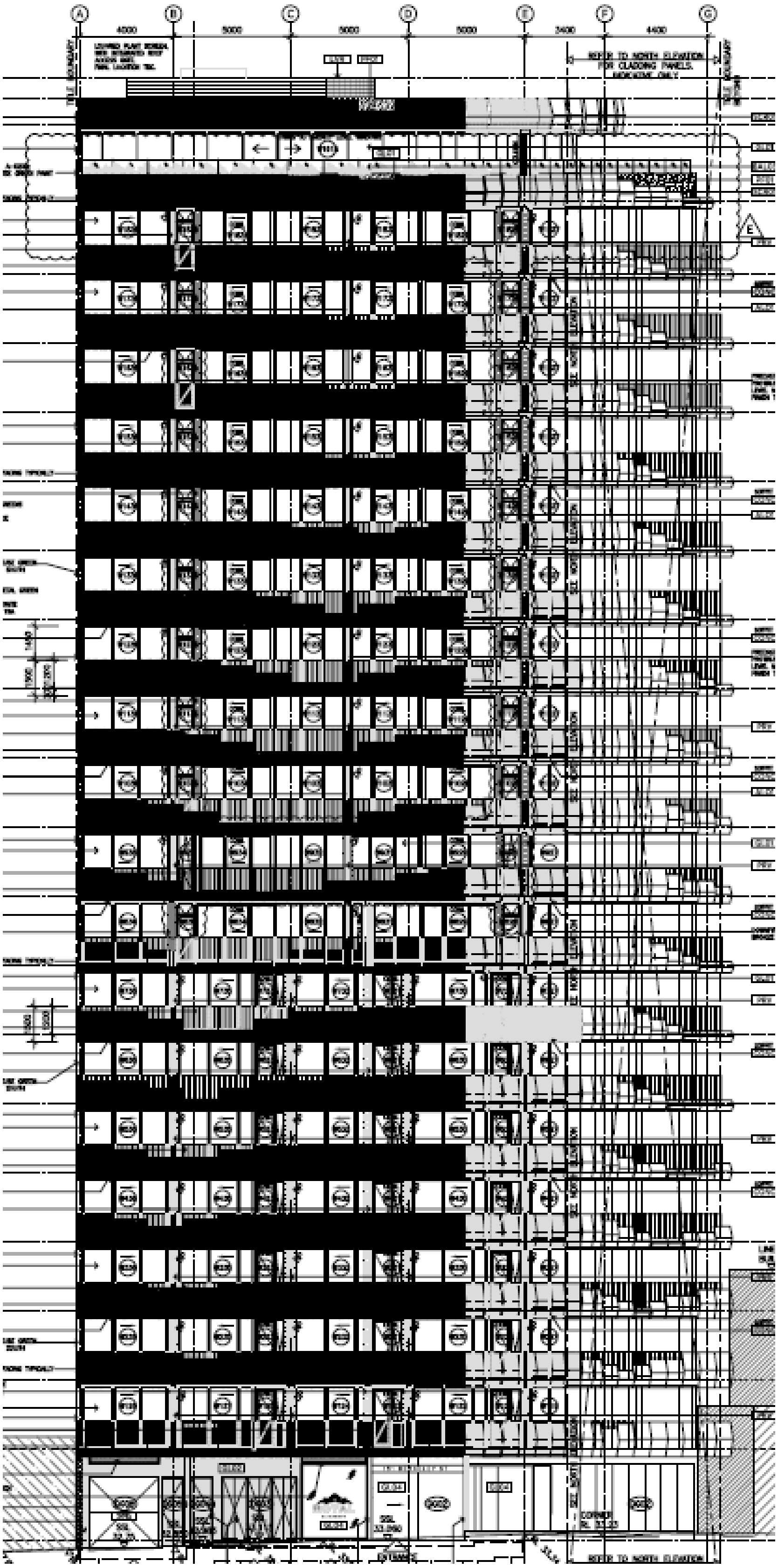
West Elevation for 690 E



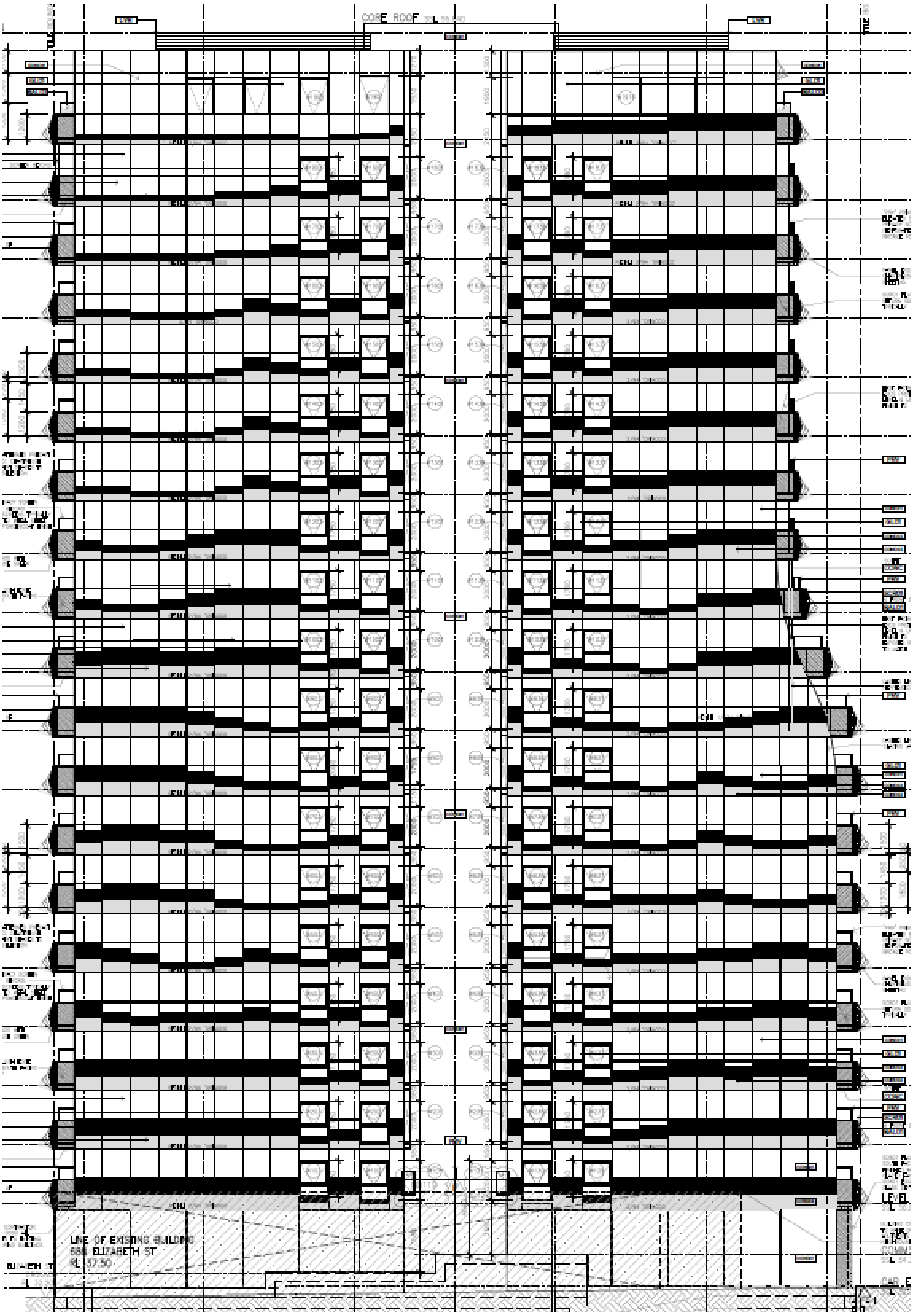
North Elevation for 690 E



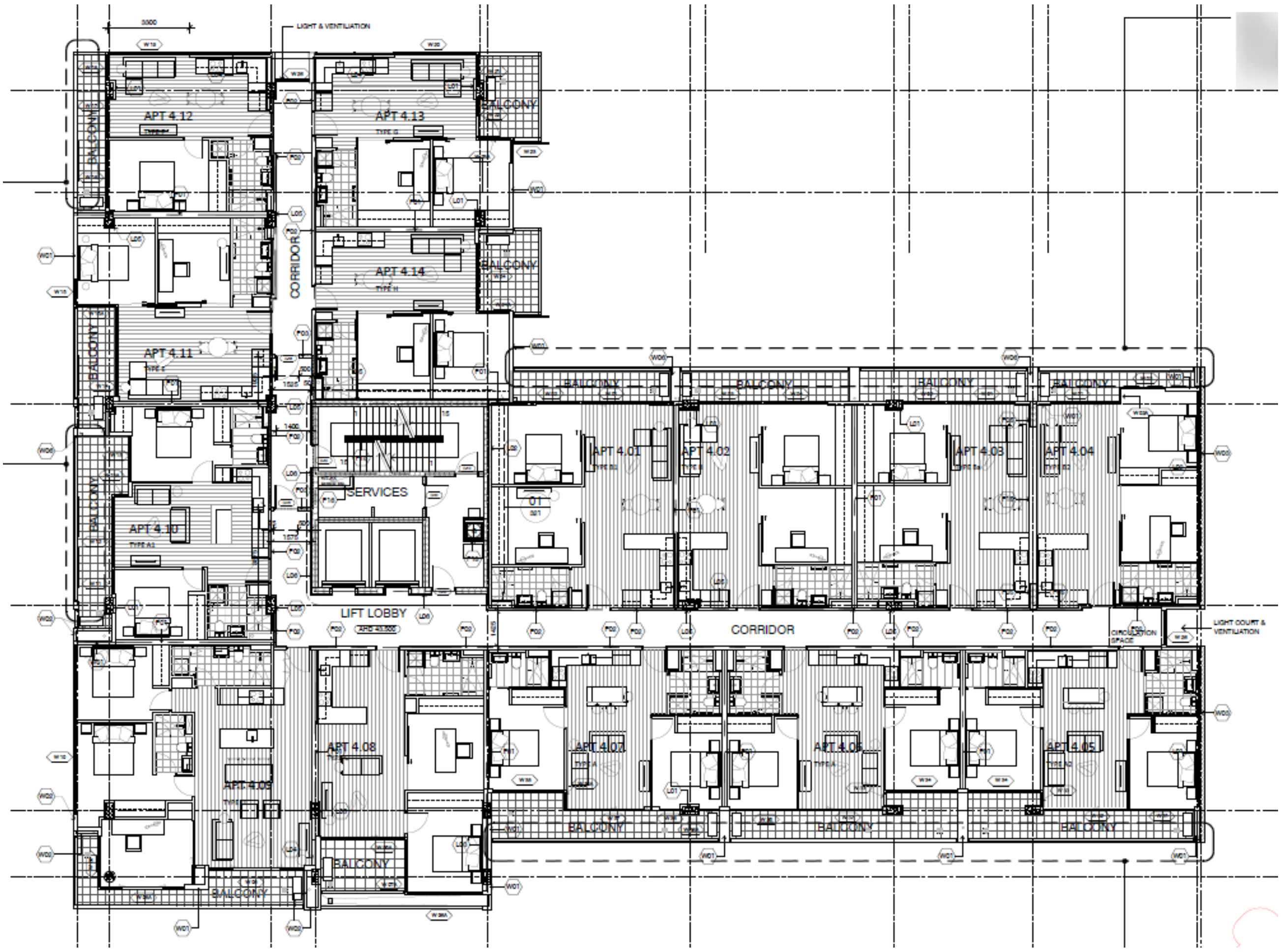
East Elevation for 690 E



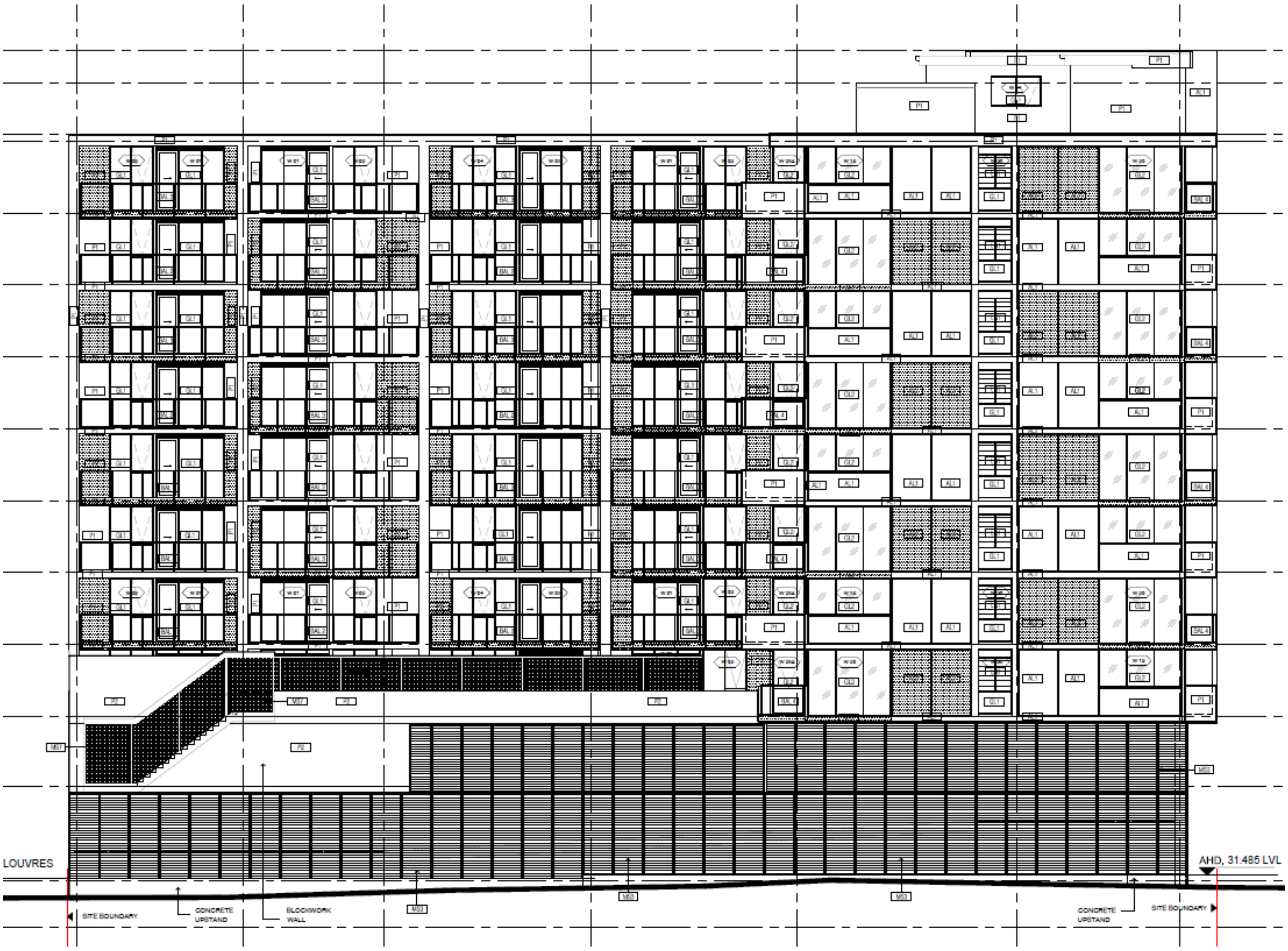
South Elevation for 690 E



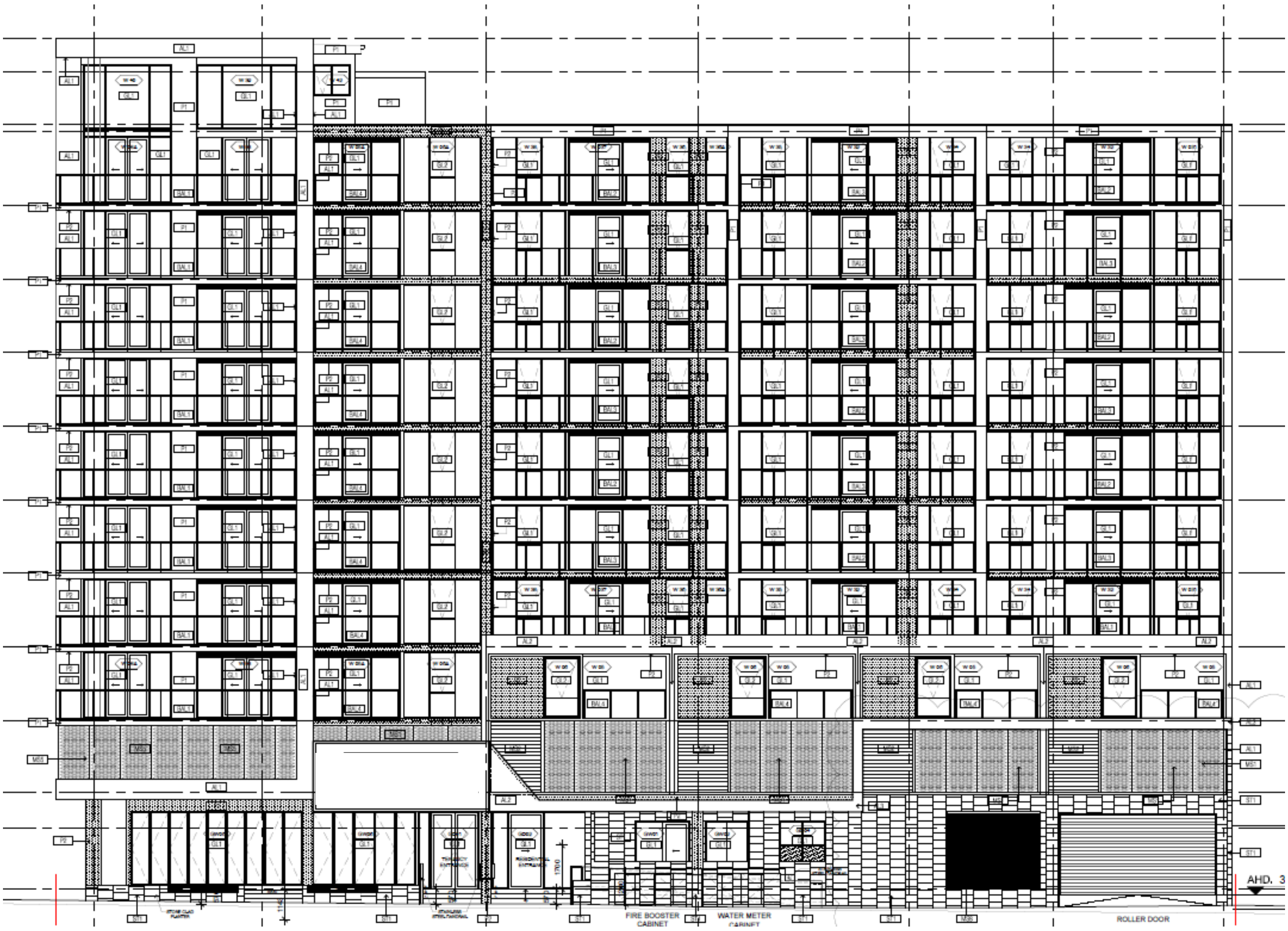
Typical floor plate for 2–6 R



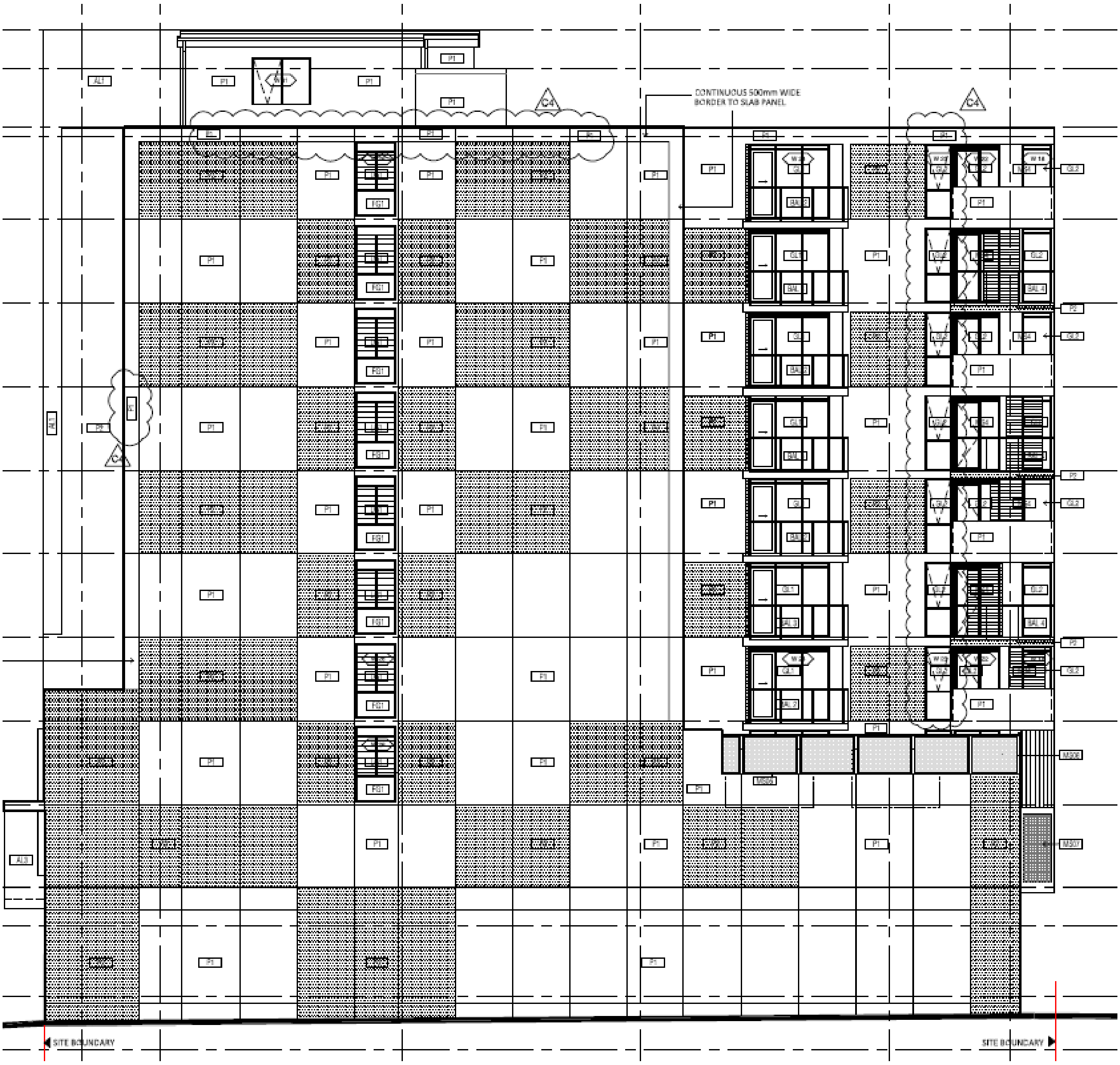
North Elevation for 2-6 R



South Elevation for 2-6 R

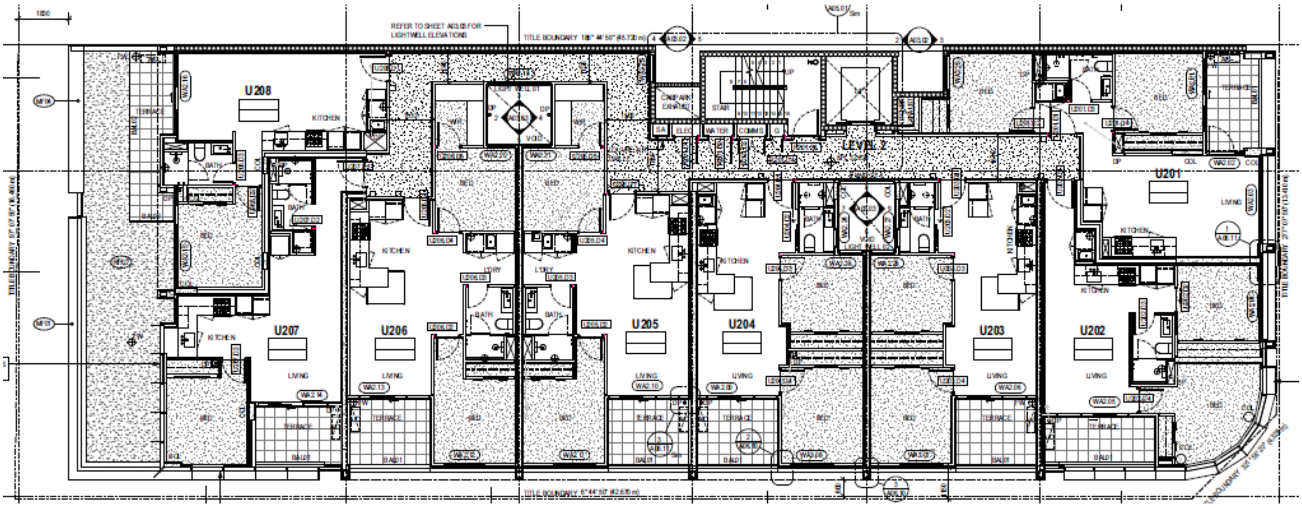


East Elevation for 2-6 R

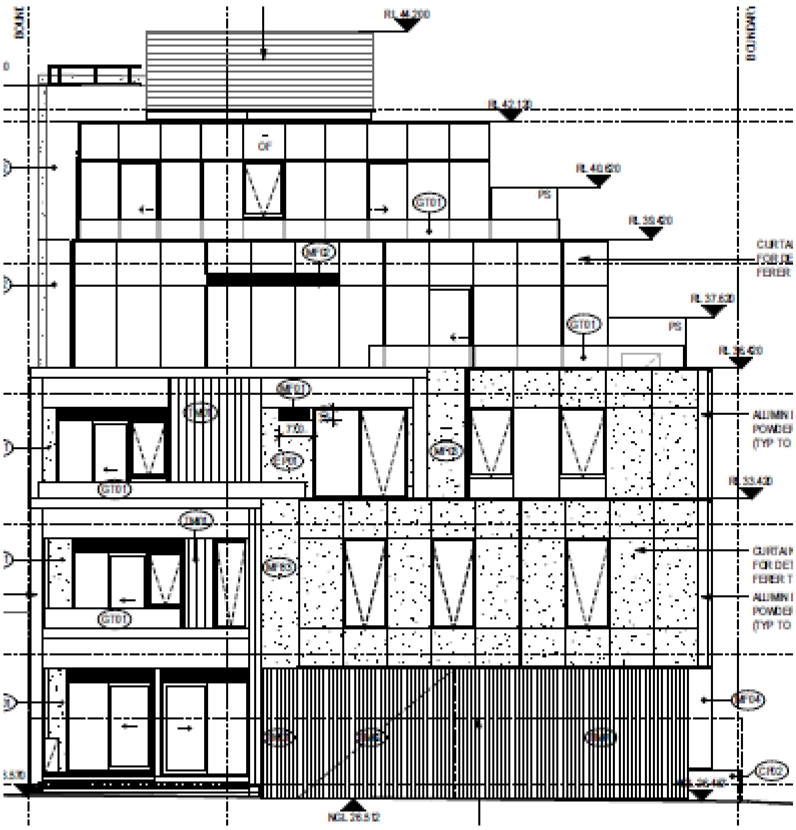


West Elevation for 2-6 R

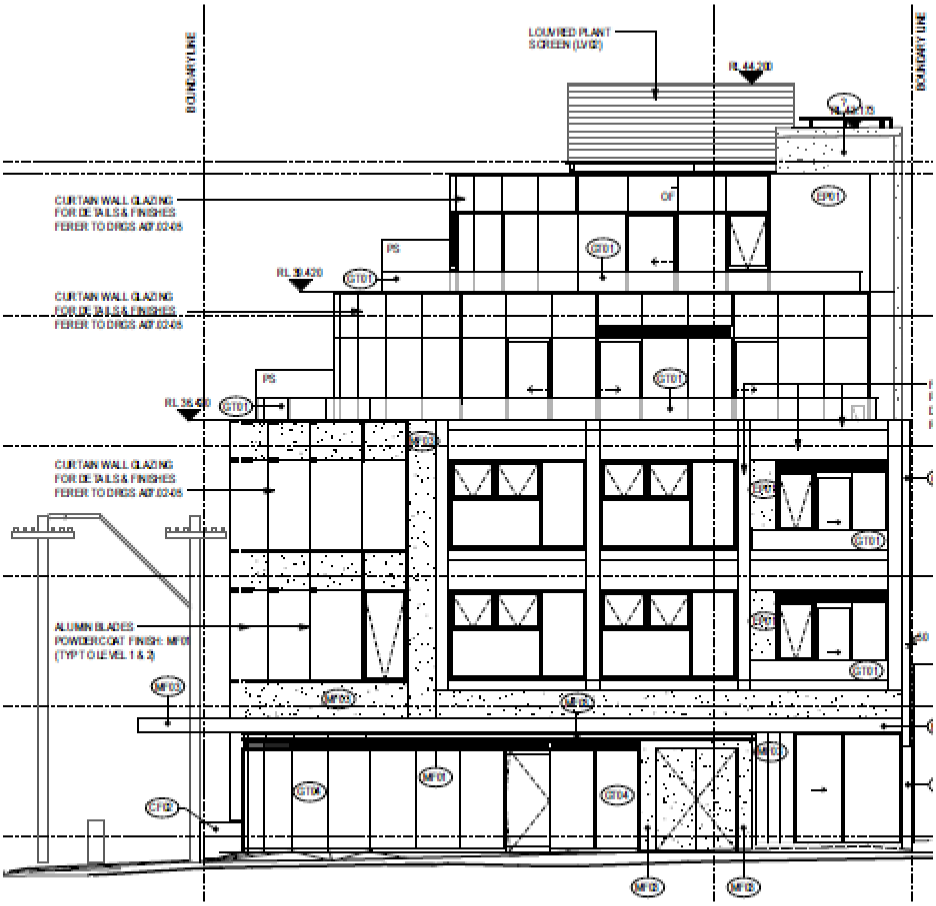
Typical floor plate for 261 C



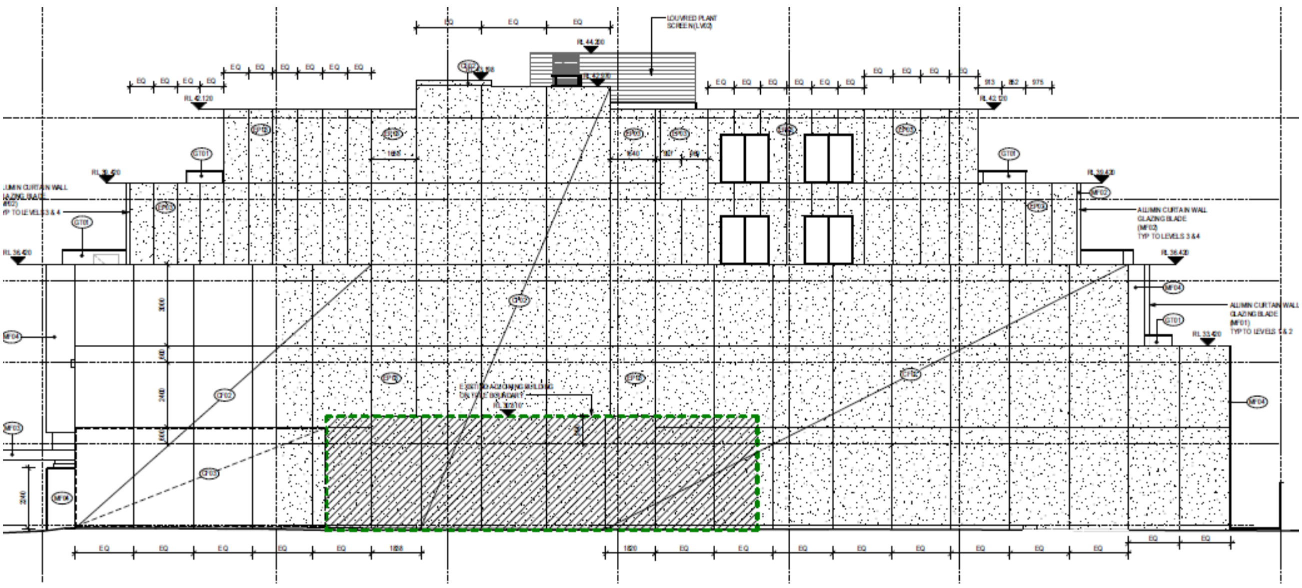
North Elevation for 261 C



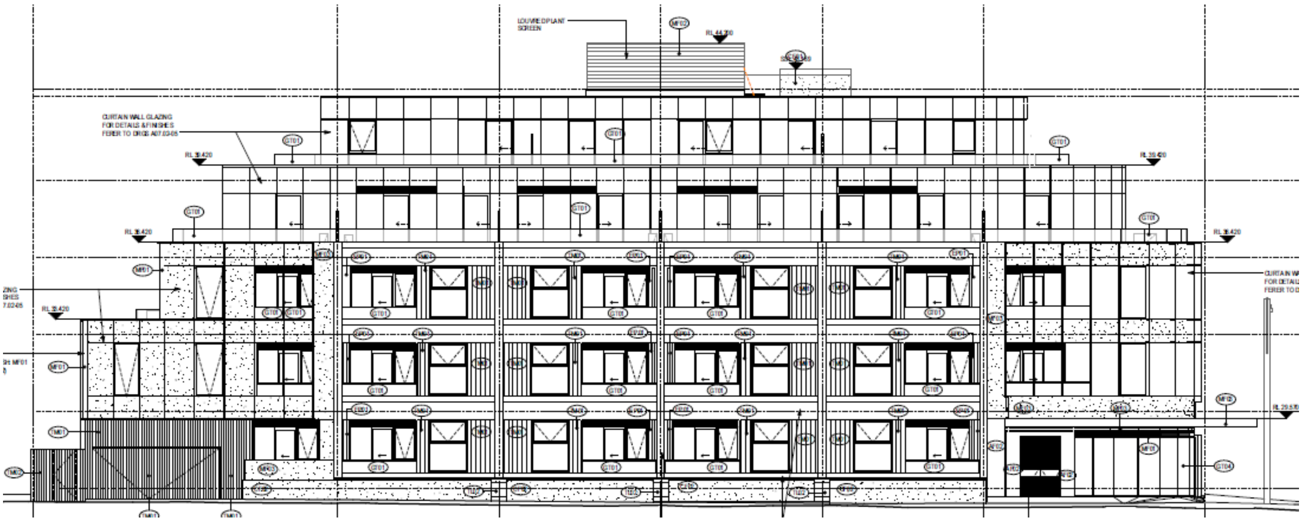
South Elevation for 261 C



East Elevation for 261 C



West Elevation for 261 C



6. Appendix B: Modifications to units required to meet the requirements of a 5.5 star minimum and cooling cap

The following tables show the modifications required to meet the two metrics - 5.5 star minimum and 30 MJ/m2 cooling load cap - in the Melbourne Central climate (NatHERS zone 21). Modifications required to meet these requirements in Moorabbin and Tullamarine are broadly similar. These tables are shown to provide an indication of the extent of change required by each metric.

6.1. Building 690 E 5.5 stars

Apartment	Star Rating as Built	Cool Load as Built	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars	
			Total	Heat	Cool	Kitchen/Living	Bedroom
101	5.2		130.6	111.4	19.1	WSW 0.194W x 2.65H = 0.51m2	ENE 1.399W x 2.523H = 3.53m2
201	5.3	35.0	130.3	100.0	30.3		ENE 1.1W x 2.523H = 2.78m2
204	5.3		131.0	104.5	26.5	NNW 0.72W x 2.650H = 1.91m2	
301	5.4		129.6	102.6	27.0		ESE 0.725W x 2.523H = 1.83m2
401	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2
404	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
501	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2
504	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
601	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2
604	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
701	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2
704	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
801	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2
804	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
808	5.2		130.6	108.3	22.3		W 1.22W x 2.523H = 3.08m2 SSW 0.73W x 2.523H = 1.84m2 Total = 4.92m2
901	5.1	31.9	130.5	105.7	24.7		ENE 1.78W x 2.523H = 4.49m2

Apartment	Star Rating as Built	Cool Load as Built	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars	
			Total	Heat	Cool	Kitchen/Living	Bedroom
904	5.4		130.4	103.2	27.2		NNW 1.112W x 1.66H = 1.85m2
908	5.3		130.2	105.6	24.6		W 0.9W x 2.523H = 2.27m2
1001	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1004	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1008	5.3		130.9	105	25.9		W 1.22W x 2.523 = 3.08m2
1101	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1104	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1108	5.3		130.1	102.7	27.4		W 1.22W x 2.523 = 3.08m2 WSW 0.1W X 2.523H = 0.25m2 Total = 3.33m2
1201	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1204	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1208	5.3		130.4	102.9	27.5		W 1.22W x 2.523 = 3.08m2 WSW 0.1W X 2.523H = 0.25m2 Total = 3.33m2

Apartment	Star Rating as Built	Cool Load as Built	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars	
			Total	Heat	Cool	Kitchen/Living	Bedroom
1301	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1304	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1308	5.3		130.5	102.9	27.5		W 1.22W x 2.523 = 3.08m2 WSW 0.1W X 2.523H = 0.25m2 Total = 3.33m2
1401	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1404	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1408	5.3		130.5	106.2	24.3		W 1.22W x 2.523 = 3.08m2
1501	5.0		130.7	109.1	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1504	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1508	5.3		130.4	102.9	27.5		W 1.22W x 2.523 = 3.08m2 WSW 0.1W X 2.523H = 0.25m2 Total = 3.33m2
1601	5.0		129.8	108.3	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1604	5.4		130.2	104.9	25.2		WSW 2.383W x 0.87H = 2.07m2
1608	5.3		129.8	104	25.8		W 1.22W x 2.523 = 3.08m2

Apartment	Star Rating as Built	Cool Load as Built	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars	
			Total	Heat	Cool	Kitchen/Living	Bedroom
1701	5.0		129.8	108.2	21.6		ENE 1.78W x 2.523H = 4.49m2 NE 1.12W x 2.523 = 2.83m2 Total = 7.32m2
1704	5.3		130.2	103.8	26.4		WSW 2.817W x 0.87H = 2.45m2
1708	5.3		130.3	102.8	27.5		W 1.22W x 2.523 = 3.08m2 WSW 0.1W X 2.523H = 0.25m2 Total = 3.33m2
1804	5.3		130.2	103.2	27.0		WSW 2.817W x 0.87H = 2.45m2
1808	5.0	32.4	130.3	101.4	28.9		W 1.22W x 2.523 = 3.08m2 WSW 1.47W X 2.523H = 3.71m2 Total = 6.79m2

6.2. Building 690 E 30 MJ/m^2

Apartment	Rating as Built	Energy Demand(MJ/m2)			Amended Rating	Energy Demand(MJ/m2)			Glazing reduction		Ceiling Fans
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom	
104	6.2	107.3	75.5	31.8	6.4	98.3	69.7	28.6	NNW 0.96W x 2.523H = 2.42m2		
201	5.3	139.7	104.7	35.0	5.6	128.6	100.0	28.6		ENE 1.1W x 2.523H = 2.78m2	1 x 900mm Ceiling Fan (Kitchen/Living)
205	5.7	123.5	86.5	37.1	6.4	99.4	70.6	28.8	WSW 2.655W x 2.65H = 7.04m2		
304	5.7	125.7	93.1	32.5	5.8	119.7	90.3	29.3	NNW 0.54W x 2.65H = 1.35m2		
305	5.9	114.5	76.8	37.6	6.7	91.6	61.7	29.9	WSW 2.655W x 2.65H = 7.04m2		
405	5.9	118.0	84.5	33.5	6.4	102.5	73.4	29.2	WSW 1.77W x 2.65H = 4.69m2		
505	5.9	117.9	84.1	33.7	6.4	102.3	72.8	29.5	WSW 1.77W x 2.65H = 4.69m2		
605	5.9	117.2	83.4	33.8	6.4	101.6	72.0	29.6	WSW 1.77W x 2.65H = 4.69m2		
705	5.9	116.0	82.2	33.8	6.4	100.7	71.0	29.6	WSW 1.77W x 2.65H = 4.69m2		
805	5.9	114.2	80.2	34.0	6.4	99.0	69.0	30.0	WSW 1.77W x 2.65H = 4.69m2		
905	6.1	111.0	76.9	34.1	6.6	95.6	66.0	29.6	WSW 1.77W x 2.65H = 4.69m2		

Apartment	Rating as Built	Energy Demand(MJ/m2)			Amended Rating	Energy Demand(MJ/m2)			Glazing reduction		Ceiling Fans
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom	
1005	6.1	111.2	80.4	30.8	6.5	96.6	68.8	27.8	WSW 1.77W x 2.65H = 4.69m2		
1205	6.1	111.1	79.9	31.2	6.5	96.6	68.4	28.2	WSW 1.77W x 2.65H = 4.69m2		
1305	6.1	111.0	79.3	31.7	6.6	96.2	67.9	28.3	WSW 1.77W x 2.65H = 4.69m2		
1405	6.1	110.7	78.9	31.8	6.6	95.7	67.5	28.2	WSW 1.77W x 2.65H = 4.69m2		
1505	6.1	110.1	78.5	31.7	6.6	95.2	67.0	28.1	WSW 1.77W x 2.65H = 4.69m2		
1605	6.1	110.0	78.3	31.7	6.6	95.1	67.0	28.2	WSW 1.77W x 2.65H = 4.69m2		
1705	6.2	107.1	76.9	30.3	6.7	92.9	65.7	27.2	WSW 1.77W x 2.65H = 4.69m2		
1805	5.6	127.7	94.5	33.2	6.2	108.5	79.1	29.4	WSW 2.655W x 2.65H = 7.04m2		1 x 900mm Ceiling Fan (Kitchen/Living)

6.3. Building 2-6 R 5.5 Stars

Apartment	Rating as Built	Cool as Built	Amended Rating to achieve 5.5 Stars	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars		Insulation to floor over carpark	Ceiling insulation
				Total	Heat	Cool	Kitchen/Living	Bedroom		
Manager	5.3		5.5	129.6	114.1	15.5			Increased from R 2.5 to R 3.0	Increased from R 3.0 to R 3.5
2.10	4.9	57.3	5.5	129.5	94.5	35.1		W (Bedroom 1) 1.4W x 2.65H = 3.71m2 W (Bedroom 2) 0.9W x 2.65H = 2.385m2 Total = 6.095m2		
3.09	5.0	65.7	5.5	130.6	79.0	51.6		W (Bedroom 1) 1.5W x 2.65H = 3.71m2		
4.09	4.9	58.5	5.5	130.3	87.4	43.0		W (Bedroom 1) 1.8W x 2.65H = 4.77m2		
5.09	5.1	53.6	5.5	129.3	87.6	41.7		W (Bedroom 1) 1.4W x 2.65H = 3.71m2		
6.09	5.1	53.7	5.5	129.7	88.4	41.3		W (Bedroom 1) 1.4W x 2.65H = 3.71m2		
7.09	5.1	53.5	5.5	130.7	89.3	41.4		W (Bedroom 1) 1.4W x 2.65H = 3.71m2		
8.09	5.1	50.2	5.5	129.9	91.4	38.5		W (Bedroom 1) 1.6W x 2.65H = 4.241m2		
9.05	5.2		5.5	130.4	110.1	20.3		S (Bedroom 1) 0.971W x 2.55H = 2.48m2 S (Bedroom 2) 0.877W x 2.55H = 2.24m2 Total		

Apartment	Rating as Built	Cool as Built	Amended Rating to achieve 5.5 Stars	Energy Demand(MJ/m2)			Reduction in Glazing required to achieve 5.5 Stars		Insulation to floor over carpark	Ceiling insulation
				Total	Heat	Cool	Kitchen/Living	Bedroom		
								= 4.72m2		
9.06	5.2		5.5	129.6	109.7	19.9	E 0.3W x 2.34H = 0.7m2	S (Bedroom 1) 0.971W x 2.55H = 2.48m2 S (Bedroom 2) 0.9W x 2.55H = 2.23m2 Total = 4.71m2		
9.07	5.1		5.5	130.7	111.0	19.6	W 0.3W x 2.34H = 0.7m2	S (Bedroom 1) 0.95W x 2.55H = 2.42m2 S (Bedroom 2) 0.875W x 2.55H = 2.23m2 Total = 4.65m2		
9.08	5.4		5.5	130.4	111.0	19.3		S (Bedroom 1) 0.7 x 2.55H = 2.56m2		
9.10	4.7	54.1	5.5	129.8	97.2	32.5	W (Living) 2.02W x 2.55 = 5.15m2 W (Living Void above) 2.02W x 2.55 = 5.15m2 S (Living) 0.6W x 2.55 = 1.53m2 S (Living Void above) 0.6W x 2.55 = 1.53m2 W (Kitchen) 1.033W x 2.55H = 2.63m2 Total = 15.99m2	W (Bedroom 3) 0.5W x 2.6H = 1.3m2		Increased Kingspan Kooltherm K10 from 60mm R 3.0 - 70mm R 3.5
9.13	5.4	41.9	5.5	129.8	89.1	40.7	W 0.5W x 2.34H = 1.17m2			

6.1. Building 2-6 R 30 MJ/m^2

Apartment	Star Rating as Built	Energy Demand(MJ/m2)			Amended Star Rating	Energy Demand(MJ/m2)			Glazing Reduction	
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom
2.10	4.9	155.0	97.7	57.3	5.7	122.7	93.7	29.0		W (Bedroom 1) 1.8W x 2.65H = 4.77m2 W (Bedroom 2) 1.2W x 2.65H = 3.18m2 Total = 7.95m2
2.13	5.9	114.6	71.2	43.3	6.5	97.0	67.2	29.8	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	
2.14	6.2	106.0	65.6	40.4	6.7	91.9	62.6	29.3	N 2.0W x 2.65H = 5.3m2	
3.09	5.0	147.8	82.1	65.7	6.4	100.8	71.2	29.6		W (Bedroom 1) 2.2W x 2.65H = 5.83m2 W (Bedroom 2) 1.5W x 2.65H = 3.98m2 W (Bedroom/Study) 1.0W x 2.55H = 2.55m2 Total = 12.36m2
3.12	6.2	109.2	61.5	47.7	7.2	77.3	48.0	29.2	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 1.1W x 2.55H = 2.8m2
3.13	6.4	101.5	59.9	41.6	7.0	81.7	52.0	29.6	N 2.0W x 2.65H = 5.3m2	

Apartment	Star Rating as Built	Energy Demand(MJ/m2)			Amended Star Rating	Energy Demand(MJ/m2)			Glazing Reduction	
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom
4.09	4.9	149.9	91.5	58.5	6.0	112.5	83.2	29.3		W (Bedroom 1) 2.0W x 2.65H = 5.3m2 W (Bedroom 2) 1.4W x 2.65H = 3.71m2 Total = 9.01m2
4.12	6.1	111.2	70.2	41.0	6.9	87.0	57.8	29.2	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 0.5W x 2.55H = 1.275m2
4.13	6.3	103.0	65.7	37.3	6.8	88.4	58.8	29.6	N 1.6W x 2.65H = 4.24m2	
5.09	5.1	145.3	91.6	53.6	5.9	114.2	84.7	29.5		W (Bedroom 1) 2.0W x 2.65H = 5.3m2 W (Bedroom 2) 0.9W x 2.65H = 2.385m2 Total = 7.685m2
5.12	6.1	110.9	69.3	41.5	6.9	86.2	56.7	29.4	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 0.7W x 2.55H = 1.785m2
5.13	6.3	103.4	66.7	36.7	6.8	88.9	59.7	29.2	N 1.6W x 2.65H = 4.24m2	
6.09	5.1	145.9	62.2	53.7	5.9	115.0	85.3	29.7		W (Bedroom 1) 2.0W x 2.65H = 5.3m2 W (Bedroom 2) 0.85W x 2.65H = 2.25m2 Total = 7.55m2
6.12	6.0	112.5	71.8	40.6	6.8	88.6	59.5	29.1	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 0.5W x 2.55H = 1.275m2

Apartment	Star Rating as Built	Energy Demand(MJ/m2)			Amended Star Rating	Energy Demand(MJ/m2)			Glazing Reduction	
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom
6.13	6.3	103.7	67.3	36.4	6.8	89.7	60.2	29.6	N 1.6W x 2.65H = 4.24m2	
7.09	5.1	146.7	93.2	53.5	5.9	116.3	86.6	29.7		W (Bedroom 1) 2.0W x 2.65H = 5.3m2 W (Bedroom 2) 0.85W x 2.65H = 2.25m2 Total = 7.55m2
7.12	6.1	111.8	70.7	41.1	6.9	87.5	58.3	29.1	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 0.5W x 2.55H = 1.275m2
7.13	6.3	104.5	68.0	36.5	6.8	90.3	60.8	29.4	N 1.6W x 2.65H = 4.24m2	
8.09	5.1	146.8	96.6	50.2	5.9	118.4	88.9	29.5		W (Bedroom 1) 2.0W x 2.65H = 5.3m2 W (Bedroom 2) 0.85W x 2.65H = 2.25m2 Total = 7.55m2
8.12	6.0	113.1	73.1	40.0	6.7	91.9	62.4	29.5	W 1.0W x 2.34H = 2.34m2 N 1.5W x 1.53H = 2.295m2 Total = 4.64m2	W 0.2W x 2.55H = 0.51m2
8.13	6.3	104.7	68.4	36.3	6.7	90.6	61.4	29.2	N 1.6W x 2.65H = 4.24m2	
9.10	4.7	160.1	106.0	54.1	5.6	129.0	99.4	29.6	W (Living) 2.02W x 2.55 = 5.15m2 W (Living Void above) 2.02W x 2.55 = 5.15m2 S (Living) 0.6W x 2.55 = 1.53m2 S (Living Void above) 0.6W x 2.55 = 1.53m2 W (Kitchen)	W (Bedroom 3) 0.5W x 2.6H = 1.3m2 W (Bedroom 2) 0.5W x 1.6H = 0.8m2 W (Bedroom 1) 0.5W x 2.6H = 1.3m2 Total = 2.08m2

Apartment	Star Rating as Built	Energy Demand(MJ/m2)			Amended Star Rating	Energy Demand(MJ/m2)			Glazing Reduction	
		Total	Heat	Cool >30Mj		Total	Heat	Cool < 30Mj	Kitchen/Living	Bedroom
									1.033W x 2.55H = 2.63m2 Total = 15.99m2	
9.13	5.4	135.0	93.1	41.9	6.1	110.9	81.3	29.6	W 1.0W x 2.34H = 2.34m2 N 1.7W x 1.53H = 2.6m2 Total = 4.94m2	W 1.0W x 2.55H = 2.55m2
9.14	5.8	122.0	83.3	38.6	6.2	107.1	78.0	29.1	N 2.3W x 2.65H = 6.1m2	

6.2. Building 261 C 5.5 Stars

Apartment	Star Rating as Built	Cool as Built	Energy Demand(MJ/m2)			Glazing reduction	
			Total	Heat	Cool	Kitchen/Living	Bedroom
UG05	5.4		130.6	115.0	15.6		N 0.2W x 0.8H = 0.16m2
U101	5.4		130.7	111.4	19.3		S 0.1W x 2.35H = 0.235m2
U102	5.4	32.1	130.1	100.6	29.5		W 0.5W x 2.1H = 1.05m2
U201	5.4		130.5	110.5	19.9	E 0.33W x 2.35H = 0.78m2	
U202	5.1	35.0	129.8	102.0	27.8		W 1.1W x 2.1H = 2.31m2 WSW 0.7W x 2.1H =1.47m2 Total = 3.78M2
U301	5.1		130.3	108.1	22.1	SSW 0.92W x 2.4H = 2.21m2	SSW 0.92W x 2.4H = 2.21m2
U306	5.4	57.5	130.2	75.7	54.5	N 0.4W x 2.4H = 0.96m2	
U401	5.0	36.5	130.6	99.9	30.7	W 0.925W x 2.3H = 2.13m2 SW 0.5W x 2.3H = 1.15m2 Total = 3.28m2	
U402	5.0	50.2	130.8	88.2	42.6	W 0.9W x 2.3H = 2.07m2	
U403	5.1	43.8	130.6	92.1	38.5	W 1.07W x 2.3H = 2.46m2	W 0.2W x 2.3H = 0.46m2

6.3. Building 261 C 30 MJ/m^2

Apartment	Star Rating as Built	Energy Demand(MJ/m2)			Amended Star Rating	Energy Demand(MJ/m2)			Glazing reduction			
		Total	Heat	Cool >30 Mj		Total	Heat	Cool < 30Mj	(Kitchen/Living)	Bedroom	Entry	Ceiling Fans
U107	5.9	115.5	82.0	33.5	6.1	110.5	80.7	29.7		E 0.4W 2.1H = 0.84m2		
U207	6.1	110.9	80.2	30.7	6.3	105.6	76.0	29.6	E 0.3W x 2.35H = 0.705m2			
U306	5.4	136.2	78.6	57.5	6.7	91.2	61.2	30.0	N 4.12W x 2.4H = 9.89m2	N (Bedroom2) 1.0W x 2.4H = 2.4m2		Kitchen 2 x 900mm Bedroom1 1 x 900mm Bedroom 2 1 x 900mm
U401	5.0	148.0	111.5	36.5	5.6	128.0	98.4	29.5	W 0.925W x 2.3H = 2.13m2 SW 0.7W x 2.3H = 1.61m2 Total = 3.74m2			
U402	5.0	148.1	97.9	50.2	6.5	96.5	66.8	29.7	W 2.14W x 2.3H = 4.926m2	W (Bedroom 1) 1.0W x 2.3H = 2.3m2 W (Bedroom 2) 1.0W x 2.3H = 2.3m2		
U403	5.1	144.2	100.4	43.8	6.1	110.0	80.1	29.8	W 1.07W x 2.3H = 2.46m2 E 1.0W x 1.97 = 1.97m2 Total = 4.43m2	W 1.07W x 2.3H = 2.46m2	E 1.0W x 1.97H = 1.97m2	