J1V5 Case Study
Compliance with J1P2 as part of a Combined DTS/Performance Solution

Disclaimer

This case study is published by the Australian Building Codes Board with the purpose of providing an example of how J1V5 may be used under the National Construction Code 2022 to show compliance with Performance Requirement J1P2 Thermal performance of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building.

The case study uses a combination of a Performance Solution (J1V5) and DTS Solution to meet J1P2 and J1P3, rather than the sole use of J1V5 to meet the Performance Requirements.

Please note, as J1V5 is used as part of a Performance Solution, the process for the development of Performance Solutions must be used as part of demonstrating compliance with the NCC. More information on the development of a Performance Solution is available at: https://www.abcb.gov.au/sites/default/files/resources/2022/Performance-Solution-Process.PDF.

The case study is for general guidance, not specific advice. Views expressed in the case study are the views of the consultant and do not represent the views or policy of the Australian Building Codes Board.

Use of J1V5 for compliance with J1P2 as part of meeting the Energy Efficiency Requirements for a Class 2 building

ABCB

Case Study of a Combined DTS/Performance Solution

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1.0 Introduction

This case study provides a worked example of a mixed-use building being modelled according to the Verification Methods J1V3 and J1V5 in the National Construction Code (NCC) 2022. The case study shows that it is possible to use a single model with both J1V3 and J1V5 specifications when assessing Section J building fabric compliance in the NCC 2022. The case study uses J1V3 for compliance with J1P1, J1V5 for J1P2, and the Deemed-to-Satisfy (DTS) for J1P3 and J1P4. This document is best read in conjunction with the NCC 2022.

The NCC 2022 includes two new performance requirements for Class 2 Sole Occupancy Units (SOUs) and a Class 4 part of a building: J1P2 Thermal performance of a sole-occupancy unit, and J1P3 Energy usage. These form part of a step change to the existing energy efficiency stringency requirements for Class 2 SOUs and Class 4 parts of a building that includes increased building fabric minimum standards and, for the first time, minimum standards for regulated energy using appliances. In addition, there are two new compliance pathways for Class 2 SOUs and Class 4 parts of a building, DTS elemental provisions and a reference-building based Verification Method (J1V5). The existing NCC provision, J1P1, which covers the provision for energy use and thermal comfort for parts of the building other than Class 2 SOUs, is relatively unchanged from 2019 in the NCC 2022.

For this study, in order to demonstrate how compliance with J1P1 and J1P2 could be achieved, the performance of a 15-storey mixed-use development is modelled using energy modelling software in accordance with Verification Methods J1V3 and J1V5 for the building fabric. In addition, the study shows how the DTS elemental provisions can be used to demonstrate compliance with Performance Requirements J1P1 and J1P3 for mechanical service and hot water.

Additionally, this case study will give specific software-agnostic guidance on:

- Demonstrating compliance with either centralised or individual HVAC systems are utilised for a Class 2 building for both the sole-occupancy units (SOUs) and the area other than sole-occupancy units (SOUs).
- Key aspects of the new J1V5 verification method
- How a building surveyor could approach the review of mixed-use buildings

Figure 1 presents a flow chart of the modelling and assessment process for ease of interpretation for the J1V5 pathway for the SOUs described in this report. For simplicity the requirements for J1P1 and the J1V3 methodology have been excluded from the flow chart.

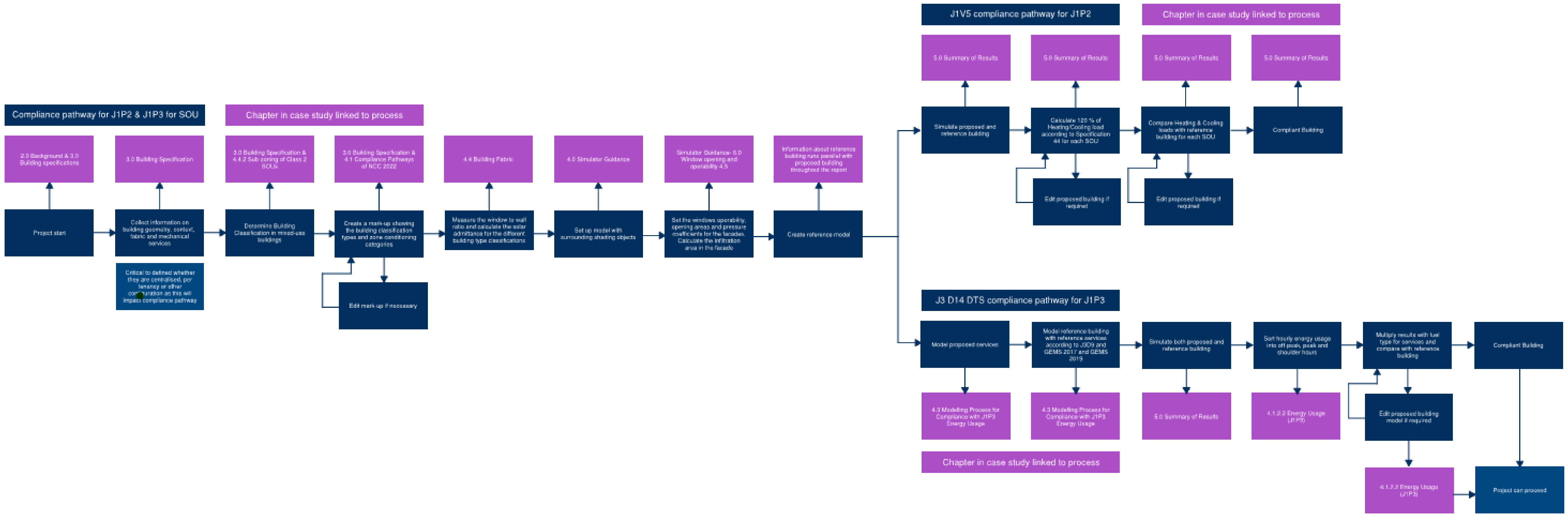

Figure 1 Flow chart showing assessment processes for Class 2 Complicate for J1P2 and J1P3. The flow chart step through each compliance pathway for J1P2 and J1P3 for SOU's

2.0 Background

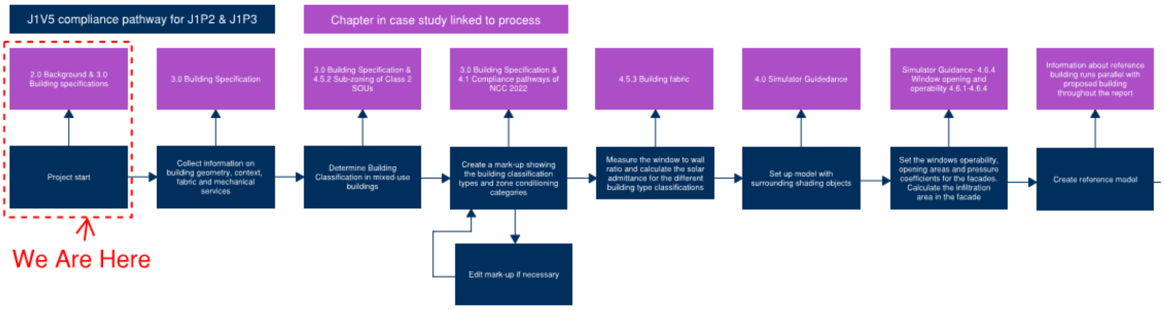

Figure 2: The red highlight indicates where we are in the overall process. This section looks at the background and building specifications

The Performance Requirements J1P2 and J1P3 respectively outline the requirements for the thermal performance of the building fabric and for the total annual energy use of the SOUs. The NCC 2022 has also resulted in a holistic change in the "numbering" of clauses to aid with readability.

The Verification Methods J1V3 and J1V5 both now allow an ASHRAE 140 compliant energy modelling tool to be used in the assessment of the non-residential parts of the building and the SOUs respectively. This enables practitioners to use a single energy model to assess both non-residential and SOUs of a mixed-use building, reducing the overall modelling burden for such projects.

The Verification Method J1V5 can be used to demonstrate compliance with J1P2 as an alternative to the Nationwide House Energy Rating Scheme (NatHERS) pathway. The NatHERS pathway was historically the only pathway for Class 2 buildings. While not the focus of this study, additional Deemed -to-Satisfy (DTS) elemental provisions have also been introduced for Class 2 buildings in the NCC 2022.

Furthermore, there are now two Performance Requirements applicable to Class 2 SOUs and Class 4 parts of a building, thermal performance (J1P2) and energy usage (J1P3).

3.0 Case Study Building Specification

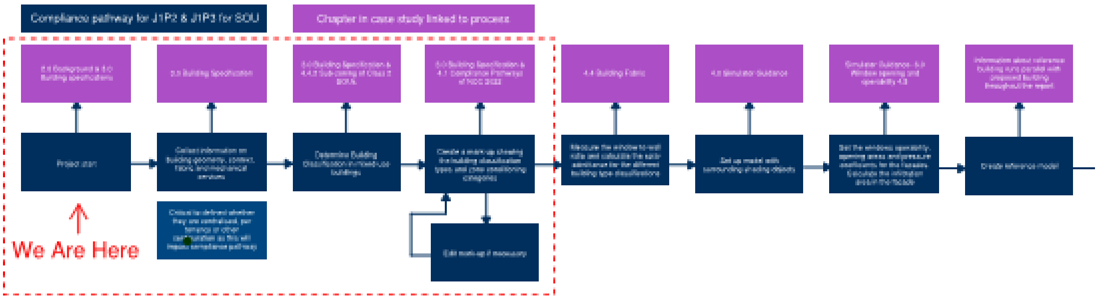

Figure 3: The red highlight indicates where we are in the overall process. This section looks at the background and building specifications, sub zoning for Class 2 SOU and compliance pathway options.

This case study is based on a real building in the city centre of a large urban area, with some modifications made to the external shading and geographic location of the building. The building includes 3 basement levels below ground and 15 levels of mixed-use above ground. The below ground levels are unconditioned and are not included in this case study. The building is approximately 50 m high and is surrounded by low-rise buildings except for a building of approximately the same height to the southwest of the assessed building. The first three levels comprise the podium of the building. These levels contain Class 6 retail and Class 5 office spaces. Levels 3 to 15 contain residential units (SOUs) of varying sizes that range from 51 m² to 120 m². Every unit in the building must be modelled when assessing the thermal performance for compliance with the NCC, however, for the purposes of this study only the units on the 3rd and the 15th floor have been modelled as these will represent extreme conditions when assessing the thermal performance of the SOUs.

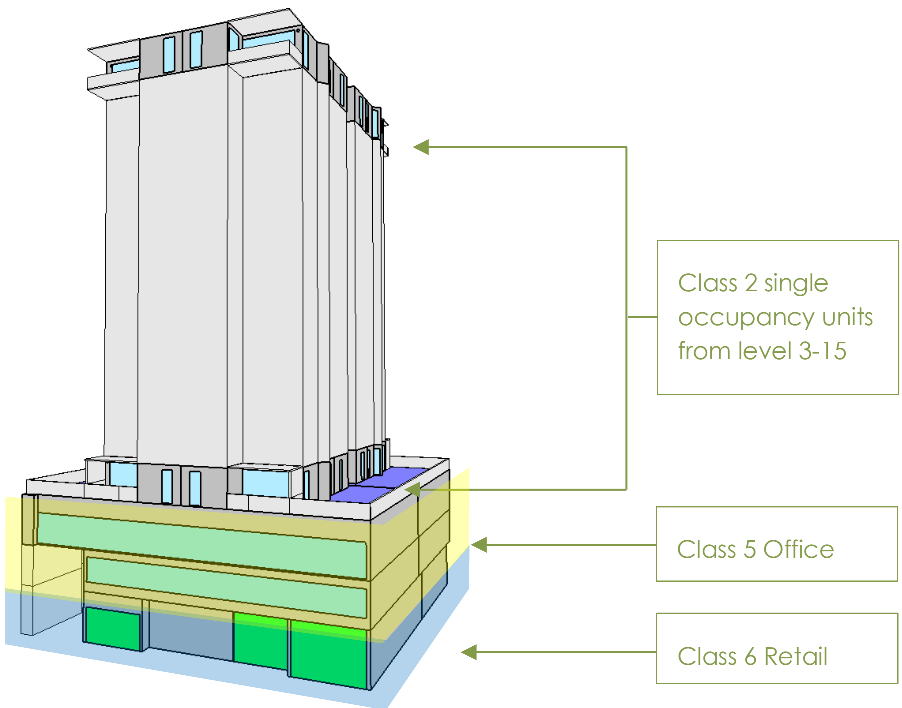

Figure 4 Visualization from the Energy Model with mark-up of the mixed-use development used for this case study

The Class 5 and Class 6 parts of the building have been modelled according to the Verification Method J1V3 in NCC 2022. The Class 2 SOUs have been modelled according to the Verification Method J1V5 in NCC 2022 for thermal performance and the DTS provisions for the net equivalent energy use.

Table 1 Summary of project details

Project Details			
Space types	Residential, office, retail		
NCC Building classifications	Class 2, 5 & 6		
Levels	Ground floor	Class 6	
	Level 1 & 2	Class 5	
	Level 3 - 15	Class 2	
Building floor area	Approx. 6,891m^2 of which 1,848m^2 is non-residential		
Building height	49m		
NCC version	2022 Volume One		
NCC Climate Zone	2		
HVAC	Ground floor	1 System Per Floor	Electric Heat Pump Heating and Cooling
	Level 1 & 2	1 System all Class 5	Electric Heat Pump Heating and Cooling
	Level 3 - 15	1 system per SOU	Electric Heat Pump Heating and Cooling
Domestic Hot Water (DHW)	Ground floor	1 system per tenancy	Electric Storage
	Level 1 & 2	1 system per tenancy	Electric Storage
	Level 3 - 15	1 system per SOU	Electric Storage
Compliance pathway	Performance Requirement	Verification Method	
	J1P2 for Class 2	J1V5	
	J1P3 for Class 2	DTS	
	J1P1 for Class 5 & 6	J1V3 for Part J4 DTS for Parts J5, J6, J7, J8	

4.0 Simulator Guidance

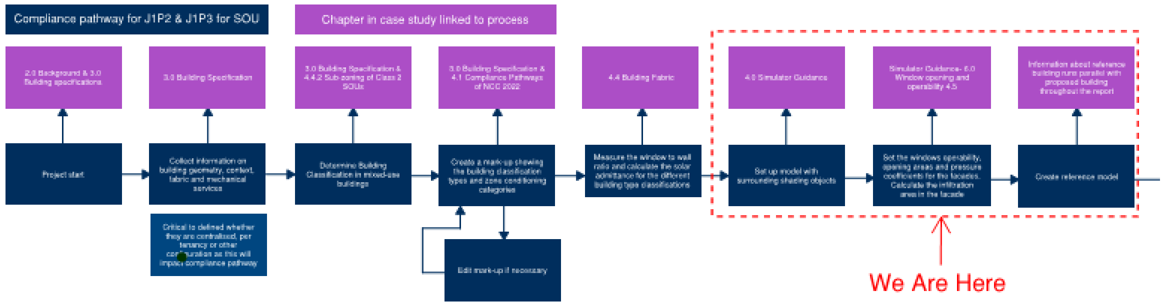

Figure 5: The red highlight indicates where we are in the overall process. This section looks at stimulator guidance and window operability.

This section of the case study aims to provide guidance to simulators on how to carry out a compliance assessment using J1V3 and the new J1V5 compliance pathway for a mixed-use development, and how this new verification methodology relates to the existing requirements.

4.1 Compliance Pathways of NCC 2022

This section of the report summarises compliance pathways options for non-residential and residential parts of buildings. Each building class needs to be evaluated so that the most suitable compliance methodology can be chosen for it. A compliance report submitted to a Surveyor / Certifier / Relevant Authority should include a tabular mark-up or tabular representation that, clearly shows the compliance pathway for each part of the building. For example:

- To comply with J1P2 for a Class 2 SOU or Class 4 part of a building, users can choose either of J1V5, DTS elemental, or DTS NatHERS.
- To comply with J1P3 for Class 2 SOU or Class 4, part of a building, either the DTS elemental or DTS NatHERS or the J1V5 compliance pathway can be selected.
- For the non-residential components to comply with J1P1, J1V3 can be used to demonstrate compliance with J2 and the DTS provisions for J5, J6, J7 and J8 or J1V3 can be used to show full compliance with J1P1.

A combination of compliance pathways may be used to demonstrate compliance through a project performance solution approach.

Compliance cannot be traded between the separate performance requirements J1P1 and J1P2 or J1P3, for example between Class 2 SOUs and parts of the building other than SOUs.

ASHRAE 140 compliant software must be used when assessing code compliance using the Verification Methods J1V3 and J1V5. These methodologies allow for all mixed-use building classes to be included in one energy model, reducing the modelling burden on projects. The reference building requirements that vary for the Verification Methods J1V3 and J1V5 can also be combined in one reference building model.

4.1.1 Parts of the Building other than SOUs

The parts of the building that are not SOUs must comply with the Performance Requirement J1P1. J1P1 can be assessed by any of the Verification Methods J1V1, J1V2, J1V3, DTS or a hybrid approach as shown in Figure 6.

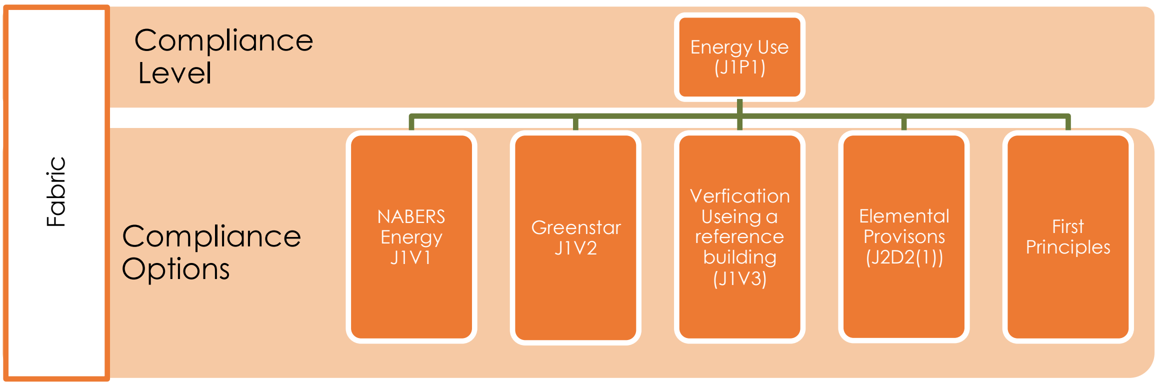

Figure 6 Compliance pathways options for J1P1

In this case study, the following Verification Method was used to demonstrate compliance with the Performance Requirement J1P1 Energy use for Class 2 other than SOUs, i.e. Class 5 and Class 6 parts of the assessed building:

- Verification Method J1V3 for the Part J4 Building Fabric
- DTS Solutions J6 to J9 for services

4.1.2 Residential SOUs

Class 2 SOUs and Class 4 part of a building need to comply with the provisions in J1P2 and J1P3 (Figure 7).

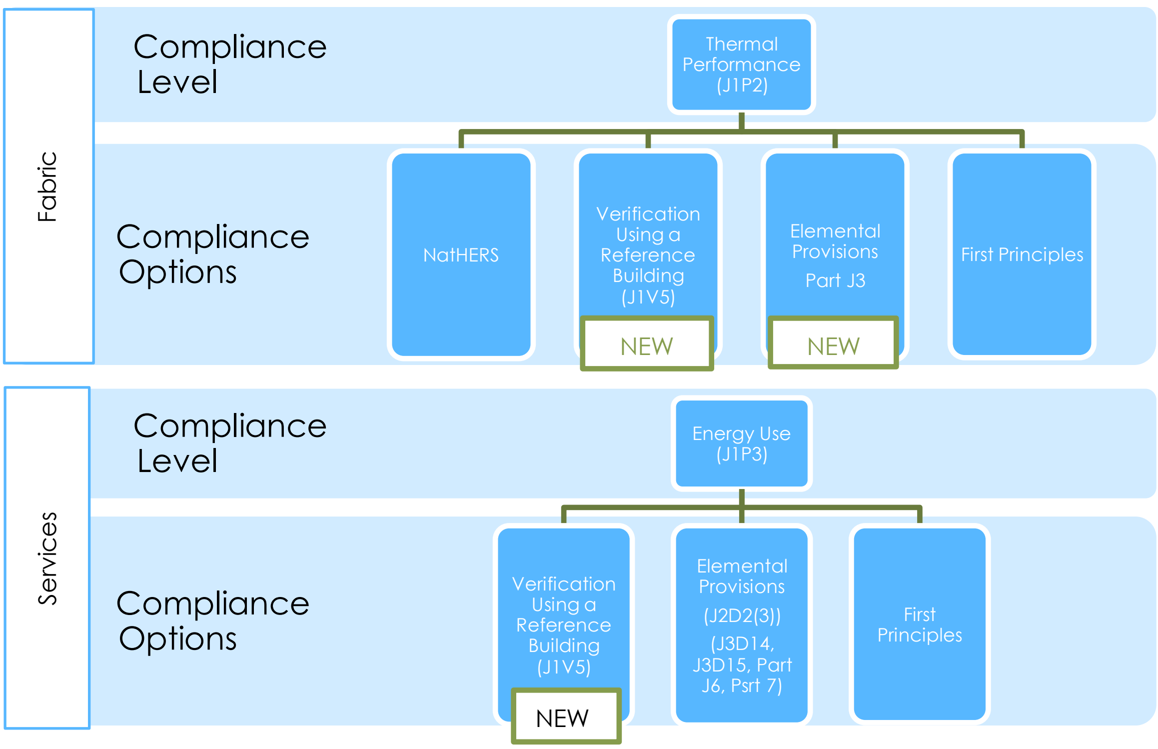

Figure 7 SOUs compliance pathway options J1P2 and J1P3

4.1.2.1 THERMAL PERFORMANCE (J1P2)

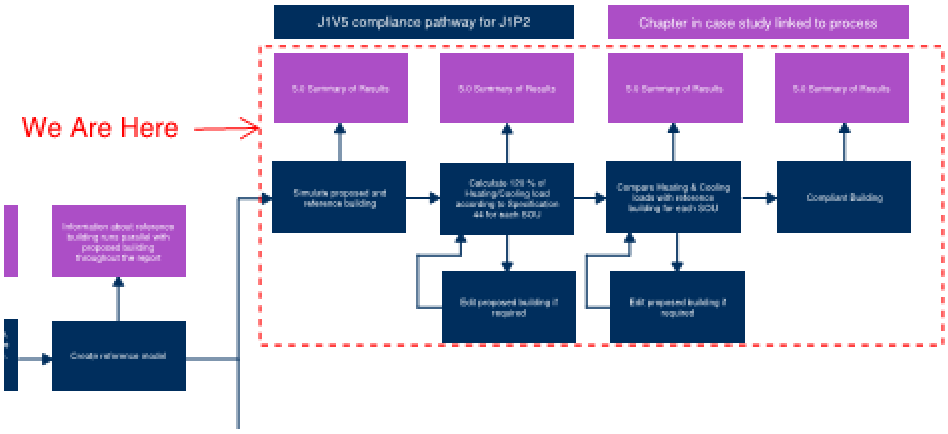

Figure 8: The red highlight indicates where we are in the overall process. The summary of results for J1P2 using the J1V5 compliance pathway.

There are three compliance pathways and a combination of either can be used when assessing compliance with J1P2, as previously shown in Figure 7. Note that J1V4 is for a partial compliance option for building sealing only.

The first option assesses the thermal performance of the building using NatHERS modelling software. The second option (Verification Method J1V5) compares the thermal performance of a proposed building with a modelled reference building. The Verification Method J1V5 requires that the proposed building performs not worse than the reference building. In addition, J1V5 sets the absolute limits for heating load, cooling load and thermal energy load for SOUs. These maximum limits are set to be 120 % of the limits for compliance with J1P2 and Housing Provisions H6P1described in Specification 44. Note that, while the NCC uses 'load' as the terminology, the criteria are related to energy (e.g. MJ, or kWh) and not thermal loads (e.g. kW).

For instance, the cooling load limit (CLL) defined in S44C3 of Specification 44 is as follows:

$$CLL = \left(5.4 + 0.00617 \times (CDH + 185DGH)\right) \times F_C$$

Values for cooling degree hours (CDH) and dehumidification gram hours (DGH) for a desired location are found in Table S45C3a. For Brisbane CDH and DGH are 2,228 and 1,415 respectively. For apartment 3.01, with an area of 58 m^2, and using the formula in S44C3, the CLL in Brisbane is 47.3 MJ/m^2.annum. The 120% of this is 56.8 MJ/m^2.annum, which is the maximum limit under the Verification Method J1V5.

The third option is direct compliance with the DTS elemental provision in the NCC 2022.

4.1.2.2 ENERGY USAGE (J1P3)

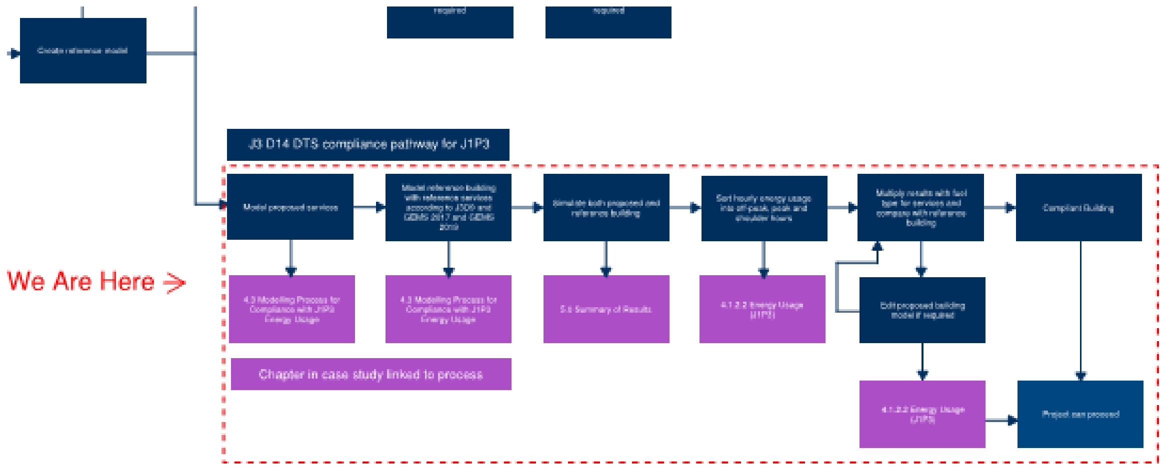

Figure 9: The red highlight indicates where we are in the overall process. The summary of results for J1P3 using the J3 D14 DTS compliance pathway.

J1P3 energy use compliance for SOUs can be assessed using either of the DTS provisions J3D14 or DTS NatHERS J3D15 or the J1V5 verification methodology.

For the case study, compliance with J1P3 was determined using J3D14.

Another option is to use the Verification Method J1V5, which is well suited for buildings with centralised plant systems. When using J1V5, compliance with J1P3 is achieved when the energy value of the domestic services, including all centralised domestic services infrastructure, of a proposed building is less than that of a reference building. If a building provides centralised services to the SOUs, the proposed building energy value should include all energy used to distribute the heating or cooling fluids, such as circulation pumps. However, the energy value for the reference building must be calculated by assuming that each SOU is served by benchmark appliances(decetralised systems) and then summing the energy value across the building. The proposed building and reference building need to be modelled with the same level of servicing e.g. definition of conditioned areas needs to be consistent. If a centralised system serves both SOUs and non-SOU areas, then a critical factor is to isolate the energy use for Class 3, 5-9 from that being used by Class 2 SOUs and 4 parts of the building. This can be done typically through separate metering of the required thermal zones or post-processing of results to combine zones within each SOU.

The energy values for the proposed and reference building are calculated by sorting the energy use for each hour of the day for the whole simulation period into one of the following categories of usage as shown in Table 2.

Table 2 Categories of usage

Categories of usage	Hours
Off-Peak	00:00-07:00 and 22:00-24:00
Peak	07:00-09:00 and16:00-20:00
Shoulder	09:00-16:00 and 20:00-22:00

Compliance via the J1V5 pathway requires that the energy value of domestic services, including all centralised domestic services infrastructure, of a proposed building is less than that of a reference building. When:

a) each sole-occupancy unit of a reference building has-

i) a 3-star ducted air-to-air heat pump, rated under the 2019 GEMS determination, heating all spaces that are provided with heating; and[1]

ii) a 3-star ducted heat pump, rated under the 2019 GEMS determination, cooling all spaces that are provided with cooling; and[1]

iii) a 5-star instantaneous gas water heater, rated under the 2017 GEMS determination, providing all domestic heated water; and

iv) a lighting power density of 4W/m^2 serving all internal spaces that are provided with artificial lighting; and

b) the proposed building and a reference building comply with the additional requirements in Specification 33 and 45 as applicable.

3) the calculation method used for (1) and (2) must(which are not present on this page)-

(a) comply with ANSI/ASHRAE standard 140; and

(b) not be house energy rating software.

The J1V5 pathway allows compliance for whole of building services connected to Class 2 SOUs. The energy use for each categories of usage is multiplied by the fuel type factors in Table S45C3b. The additional requirements in S33C2 must also be met.

4.2 Modelling Process J1P1 and J1P2

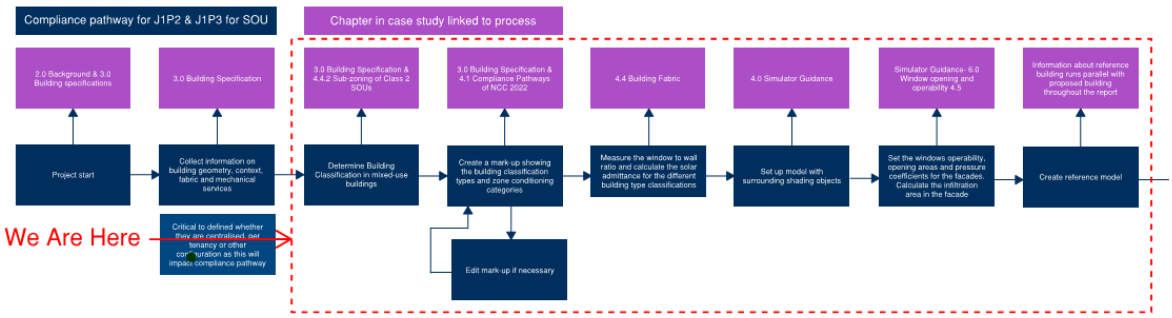

Figure 10 The red highlight indicates where we are in the overall process. This section looks at the building specification, compliance pathway, simulator guidance and window operability's.

[1] The heating and cooling star rating of a heat pump unit is based on the Heating Seasonal Performance Factor (HSPF) and the Total Cooling Seasonal Performance Factor (TCSPF) that are calculated in accordance with Annex B of AS/NZS 3823.4.1:2014. The star ratings matching the Performance factors TCSPF and HSPF can be found in the publication "Greenhouse and Energy Minimum Standards (Air Conditioners up to 65 kW) Determination 2019" dated 25 March 2019.

A single model has been created using the simulation software Design Builder v7.0.2.004. This is a widely used software for energy performance simulation in Australia at time of case study publication. The software incorporates Energy Plus, which is a whole-of-building dynamic simulation engine developed and maintained by the US Department of Energy (USDOE). It is also possible to use other simulation software that is compliant with ANSI/ASHRAE Standard 140.

The model has been set up to distinctly identify each building class..

For Class 2 SOU thermal performance, the model has been set up with the level of sub-zoning as per sub-clause S45C3(n) for both the reference and proposed building. The heating and cooling load (MJ per m^2 per year) for each SOU was extracted from the model. The proposed building was benchmarked against a reference model that was built in accordance with Specification S45C2 Reference building sole-occupancy unit and Specification S45C3 Proposed building and reference building.

For Class 2 SOU net equivalent energy usage, calculations have been carried out in Microsoft Excel, in accordance with J3D14.

Class 5 and 6 parts have been assessed using the Verification Method J1V3 in accordance with Specification 33 and Specification 34. J1V3 includes requirements for the annual greenhouse gas emissions and the thermal comfort level.

4.3 Calculation Process for Compliance with J1P3 Energy Usage

To comply with J1P3 (also known as energy usage requirements for Whole Of Home (WOH)) the elemental DTS compliance pathway for a Class 2 SOU or Class 4 part of a building necessitates that all the requirements in J3D14 to be met.

To new WOH energy usage requirement provides a prescriptive approach to complying with the Housing Energy Efficiency Performance Requirements. The DTS provisions when followed in their entirety meet the performance requirements.

TheJ3D14 requirements for the WOH compliance pathway is as follows:

- The net equivalent energy usage for the building is based on the floor area of the SOU and its location (Climate Zone).
  - The criteria that must be met are;

$$A \times E_F$$

  - A= floor area of the unit multiplied by an area factor that is obtained from Table J3D14a in the NCC.
  - $E_{F=}$ the energy factor dependant on the climate zone and the unit location.
- When calculating the proposed energy usage for the proposed house or sole-occupancy unit the following formulae is used:
  - $(\mathrm{A} \times \mathrm{E_E}) + \mathrm{E_P} + \mathrm{E_S} - \mathrm{E_R}$ where:
  - A= floor area of the unit multiplied by an area factor that is obtained from Table J3D14a in the NCC.
  - E_E= the main space conditioning and main water heater efficiency factor that is obtained from the ABCB Standard for Whole-of-Home Efficiency Factors; and
  - E_P=the swimming pool pump energy usage
  - E_S=the spa pump energy usage
  - E_R=the installed capacity of on-site photovoltaics apportioned to the sole-occupancy units of a Class 2 building or Class 4 part of building (kW)
  - $E_P = V \times FP/1000$

- FP = the swimming pool pump factor from table 13.6.2c of the ABCB Housing Provisions

The pump energy usage for the spa (Es) is calculated with the following formula

FSB= the spa pump factor in table13.6.2d of the ABCB Housing Provisions.

$$E_S = V \times FSB/100$$

ABCB has provided a calculator for the DTS Whole of Home pathway. This has been used to assess the energy efficiency performance of the units in the case study. The result from this assessment is shown in Table 13 in this report. For the case study E_P, E_S and E_R are set to zero.

When using the elemental (DTS) pathway to assess compliance with J1P3 the elemental provision in Part J6 and J7 must also be met. These refer to the elemental provisions for ventilation and air-conditioning as well as artificial lighting and power respectively.

4.4 Modelling Guidance for Compliance with J1P2 Thermal Performance

4.4.1 Climate

The Typical Meteorological Year (TMY) weather files published by CSIRO must be used for the Verification Method J1V5 in the NCC 2022. In the case study the CSIRO weather data is used for compliance assessment for both the residential part and the other building parts for consistency. The CSIRO TMY weather files are based on the data drawn from 1990 to 2015 and are recommended for use in J1V3 as it reflects recent climatic trends. Table 3 summarises the heating and cooling compliance requirements for each Climate Zone.

Table 3 Class 2 SOU heating and cooling load requirements

Climate Zone	J1V5 Compliance Requirements
1 & 2	Cooling only assessed
3, 4 & 5	Cooling and heating assessed
6, 7 & 8	Heating only assessed

This case study utilised the CSIRO TMY weather file for Brisbane (NCC Climate Zone 2/NatHERS Climate Zone 10). As Brisbane is in Climate Zone 2, only the cooling energy is assessed for these residential units. To reflect the solar environment as accurate as possible, it is essential that an assessed building is correctly oriented in a model. The building model must be constructed in a way that it reflects the shading from its surrounding buildings, which are to be included in the model to account for shading.

The mandating of the climate files in the NCC is to provide consistency in the climatic conditions used in the assessment by practitioners and the heating degree hours, cooling degree hours, and dehumidification gram hours used to calculate the load limits for J1V5. The new climate files have been created based on a more recent 25-year data set to account for post-1990 variation being seen in the climate. The climate files have been produced for all locations considered under the NatHERS (69 locations). The weather file, which is closest to the project site is to be used within the modelling process.

In some locations, professional judgement may be required as the closest weather file may not be representative; for example, the weather data may be for a coastal location, and the project in question may be up on a nearby tableland with a significantly higher elevation. Where this scenario exists, it is recommended that a brief explanation is included to substantiate why the closest weather file has not been selected. It is strongly recommended that the Climate Zone is agreed with the building surveyor/ certifier prior to the modelling being undertaken.

4.4.2 Sub-zoning of Class 2 SOUs

As required in J1V5, internal zoning of each SOU must be on a per room basis, as outlined in Specification S45C3(1)(n)(Figure 11). Examples of the zoning in accordance with S45C3(1((n)are outlined in Table 4 below. The kitchen was modelled as an unconditioned virtual zone except when it has an external wall in which case it is modelled as a conditioned zone.

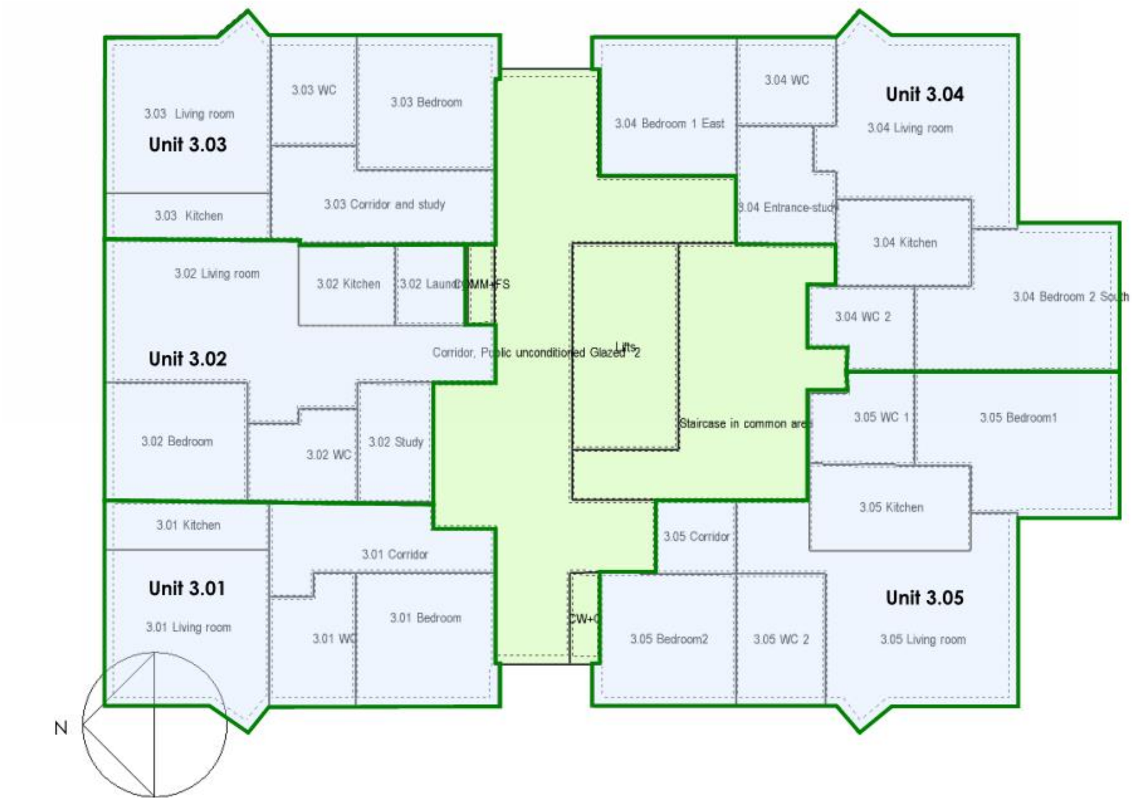

Figure 11 Residential unit layout with including sub- zoning required by J1V5

Table 4 Class 2 zones included in case study model

Zone type	Conditioned	Unconditioned	Daytime	Nighttime
	Class 2			
Bedroom	x			x
Kitchen	X[#]	X[#]	x	
Living room	x		x	
Study	x		x	
Bathroom/Toilets/WC		x	x	
Laundry		x	x	
Corridor		x	x	
Common areas. Incl. Lifts, stairs, and common corridors		x	x	

In each SOU, each room needs to be zoned separately. This is to enable the level of detail regarding energy use and scheduling to accurately reflect the modelling requirement as outlined in the NCC. This also ensures modelling consistency among all the Class 2 SOU modelling pathways with the NCC. Air exchange between internal zones must also be modelled by setting appropriate schedules and operability to internal doors and windows. For the case study the schedule for the doors follows Specification 45 occupancy schedules (S45C3i) and the opening area for the doors was set to 50 % of the door opening. The internal doors were assumed to only be open 5 % of the scheduled time.

Table 5 and Table 6 document the zones included for the Class 5 and Class 6 part of the case study building.

Table 5 Class 5 zones included in case study model

Zone type	Conditioned	Unconditioned
Lifts, stairs		x
Lift lobby		x
Office	x	
Toilets/WC		x

Table 6 Class 6 zones included in case study model

Zone type	Conditioned	Unconditioned
Corridors		x
Entry foyer	x	
Ground level car park		x
Loading dock		x
Retail spaces	x	
Substation		x
Lifts and stairs		x

4.4.3 Building fabric

This section summarises the information used to assess the building fabric compliance for both the proposed building and the reference building. The total R-value must include the effects of thermal bridging in the façade system.

External Walls:

The external walls on the west and east façades are concrete walls with interior insulation. The walls on the north and the south façades are mainly spandrels.

The R-values for the building fabric, glazing U-values and solar heat gain coefficients (SHGCs) for the reference building are calculated using Method 2 in Specification S37C6 and the values in table S37C6a.

The window-to-wall ratio (WWR) that is used to calculate the solar admittance according to Specification S37C6 Method 2 is shown in Table 7.

Table 7 Window-to-wall ratio for different building levels

Level	North	East	South	West

Window-to-wall ratio (WWR) %				
Ground Level	74	0	25	59
Level 1 & 2	68	0	75	34
Level 3-15	67	27	51	27

The maximum allowable compliant solar admittance is used to calculate the SHGC for the glazing in the proposed building.

Shading:

The building is shaded by a neighbouring building on the southwest side of the building. The windows on the west façade on ground level and Level 1 are shaded by an external load bearing wall to the west that creates a shaded passageway for traffic on the west side of the building. The windows on the south and north façade of the ground floor and level 1 and 2 are shaded by horizontal sunshades 450 mm from the glazing.

The windows on the residential floors are not shaded on the east and west façades, but the large windows and sliding doors towards the north and south are shaded by the balconies above and by vertical structural shading (wing walls) on the sides of the balconies.

Building Envelope Performance:

The thermal performance and the SHGCs for the proposed and reference building that were used to assess compliance with J1P1 using J1V3 are shown in Table 8 and Table 9.

Table 8 Thermal performance and solar absorptance for the proposed and reference building for Class 5 &6

Construction	Reference fabric		Proposed fabric		Solar absorptance
Roof total system R-value [m²K/W]	3.7		4.5		0.45
Opaque external wall (excl. spandrels) but incl. thermal bridging Total system R-value [m²K/W]	1.0		1.0		0.60
External floors total system R-value [m²K/W]#	2.0		2.0		-
Infiltration rate (ac/h)	0.7 for zones without mechanically supplied outdoor air and 0.35 air changes per hour at all other times		0.7 for zones without mechanically supplied outdoor air and 0.35 air changes per hour at all other times		-
Spandrels total system R-value [W/m²K]	1.0		1.0		0.60
Glazing	**Reference glazing U-value [W/m²K]**	**Reference SHGC-**	**Proposed glazing U-value [W/m²K]**	**Proposed SHGC-**	
Display window at ground level	5.8	0.33	5.0	0.31	-
Total system glazing Level 1 and 2	4.4	0.86	3.5	0.41	-

The U-value for the floor includes the floor towards the basement and the suspended floor in level 2 above the driveway.

All U-values and R-values are inclusive of thermal bridging.

The thermal performance of the fabric and glazing used to assess J1P2 compliance is shown in Table 9.

Table 9 Thermal performance and solar heat gain coefficients for building fabric for Class 2

Construction	Reference fabric R-value [m²K/W]	Reference Solar absorptance	Proposed fabric R-value [m²K/W]	Proposed Solar absorptance -
Roof	4.5# (J3D7)	0.45	4.5	0.60 Shading device overhang >300 mm
External wall	2.2 (J3D9)	0.60	1.0	0.60 Shading device overhang
External floors	The residential part of the building does not have floors to the exterior	-	-	-
Spandrels	1.0 (J3D9 3a&4)	1.0	1.0	0.60 Shading device overhang >300 mm
Unit	**Reference Glazing U-value [W/m²K] (J3D9)**	**Reference SHGC**	**Proposed Glazing U-value [W/m²K]**	**Proposed SHGC**
3.01	2.9	0.27		
3.02	4.0	0.62		
3.03	2.7	0.26		
3.04	4.5	0.34		
3.05	4.4	0.32	3.5	0.23
15.01	2.9	0.27		
15.02	4.8	0.62		
15.03	4.5	0.34		
15.04	4.4	0.32		

For Climate Class 2 flat concrete roofs and interior insulation.

All U-value and R-values are inclusive of thermal bridging.

4.5 Modelling Guidance for Natural Ventilation and Infiltration

The indoor climate in the residential units is controlled by opening and closing windows. Unoccupied zones such as common corridors, stairs and lifts are simulated without active heating and cooling. All the zones that have a window to the exterior wall are modelled with natural ventilation.

There are two main forces that affect natural ventilation, these are:

- Wind pressure
- Stack pressure (buoyancy)

4.5.1 Wind Pressure

When the wind strikes a building, it induces pressure zones on the façade surfaces. This results in areas of mean positive and negative pressures on the building.

The wind pressure coefficients on the building surface are dependent on the air flow direction, the building shape and height and the surrounding elements obstructing air flow around the building.

The dominating term in determination of wind induced surface pressure is the building height, as wind speed increases with height and pressure increases with the square of the velocity (Orme, Liddament, Wilson, 1994). The wind speed derived from the climate files is extrapolated using wind velocity profiles above the boundary layer. An approximate correction equation to account for height difference and intervening terrain is given below.

$U_z = U_m k z^a$ (m/s)

Where Uz = Building height wind speed (m/s)

Um = Wind speed measured in open country at a standard height of 10m (m/s) (data from climate file)

z = building height (m)

k, *a* = constants dependant on terrain (see below)

Terrain Coefficient	**k**	**a**
Open, flat country	0.68	0.17
Country with scattered wind breaks	0.52	0.20
Urban	0.35	0.25
City	0.21	0.33

Source: BS5925:1991

The wind speed can be edited by exporting the weather file and editing the hourly wind speed data with the above equation. This must be done for each SOU. Energy modelling software packages often enable these properties to be input within the package.

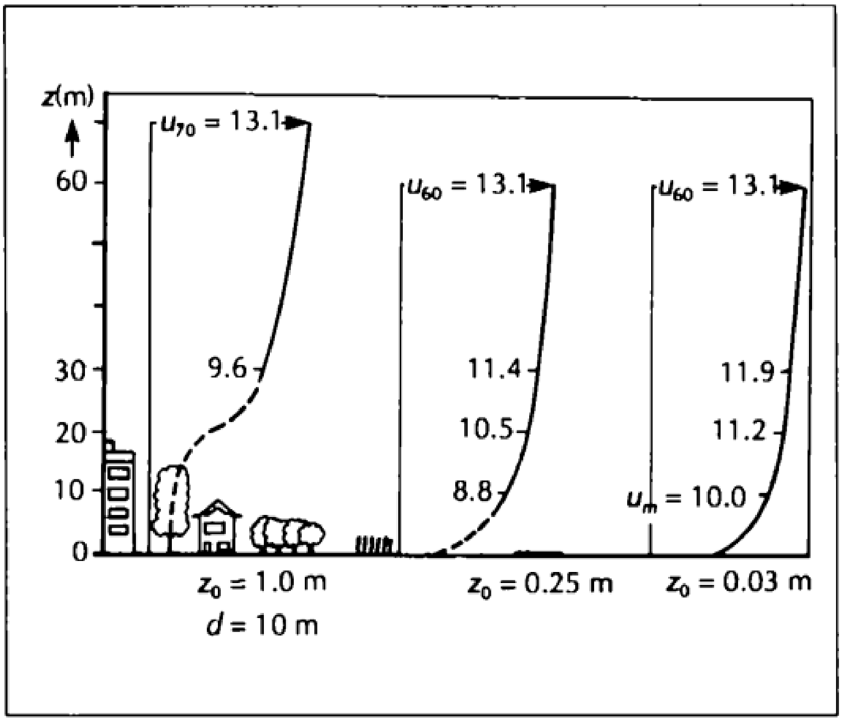

Figure 12 Logarithmic velocity profiles for three example roughness lengths: 1m, 0.25m and 0.03m (Orme et al.)

NCC 2022 also includes pressure coefficients for buildings based on the building height (Tables S45C3n to S45C3o). The pressure coefficients must be used for both the proposed and the reference building when assessing J1P2 compliance using the J1V5 method. For building above 12 meters the pressure coefficients need to be assessed for each floor of the building by calculating the ratio between the height of the openings above ground level (h) and the roof height above ground level (H). The h/H ratio for each level should be rounded off to the nearest value given in table S45C3o. The pressure coefficients will be different depending on whether the building is exposed, semi-exposed or sheltered. It is therefore, essential that the buildings wind exposure is determined for each facade before the pressure coefficients are assigned to the model.

This would need to be calculated in a similar way in all ASHRAE 140 compliant modelling tools.

4.5.2 Stack Pressure (Buoyancy)

Stack (or buoyancy) pressure is generated from differences in density between indoor and outdoor air. The differences in densities result from differences in temperature and relative humidity in the air. A vertical pressure difference drives the ventilation rate dependent on the stack pressure. This effect is relatively small when compared to the wind induced ventilation rates. However, this effect is more significant for tall buildings that that are sheltered from the wind.

4.5.3 Discharge Coefficient for Operable Windows

The discharge coefficient affects the natural ventilation rate of a window. This value needs to be assigned to the model. The discharge coefficient is the ratio of the actual discharge to the ideal discharge and has a lower and upper limit of 0 and 1. It is difficult to find data on discharge coefficients for windows, doors and openings as the information is often not available in the early stages of the design phase. The discharge coefficient for a typical window opening with unidirectional flow has been estimated to be in the range of 0.60 to 0.65 (CIBSE, 2005; Etheridge and Sandberg, 1996). Given other uncertainties in natural ventilation calculations it is advised that a discharge coefficient between 0.6 and 0.65 is used. For the case study a default value of 0.65 is used for all windows, doors and openings for both the reference building and the proposed building.

4.5.4 Window Openings and Operability

The operability of windows is important when considering natural ventilation flow rates. The size, operability, shape and location of the window determines how much outside air enters and leaves the simulated zone. To determine the opening size of an operable window the window type needs to be determined.

NCC 2022 provides values for opening areas for various window types as percentage of glazing in table S45C3m.

The natural ventilation rate is modelled the same for the proposed and the reference building.

Table 10 NCC S45C3m Window opening area percentage

Window type	Opening area
Any window with restricted opening due to safety requirements	10 %
Sliding and double hung	45 %
Casement, awning, louvre, bi-fold, pivot, tilt and turn and French	90%

The 2020 Advisory Note from ABCB on protection of openable windows identifies provisions for safety features for openable windows in new residential buildings (i.e., houses, apartments, hotels and the like) where the floor below the window is more than 2m above a solid surface or ground. The safety requirements in clause D1.P3 of NCC Volume One, and clauses H5P2 and H5V1 of NCC Volume Two require the affected window be fitted with either a device to restrict the window opening, or a suitable screen, so that a 125mm diameter sphere (representing the size of a young child's head) cannot pass through.

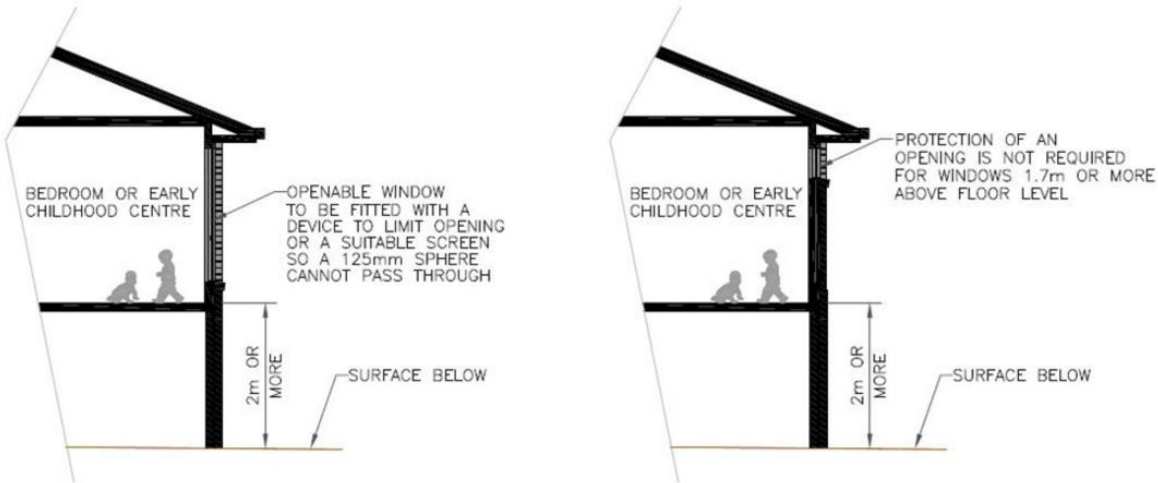

Figure 13 NCC safety provisions for operable windows demonstrating where opening must be restricted to 125mm for safety

When developing a thermal performance model, it is important the safety requirements for the window operability is defined for the façades and that there is documentation behind the assumptions that show compliance with the building code. Opening areas greater than 10 % on high-rise residential units must not be allowed unless the window open towards a balcony or a terrace.

In the case study, all the windows that are not adjacent to balconies or terraces are assumed to have an opening equivalent to 10 % of the glazing area. Sliding doors that open adjacent to balconies and terraces are modelled with 45 % openings according to table S45C3m in NCC 2022.

4.5.5 Window Opening Control

Most ASHRAE 140 compliant modelling programs have multiple control options with respect to opening and closing of windows. It is important the windows operation settings are in accordance with S45C3. The window operation of both the proposed and reference building must be controlled so that the windows/doors shut when:

i. The external dry bulb temperature is less than or equal to a temperature the air-conditioning cooling set point; and
ii. Openings must shut when the external dry bulb temperature is greater than or equal to the air-conditioning service heating set point; and
iii. Openings must remain open for all hours of the year that do not meet the above closing condition.

Figure 14 illustrates the conditions for heating, cooling and natural ventilation.

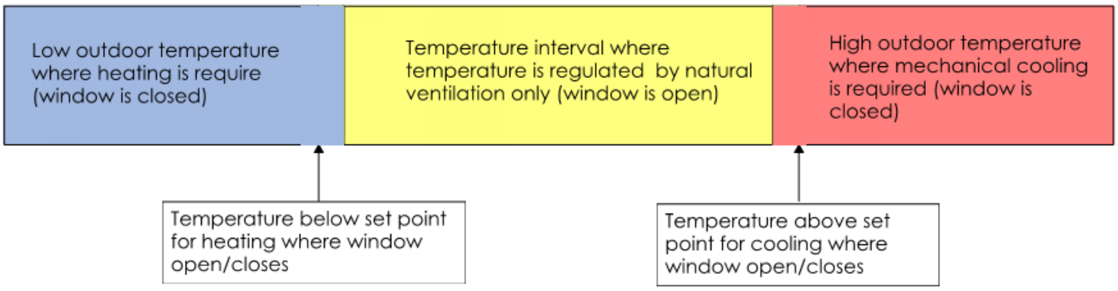

Figure 14 Rules for window operation according to S45C3(3)(e), visual representation of section 4.5.5

The operability is modelled as a schedule with a 24/7 operation that is switched off when the outdoor temperatures match the criteria above. In Design Builder using the "Calculated Natural Ventilation" method must be used to open and close windows based on the set point temperature. This will be similar in other tools and the tools guidance notes need to be checked on the correct settings.

As an example, Design Builder allows for modulation of openings. This function allows for the openings to vary in size over time and can be controlled by setting upper and lower limits on the opening areas during the simulation period. This method of evaluating the opening areas will not be consistent with opening areas in table S45C3m, it is therefore important that the opening areas are set as constant values for the entire simulation period.

4.5.6 Infiltration

The infiltration rates vary for the J1V3 and the J1V5 Verification Methods.

The infiltration rate for the reference building for Class 5 & 6 is set using criteria set out in J1V3. The infiltration rate is set to 0.7 ac/h for zones with no mechanically supplied outdoor air: and 0.35 ac/h for all other zones at all other times. The proposed building the whole building infiltration rate at 50 Pa may be converted into a whole building infiltration value for the proposed building infiltration using tables 4.16- 4.24 of CIBSE Guide A:

a. Additional sealing provisions to those required by Part J5
b. An intended building leakage of less than $10 m^3/hr.m^2$ at 50 Pa
c. Pressure testing to verify achievement of the intended building leakage

For simplicity in the case study the infiltration rate for the proposed class 5 & 6 building is set to the same value as for the reference building.

For Class 2 SOUs the modelling methodology has been developed to create alignment between the NatHERS and J1V5 process. In most ASHRAE 140 compliant modelling tools, infiltration and operable windows cannot be modelled simultaneously. As such, to mimic the NatHERS process, the modelling methodology has been written such that the infiltration function in the simulation program must be switched off or set to zero, then an opening/hole 3.8×10^{-4} m^2 per m^2 (in accordance with S45C2) must be modelled in each apartment to account for infiltration. This methodology must be adopted in both the proposed and the reference building unless the building infiltration is being verified in accordance with J1V4.

4.6 Modelling Guidance for Building Services

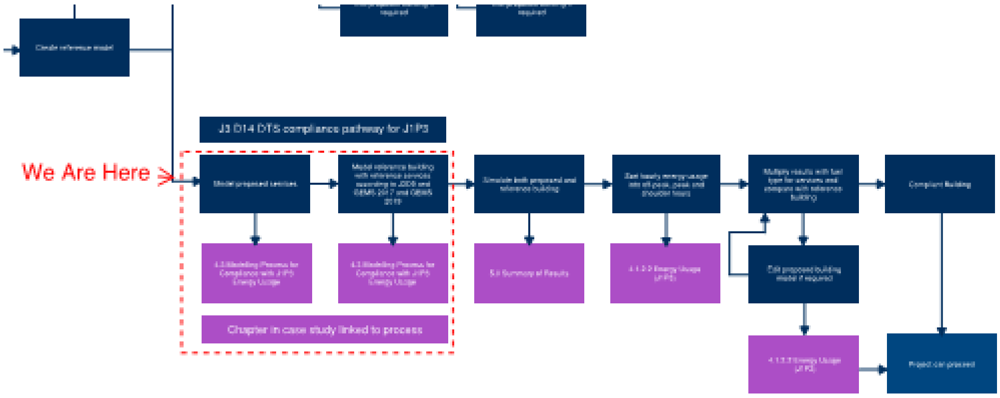

Figure 15: The red highlight indicates where we are in the overall process. This section looks at the modelling process for J1p2 using the J3 D1 DTS provisions.

4.6.1 HVAC

In this case study, J1V3 and J1V5 are only used to determine the compliance of the building envelope. Therefore, the services which include air conditioning, heating and mechanical ventilation, heated water supply, artificial lighting, vertical transport and the like within the building are modelled as being the same for the proposed and the reference. The case study uses Deemed-to-Satisfy elemental values for the building services in both the proposed and the reference model.

For the SOUs, the reference building and the proposed building are modelled with benchmark appliances, that is, a 3-star ducted heat pump for heating and cooling under GEMS 2019.

For the non-residential part of the building an electric heat pump for heating and cooling is used. Sperate systems are used for the ground floor retail areas and office area. The system performance is DTS compliant.

The ventilation flow rate for the retail and office part of the building is calculated according to net floor area per person and quantities from AS 1668.2-2012 and is used for both the proposed and the reference buildings. The operation schedules for the ventilation systems for classes other than 2 SOU and 4 parts of buildings are provided in Specification 35.

The domestic hot water in the building is assumed to be supplied by electric heating per tenancy or SOU.

4.6.2 Auxiliary Energy

Deemed-to-Satisfy provisions are used in the case study. When assessing the energy performance of a Class 3, 5, 6, 7, 8 or 9 building, the building services for the proposed and the reference buildings must comply with the requirements in S34C4. Auxiliary energy which includes fans, pumps, control gear and other related equipment is modelled with standardised values for both the proposed and the reference buildings in the case study. Some projects, such as this case study, elect to use the DTS elemental provisions for J6 and J7 to remove the need to model the proposed building with proposed services.

4.6.3 Plant capacity

The building plant must meet the Minimum Energy Performance Standards for services. For the case study it is assumed that the building's heating and cooling is supplied through heat pumps that run on electricity. By auto sizing the thermal plant in the energy model the plant will always deliver enough heating and cooling to meet all the cooling and heating demands in the building. It is typical for plant capacity to be auto sized in energy modelling software during the early stages of a project. If the DTS elemental pathway is not being used for J6, a proposed model with proposed services must be modelled.

4.6.4 Centralised Services

Where centralised HVAC plant or domestic hot water services is used the energy needs to be apportioned between the residential and non-residential services. HVAC energy use will be apportioned differently depending on the system type, but generically they are apportioned based on the energy demand of the thermal zones. For example, if the Class 2 part of a building uses 80% of the domestic hot water volume, and the Class 5 part of a building uses 20%, the energy may be divided across the building classes by hot water use. Depending on the complexity of the centralised service system and use cases, it may be easier to calculate domestic hot water energy use outside the energy modelling software.

4.6.5 Ceiling fans

As J1V5 considers thermal energy, ceiling fans have no impact on the J1V5 calculations. Ceiling fans can be chosen to be installed but will not contribute to the compliance assessment.

When assessing compliance with the NatHERS methodology, ceiling fans can be modelled directly within the software tool to promote air movement and reduce cooling energy when coupled with operable windows. There are now new DTS elemental provisions that address ceiling fans use when this pathway is utilised.

4.6.6 Lighting

For Class 2 & 4 parts of buildings lighting power is simulated as 4 W/m^2 and serve all the internal spaces that are provided with artificial lighting. For Class 5 this is 4.5 W/m^2 and for Class 6 it is 14 W/m^2.

5.0 Summary of Results

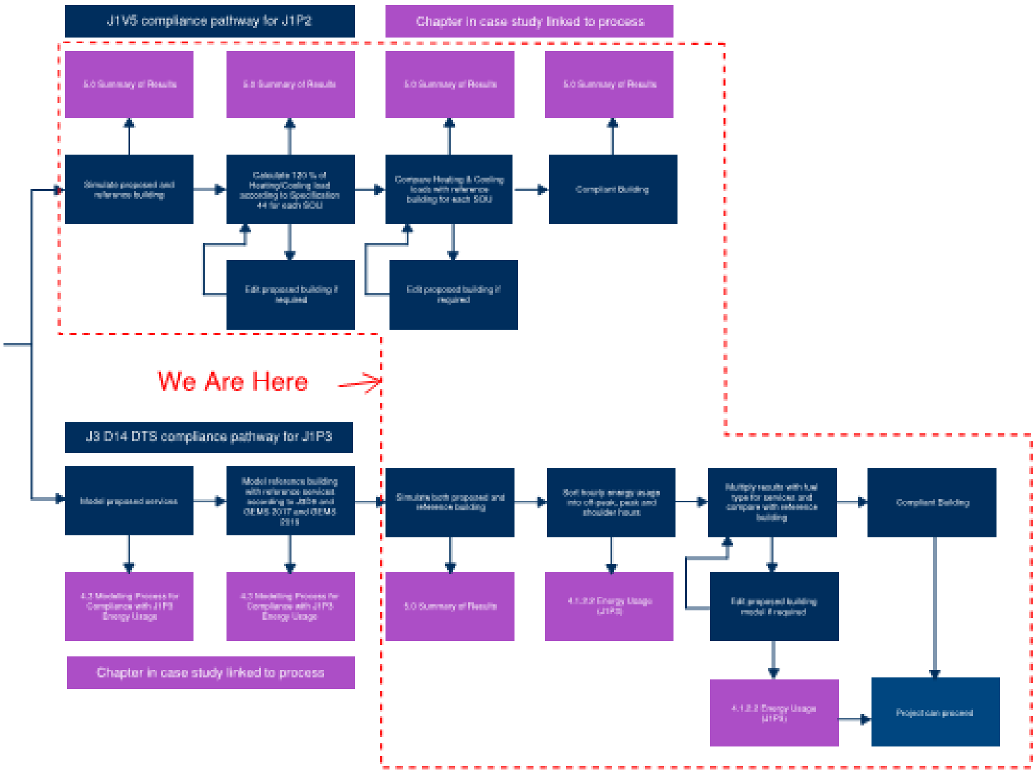

Figure 16: The red highlight indicates where we are in the overall process. This section summarises the results of both the J1P2 and J1P3 compliance processes

The results from the case study are summarised in Table 11 to Table 13. The results are presented separately to demonstrate compliance with Performance Requirements J1P1 and J1P2:

- the J1V3 assessment demonstrating compliance with J1P1 Class 2 common areas, Class 5 and Class 6 parts of the building.
- the J1V5 assessment demonstrating compliance with J1P2 for the SOUs.
- the net equivalent energy use DTS calculations demonstrating compliance with J1P3 for the SOUs.

In Table 12, 5 apartments fail to achieve the Cooling Load Limit despite using less energy than the reference building. As such these apartments will need to be redesigned with effective external shading, reduced WWRs, improved ventilation, improved SHGC or other design changes to reduce the cooling load such that it falls within the allowable limit.

Table 11 J1V3 assessment summary Class 5 & 6 incl. common areas in Class 2

J1V3 Part	Description	Result	Compliance
J1V3(a)(ii)	Annual Greenhouse Gas Emissions	9.6 % improvement on Reference Model	✓
J1V3(b)	Thermal Comfort	≥ 100% hours within PMV ±1 (≥ 95% of floor area)	✓

Table 12 J1V5 Assessment summary Class 2 SOU cooling loads

Unit no.	Area [m²]	Reference Cooling Load MJ/m².annum	Proposed Cooling Load MJ/m².annum	J1V5 120% CLL MJ/m².annum	Compliance Pass/Fail
3.01	58.1	87.6	50.8	56.8	Pass
3.02	72.2	53.2	38.0	56.3	Pass
3.03	54.1	64.5	54.5	56.8	Pass
3.04	78.7	73.0	58.1	53.7	Fail, exceeds CLL Redesign Required
3.05	81.4	80.0	55.1	56.1	Pass
15.01	70.4	79.5	45.7	56.8	Pass
15.02	126.2	99.7	47.6	48.7	Pass
15.03	87.8	70.0	51.5	55.0	Pass
15.04	92.4	63.7	56.0	53.4	Fail, exceeds CLL Redesign Required

Table 13 Whole of Home energy efficiency performance of SOUs according to Whole-of-Home pathway

Unit	Net equivalent energy usage (Allowance)	Net equivalent energy usage (Performance)	Compliance (Pass/Fail)
3.01	1.8	1.6	Pass
3.02	2.1	1.8	Pass
3.03	1.6	1.4	Pass
3.04	2.3	1.9	Pass
3.05	2.5	2.1	Pass
15.01	2.0	1.7	Pass
15.02	3.3	2.8	Pass
15.03	2.5	2.1	Pass
15.04	2.5	2.2	Pass

The results in Table 13 are calculated using the Whole-of-Home calculator released by ABCB.

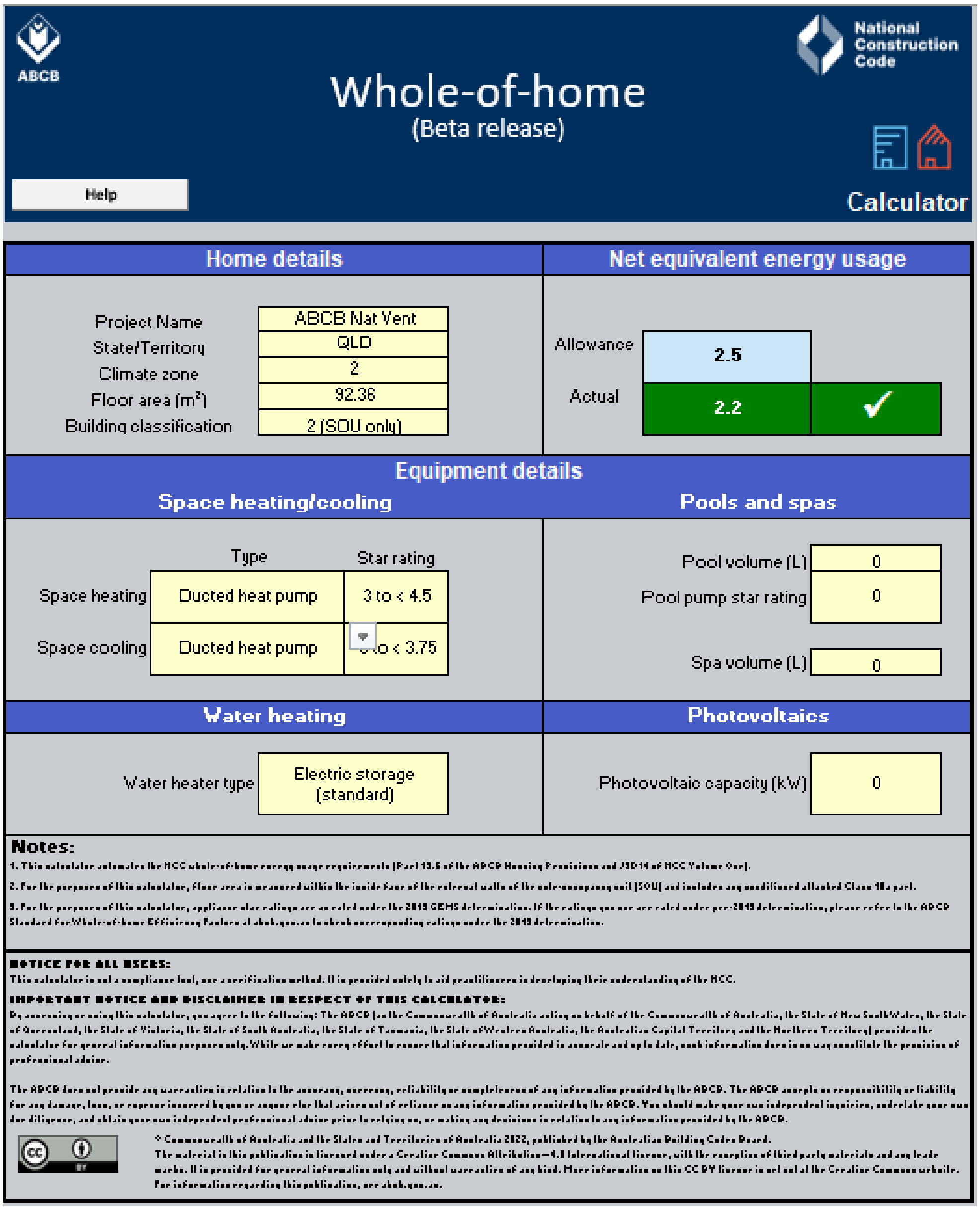

Figure 17 Example of Whole-of-Home calculator demonstrating the input and outputs

5.1 Conclusion

The results show that the non-residential part of the building is compliant with the energy efficiency requirements in the building code. Some of the residential units are not compliant on the thermal performance. Mitigating strategies that reduce the solar heat gain must be assessed to ensure compliance for the non-compliant units, this may include the incorporation of shading, reduction to the SHGC or a reduction in the WWR.

6.0 Building Certifier Guidance

This section aims to highlight the key aspects for building certifiers to review, when Section J compliance reports for a mixed-use development that includes Class 2 and other classes are submitted to building surveyor / certifier.

6.1 Compliance Pathway

Projects can use a combination of DTS Solution and Performance Solutions to comply with the building code. It is important in the assessment of a mixed-use building that the compliance pathway is clearly stated. A performance-based design brief (PBDB) that shows the chosen compliance pathway for each building class should be presented prior to the submission of a Performance Solution report.

Care must be taken that compliance pathways are not being inappropriately mixed in the same class, e.g. some SOUs demonstrate compliance via the elemental provisions, some SOU demonstrate compliance via NatHERS, and others via J1V5.

6.2 Climate Zones

The assessment of the heating and cooling loads is climate specific and is stipulated in Specification 45, Table S45C3a. Furthermore, for Climate Zones 1 & 2, only cooling load is assessed against the limit. For Climate Zones 3, 4 and 5 both heating and cooling loads are assessed, and for Climate Zone 6, 7, and 8 only heating load is assessed. A building certifier must check compliance is being assessed to the correct heating and cooling loads.

6.3 Reference Fabric

The reference building models for Verification Methods J1V3 and J1V5 use predetermined and climate specific data for the Climate Zone that the building is situated in. It is also advised that the building certifier to check that the report contains climate specific R-values for the building fabric for both the Verification Methods J1V3 and J1V5 when mixed-use buildings are reviewed. For the J1V3 pathway the fabric R-values for the reference building must correspond to the Deemed-to-Satisfy provisions in J4-J8 for the building Climate Zone. The fabric R-values for the reference building of the residential part of the building that is assessed according to the J1V5 pathway, must correspond to the values in J3D7, J3D9, J3D10 for the specific Climate Zone. The fabric R-values for the reference building should be stated in the compliance report.

6.4 Thermal Bridging

The building certifier to be satisfied that the inputs into the model include the effects of thermal bridging for relevant building fabric elements, most likely supported by a series of calculations that demonstrates this. Design documentation or details from the designer are to be presented that show design elements that are captured in the thermal bridging calculations.

6.5 Results Presentation

Given that J1V3 assesses greenhouse gas emissions and J1V5 assesses heating and cooling energy there needs to be a clear delineation in the presentation of results and the metrics the results are presented in. The external ventilation rates through natural ventilation should be stated in the report. Tall buildings with a high wind exposure should have higher air exchange rates than shorter and more sheltered buildings.

6.6 Reference Building

The reference building for Class 2 and 4 buildings and other building classes (Class 3, 5-9) have different methodologies and specifications for how they should be modelled. Reports should clearly show the delineations between the different building classes when presenting the reference building.

The building services must be presented for the J1V3 models as this can impact the thermal comfort of the assessed building. The building certifier must check to see that the services are not compensating for poor fabric and glazing design.

6.7 Zoning

Zoning is a critical assumption for both J1V3 and J1V5. There should be clear presentation in the reports about how zoning was undertaken. A tabular summary or mark-up is recommended to ensure that the zone is consistent with the relevant requirements under J1V5.

J1V5 modelling requires sub-zoning to each room of SOU, incorporating the right partitions and “holes” to each apartment. Typically, when undertaking J1V3 models there is significantly less detail with respect to the thermal zones compared to J1V5.

6.8 Glazing

Assumptions regarding performance of glazing need to be clearly stated in the report for the different parameters. Window operability assumption in a Class 2 building should be clearly stated and supported by window types and opening details on a glazing schedule or architectural elevation. The placement of the window in the façade also needs to be assessed when reviewing the operability of windows and door as this will affect the air flow calculations and the consequent heating and cooling loads calculated by the software.

The assessment of the reference building for both Class 1, 2, 4 and Class 3, 5-9 have fundamentally different calculations underpinning them. Clear presentation for how the reference glazing thermal performance is obtained for different classes is key to ensure that the assessment is not being inappropriately manipulated. This may be through use of the respective glazing calculator spreadsheets, or manual calculation in accordance with the equations provided in the NCC.

6.9 Building Height and Wind Exposure

Information about the building height of the proposed building and its surrounding buildings should be presented in the report. This is necessary information for assessing natural ventilation. If it is missing from the report, it could indicate that the pressure coefficients are not adjusted for the local conditions. An example of this can be found in Appendix A.

6.10 Natural Ventilation

The report should contain information about the average natural ventilation rates for each month of the year so that it is possible for the building certifier to assess if the calculated ventilation rates for the zones are reasonable. An example of how these results can be presented is shown in Appendix A. If the ventilation rates are very high or almost constant every month then the building certifier should ask for more information on how the natural ventilation has been modelled. Constant ventilation rates could be a sign that natural ventilation has been modelled as a schedule instead of dynamically modelling the natural ventilation based on wind pressure and coefficients. The window types and operability must be given in the report as well as information about the operability of the internal doors.

Appendix A

Building location, exposure, and height

Location	Level	Exposure (Exposed, Semi-exposed or sheltered)	Building height (H) in meters [m]	Average height of opening (h) on level (measured in meters [m] above the ground)
Brisbane	3	All SOU modelled as semi-exposed	49	12.9
Brisbane	15	All SOU modelled as semi-exposed	49	47.5

Room Electricity (kWh)	1162.42	1049.93	1236.90	1197.00	1236.90	1317.66	1361.58	1361.58	1197.00	1236.90	1197.00	1162.42
Lighting (kWh)	112.06	101.21	126.97	122.87	126.97	139.78	144.44	144.44	122.87	126.97	122.87	112.06
Heating (Electricity) (kWh)	0.00	0.00	0.26	9.38	68.43	238.68	396.48	271.66	48.28	28.55	0.60	0.03
Cooling (Electricity) (kWh)	778.99	672.04	261.48	111.27	6.70	0.58	0.06	1.61	5.61	91.36	297.01	455.67
DHW (Electricity) (kWh)	975.76	883.22	980.63	944.92	975.76	949.78	975.76	978.20	947.35	975.76	947.35	978.20
Air Temperature (°C)	25.87	25.78	24.58	23.28	21.52	20.14	19.69	20.33	21.29	22.70	24.30	25.13
Radiant Temperature (°C)	26.12	26.04	24.66	23.19	21.26	19.64	19.06	19.84	21.05	22.62	24.45	25.34
Operative Temperature (°C)	26.00	25.91	24.62	23.24	21.39	19.89	19.38	20.08	21.17	22.66	24.38	25.23
Outside Dry-Bulb Temperature (°C)	24.81	24.81	23.03	20.78	18.25	15.49	14.29	15.38	17.78	19.95	22.20	23.64
Internal Natural vent. (kWh)	-14.56	-19.17	-49.30	-17.50	-12.96	-6.42	-3.56	-9.72	-10.13	-23.04	-32.14	-23.82
External Vent. (kWh)	-833.40	-873.49	-1562.27	-1320.03	-1109.90	-778.16	-676.43	-888.32	-1141.53	-1533.23	-1719.95	-1432.22
General Lighting (kWh)	111.38	100.60	126.20	122.13	126.20	138.94	143.57	143.57	122.13	126.20	122.13	111.38
Catering (kWh)	284.00	256.52	326.22	315.70	326.22	356.55	368.43	368.43	315.70	326.22	315.70	284.00
Computer + Equip (kWh)	878.42	793.41	910.68	881.31	910.68	961.11	993.15	993.15	881.31	910.68	881.31	878.42
Occupancy (kWh)	343.38	314.15	378.72	396.93	454.99	471.94	495.65	482.49	447.17	425.76	373.34	364.42
Solar Gains Exterior Windows (kWh)	1142.60	939.97	948.72	897.30	968.09	1038.70	1123.33	1107.20	1025.79	1133.67	1212.01	1225.98
Zone Sensible Heating (kWh)	1.22	0.91	0.85	28.54	209.31	730.97	1215.76	832.31	147.05	87.51	2.04	0.41
Zone Sensible Cooling (kWh)	-1919.85	-1678.78	-612.20	-258.78	-13.65	-1.20	-0.16	-2.79	-9.98	-221.80	-726.57	-1135.26
Sensible Cooling (kWh)	-1933.59	-1689.33	-615.78	-260.21	-13.77	-1.20	-0.16	-2.85	-10.15	-223.72	-731.48	-1142.12
Total Cooling (kWh)	-2414.87	-2083.31	-810.60	-344.94	-20.77	-1.79	-0.20	-5.01	-17.38	-283.22	-920.73	-1412.58
Zone Heating (kWh)	0.00	0.00	0.81	29.07	212.12	739.90	1229.08	842.14	149.66	88.49	1.86	0.11
Mech Vent + Nat Vent + Infiltration (ac/h)	2.55	2.79	5.28	3.54	3.06	2.07	1.39	2.34	3.54	4.01	4.75	4.92

Figure 18: Results summary table with Natural ventilation and infiltration rates marked in green