ABCB

National Construction Code

Case Study

Hotel Façade

Energy efficiency

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Case study: Hotel façade energy efficiency

General information

Topic	Building façade energy efficiency
Compliance Solution	Deemed-to-Satisfy (DTS) and Performance (JV3) NCC 2019, Volume One, Section J
Performance Requirement	JP1 (part of)
Climate zone	5
Building classification	Class 3

Contents

REMINDER

This case study is not mandatory or regulatory in nature and compliance with it will not necessarily discharge a user's legal obligations. The case study should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The case study also needs to be read in conjunction with the relevant legislation of the appropriate State or Territory. It is written in generic terms and it is not intended that the content of the case study counteract or conflict with the legislative requirements, any references in legal documents, any other documents issued by the Administration or any directives by the Appropriate Authority.

Introduction

This case study describes two different compliance pathways for the façade of a Class 3 hotel building with substantial glazing. The compliance pathways use either a DTS Solution (six different scenarios) or a Performance Solution using the Verification Method, JV3 Verification using a reference building.

The energy efficiency requirements for a building façade form part of the broader energy efficiency requirements of the National Construction Code (NCC). The NCC DTS building façade provisions for a Class 3 hotel are in Part J1 of NCC Volume One. The Verification Method JV3 is also in Section J of NCC Volume One. Both compliance pathways can be used to satisfy relevant parts of the Performance Requirement, JP1.

In this case study, there are references to the NCC. As the DTS building envelope provisions for energy efficiency are in NCC Volume One Part J1, they are in the form of J1.x. JV3 references commonly have JV as a prefix. To read these references, refer to the NCC, available from the ABCB website (ncc.abcb.gov.au).

This case study targets practitioners with a basic understanding of the NCC energy efficiency provisions and an overall understanding of the performance-based NCC.

Purpose and limitations

This case study aims to demonstrate the practical application of the NCC energy efficiency requirements when designing a Class 3 hotel with substantial glazing, located in the eastern Sydney metropolitan region within climate zone 5.

The guidance in this case study is limited to the wall and glazing requirements of J1.5 and the development of compliant building solutions using either the DTS Provisions or the Verification Method JV3. The DTS Provisions of J1.5 have several variables that must be considered when seeking a compliant design, including the:

- percentage of the wall that is glazed;
- Total R-Value of wall component;
- glazing component Total System U-Value and Solar Heat Gain Coefficient (SHGC); and
- shading applied to the glazing.

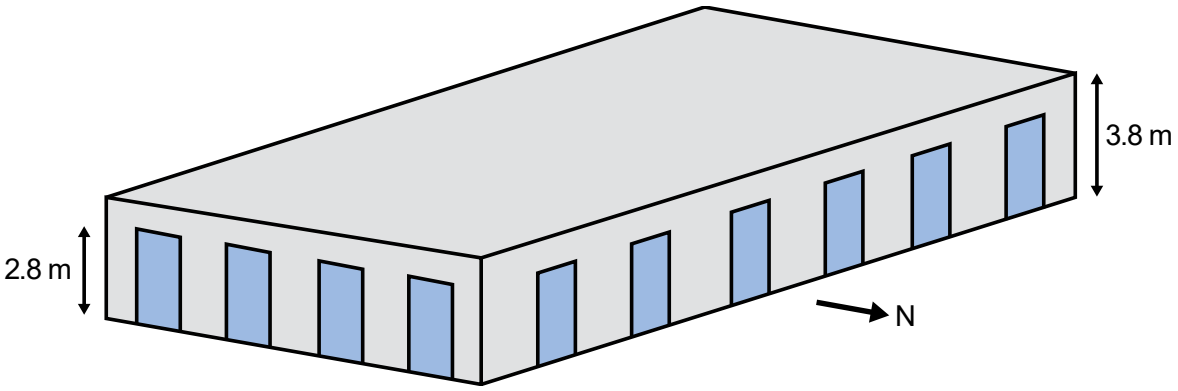
Users of the case study are encouraged to check for any relevant State and Territory NCC variations and additions that may apply in their jurisdiction. Furthermore, users should be aware of any applicable legalisation within their jurisdiction that may have a bearing on the content of this case study.

The Design

A representative floor design for the hotel was created to assess potential designs compliant with J1.5 and JV3. The building is in the eastern Sydney urban area, which is located in climate zone 5. Additional details for this climate zone are provided in the next section.

A typical floor (Figure 1) is being examined in this case study; with the outcomes of the floor applied to the whole of the building. The floor's slab-to-slab height is 3.8 m and the glazing heights are assumed to be 2.8 m with no sill height. The glazing consists of a façade wall system with a wall-glazing construction of less than 80%.

Figure 1 Diagram of typical floor



Six different scenarios for DTS Solutions are presented for determining different wall-glazing options based on:

1. wall only R-value
2. percentage glazing allowance
3. fixed glazing (Total System U-Value)
4. fixed glazing (Total System SHGC)
5. fixed glazing area
6. horizontal shading.

An approach using the Verification Method JV3 is also provided.

The Solution

This case study will examine two methods of how the building façade of a hotel can demonstrate compliance with the relevant provisions of NCC 2019 through:

1. the DTS Provisions of Part J1; and
2. the Verification Method JV3.

NCC climate zone

The DTS Provisions and some Verification Methods use 'climate zones' to delineate the technical requirements for energy efficiency in particular locations. The climate zones group together parts of Australia with broadly similar climatic conditions. The first step in developing a solution is to determine the applicable NCC climate zone.

Alert

'Climate zone' is a defined term in the NCC. An explanation of this term is contained within Schedule 3 Definitions of Volume One. There is also a map of Australia showing the extent of each zone and an accompanying table detailing the climate zone for common locations. For locations that are more difficult to determine, a suite of State and Territory climate zone maps may also be viewed on the ABCB website (abcb.gov.au).

As the hotel is located in the eastern Sydney metropolitan area, the building falls within climate zone 5 (warm temperate). The main characteristics of this climate zone are:

- warm temperate;
- low diurnal temperature range near the coast to high diurnal range inland; and
- four distinct seasons (summer and winter can exceed human comfort range, spring and autumn are ideal for human comfort, mild winters with low humidity, hot to very hot summers with moderate humidity).

DTS Approach

The ABCB Facade Calculator (available from the ABCB website (abcb.gov.au)) was used to assess potential compliance options for the wall and glazing construction for J1.5. The tool calculates and compares the average Wall R-Value, Wall-Glazing U-Value and solar admittance for the façades in accordance with Specification J1.5a; and shows compliance with J1.5(c) and J1.5(f).

Scenario 1 Wall-only R-Value

The glazing of the hotel consists of a façade wall system with a wall-glazing construction of less than 80%. As the wall is less than 80%, J1.5(d) requires the wall component to achieve a minimum Total R-Value, accounting for thermal bridging, of R1.0.

In this part of the case study, we investigate the effect of increasing the R-Value above the R1.0 minimum to determine what this means for the level of thermal performance the glazing must achieve and the amount of glazed area that will be possible. We will model the wall at three points: R1.0, R1.5 and R2.0 (accounting for thermal bridging).

Alert

AS/NZS 4859.2 is the design standard for thermal insulation materials for buildings. The standard provides prescriptive system Total R-Value calculations. The standard uses a calculation method (NZS 4214) that takes into account the impact of thermal bridging on the thermal performances of a façade. Depending on the extent of thermal bridging within a façade, extra insulation may need to be added, or thermal breaks installed in order for a façade to be compliant.

J1.5(a) Walls and glazing - Total System U-Value

J1.5(a)

(a) The *Total System U-Value* of *wall-glazing construction* must not be greater than—

(i) for a Class 2 common area, a Class 5, 6, 7, 8 or 9b building or a Class 9a building other than a *ward area*, U2.0; and

(ii) for a Class 3 or 9c building or a Class 9a *ward area*—

(A) in *climate zones* 1, 3, 4, 6 or 7, U1.1; or

(B) in *climate zones* 2 or 5, U2.0; or

(C) in *climate zone* 8, U0.9.

The required maximum Total System U-Value of the wall-glazing construction in the hotel (i.e. Class 3 and climate zone 5) is U2.0.

J1.5(d) Walls and glazing - Total R-Value

J1.5(d)

(d) Wall components of a *wall-glazing construction* must achieve a minimum *Total R-Value* of—

(i) where the wall is less than 80% of the area of the *wall-glazing construction*, R1.0; or

(ii) where the wall is 80% or more of the area of the *wall-glazing construction*, the value specified in Table J1.5a.

Table J1.5a Minimum wall Total R-Value – Wall area 80% or more of the wall-glazing construction area

Climate zone	Class 2 common area, Class 5, 6, 7, 8 or 9b building or a Class 9a building other than a ward area	Class 3 or 9c building or a Class 9a ward area
1	2.4	3.3
2	1.4	1.4
3	1.4	3.3
4	1.4	2.8
5	1.4	1.4
6	1.4	2.8
7	1.4	2.8
8	1.4	3.8

If the wall component of the hotel was at least 80% of the wall-glazing construction, the minimum Total R-Value for the wall components of the hotel (i.e. Class 3 building in climate zone 5) would be 1.4.

Scenario 2 Percentage glazing allowance

This section investigates the effect of varying the different glazing thermal performance properties on the amount of glazing possible per façade total area. The two glazing performance variables that will be investigated are the Total System U-Value and the Total System SHGC.

It is assumed that no shading is provided to the glazing and, therefore, the requirement for solar admittance and wall-glazing construction Total System U-Value are the same for all façade orientations.

Below is a NCC extract showing Table J1.5c Maximum wall-glazing construction solar admittance requirements for a Class 3 or 9c building, or a Class 9a ward area. As this case study is a hotel (Class 3 building) in climate zone 5, the required maximum solar admittance of the wall-glazing construction is 0.10 for all facades.

Table J1.5c

Table J1.5c Maximum wall-glazing construction solar admittance – Class 3 or 9b building or Class 9a ward area

Climate zone	Eastern aspect solar admittance	Northern aspect solar admittance	Southern aspect solar admittance	Western aspect solar admittance
1	0.07	0.07	0.10	0.07
2	0.10	0.10	0.10	0.10
3	0.07	0.07	0.07	0.07
4	0.07	0.07	0.07	0.07
5	0.10	0.10	0.10	0.10
6	0.07	0.07	0.07	0.07
7	0.07	0.07	0.08	0.07
8	0.08	0.08	0.08	0.08

Scenario 3 Fixed Glazing Total System U-Value

For this section to test the impact of changing Total System U-Value of a window on the amount of glazed area possible, three glazing types were created in the “Glazing Systems” portion of the Facade Calculator.

- Total System U-Value of 3.5 W/m^2.K and Total System SHGC of 0.35
- Total System U-Value of 3.5 W/m^2.K and Total System SHGC of 0.30
- Total System U-Value of 3.5 W/m^2.K and Total System SHGC of 0.25

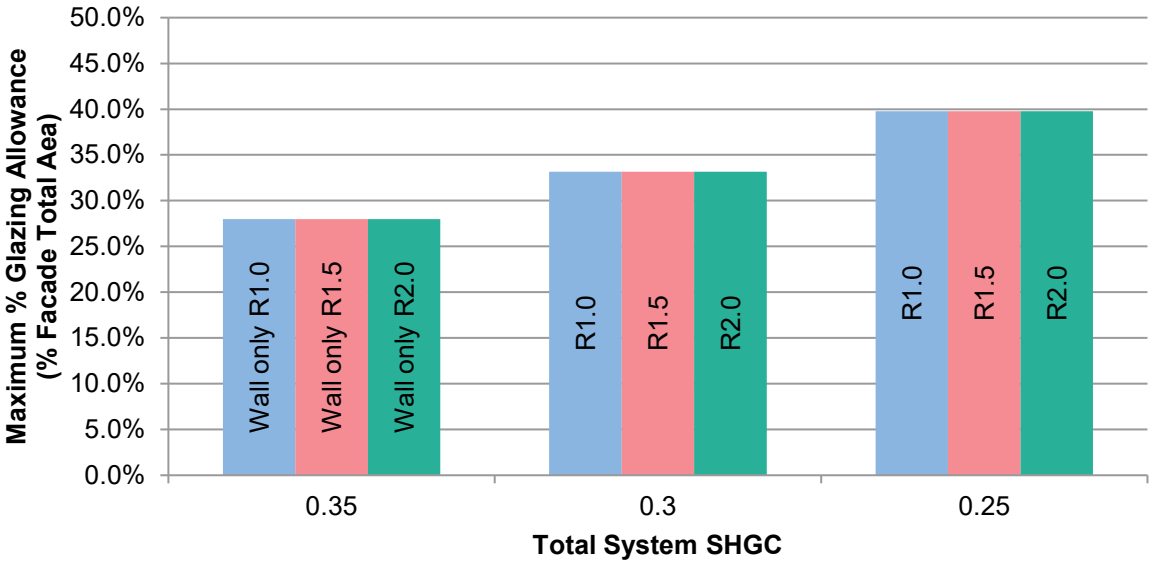
The Total System U-Value was set as fixed, as the only variables tested in this part of the case study are the glazing Total System SHGC and wall-only R-Value (tested at R1.0, R1.5 and R2.0). The glazing area for each orientation in the “Wall-glazing Area + Results” was adjusted to ensure that the wall-glazing U-Value, solar admittance and Average Wall R-Value show compliant solutions (highlighted green in the Façade Calculator).

Reminder:

Total System SHGC and Total System U-Value are required to be calculated for the glazing including its supporting frame as opposed to centre of panel values.

The NCC also requires a whole-of-façade Total System U-Value. In this case, this refers to both the wall and glazing components in a wall-glazing construction.

Figure 2 Maximum percentage glazing allowance for different glazing SHGC (constant glazing Total System U-Value = 3.5 W/m^2.K)



The conclusions drawn are:

- For a glazing with a Total System SHGC of 0.35, the maximum allowed glazed area is 28% of the total façade area (equivalent to 38% of the floor-to-ceiling façade area), regardless of wall-only R-Value. The reason for this is the wall-glazing construction is limited by the maximum solar admittance of 0.1, which is only dependent on the glazing Total System SHGC. This is congruent with the equation for solar admittance – Method 1 under Specification J1.5a.
- Reducing the glazing Total System SHGC to 0.3, the maximum allowed glazed area is increased to 33.2% of the total façade area (equivalent to 45% of the floor-to-ceiling façade area), regardless of wall-only R-Value. As above, the wall-glazing construction is limited by the maximum solar admittance.
- Reducing the glazing Total System SHGC to 0.25, the maximum allowed glazed area is increased to 39.8% of the total façade area (equivalent to 54% of the floor-to-ceiling façade area), regardless of wall-only R-Value. As above, the wall-glazing construction is limited by the maximum solar admittance.

Scenario 4 Fixed Glazing Total System SHGC

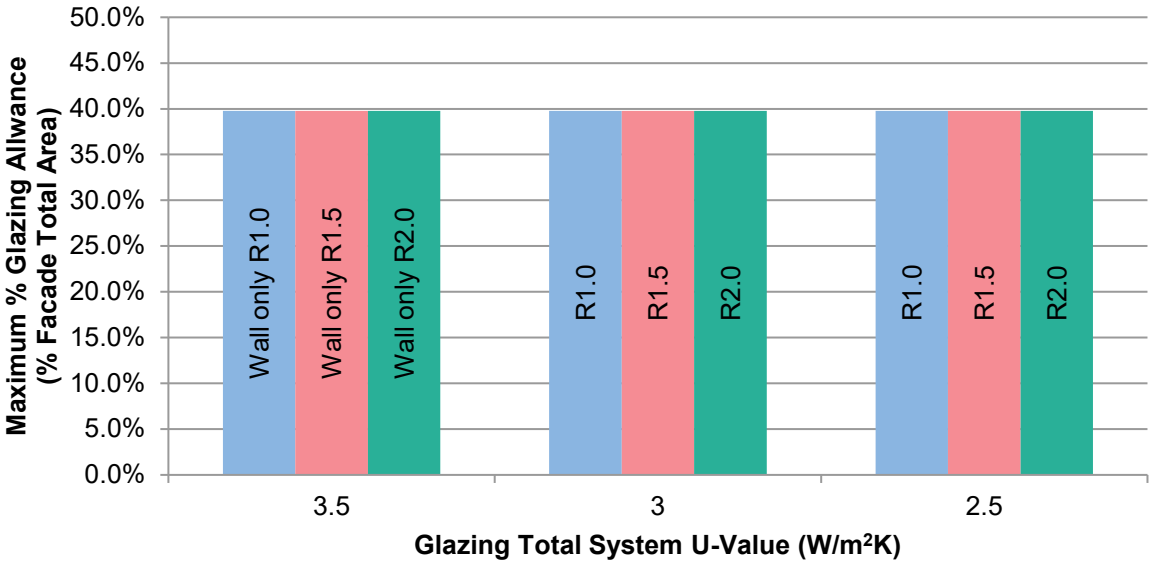
For this section, which tests the impact of changing the Total System SHGC of a window on the amount of glazed area possible, three glazing types were created in the “Glazing Systems” portion of the Façade Calculator.

- Total System U-Value of 3.5 W/m^2.K and Total System SHGC of 0.25
- Total System U-Value of 3.0 W/m^2.K and Total System SHGC of 0.25
- Total System U-Value of 2.5 W/m^2.K and Total System SHGC of 0.25

The Total System SHGC was set as fixed as the only variables tested in this part of the case study are the glazing Total System U-Value and wall-only R-Value (tested at R1.0, R1.5 and R2.0). The glazed area for each orientation in the "wall-glazing Area + Results" were adjusted to ensure that the wall-glazing U-Value, solar admittance and average Wall R-Value show compliant solutions (highlighted green in the calculator).

Figure 3 shows the maximum percentage glazing allowance per façade total area for a fixed glazing Total System SHGC of 0.25 and varying glazing Total System U-Values and wall-only R-Values. Because compliance is limited by the maximum solar admittance, regardless of R-Value, the maximum amount of glazing in the facades is 39.8% of the total façade area (equivalent to 54% of the floor-to-ceiling façade area).

Figure 3 Maximum percentage glazing allowance for different glazing U-Values (constant Total System SHGC=0.25)



Scenario 5 Fixed glazing area

This section assesses the glazing properties required to achieve a specific percentage of glazing area. The glazing properties are limited by the allowances of

minimum allowable values in the “Wall-glazing Area + Results” sheet of the Facade Calculator.

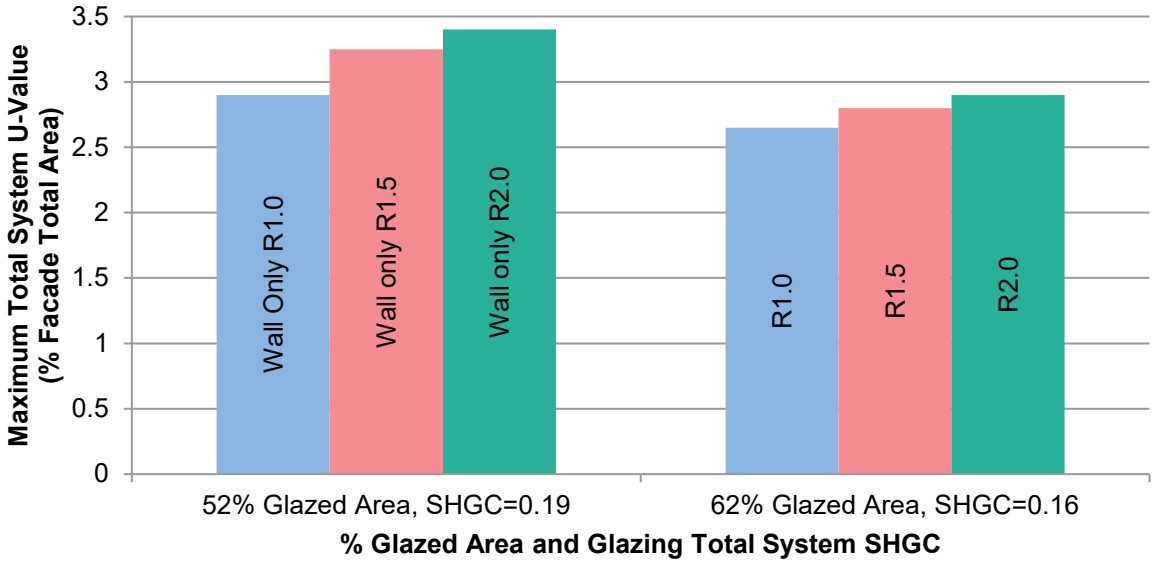
Two glazing areas were selected to be assessed:

- 51.6% of the total façade area (equivalent to 70% of the floor-to-ceiling façade area)
- 61.9% of the total façade area (equivalent to 84% of the floor-to-ceiling façade area)

For both of these glazed areas, the glazing is limited by the minimum Total System SHGC specified in the glazing properties to achieve the maximum solar admittance allowance. The glazing Total System U-Value can vary, based on the wall-only R-Value.

The maximum glazing SHGC allowed for the 51.6% and 61.9% glazed areas are 0.19 and 0.16, respectively. Figure 4 shows the maximum allowable U-Values that must be achieved to meet the targeted glazing areas based on the wall-only R-Values. Increasing the R-Values of the wall beyond the minimum requirement allows for poorer performing glazing systems (Total System U-Value), but the SHGC cannot be changed.

Figure 4 Maximum glazing U-Value Allowance for a fixed glazed area



Scenario 6 Horizontal shading

This part of the case study investigates the potential percentage glazed area that can be achieved by providing horizontal shading. Projections of both 0.5 m and 1.0 m situated directly on top of the glazing were tested. Generally, the shading reduces the wall-glazing solar admittance for all façade orientations. The solar admittance is reduced to a lesser degree for the south façade. The glazing is assumed to meet the minimum allowable values of the Façade Calculator, with a Total System U-Value of 1.8 and minimum Total System SHGC of 0.16.

Adding 0.5 m horizontal shading allows the percentage of glazing to be increased from 61.9% to 73.7% of the total façade area on the north, east and west facades as shown in Figure 5. For the south, this is increased from 61.9% to 70.0% of the total façade area, depending on the wall-only insulation as shown in Figure 6.

Adding 1.0 m horizontal shading increases the percentage of glazing allowance further to 92.1% of the total façade area for the north, east and west facades and 77.4% of the total façade area for the south façade.

Figure 5 Maximum percentage of glazing allowed on north, east and west facades for various horizontal shading projections (Total System U-Value=1.8, SHGC=0.16)

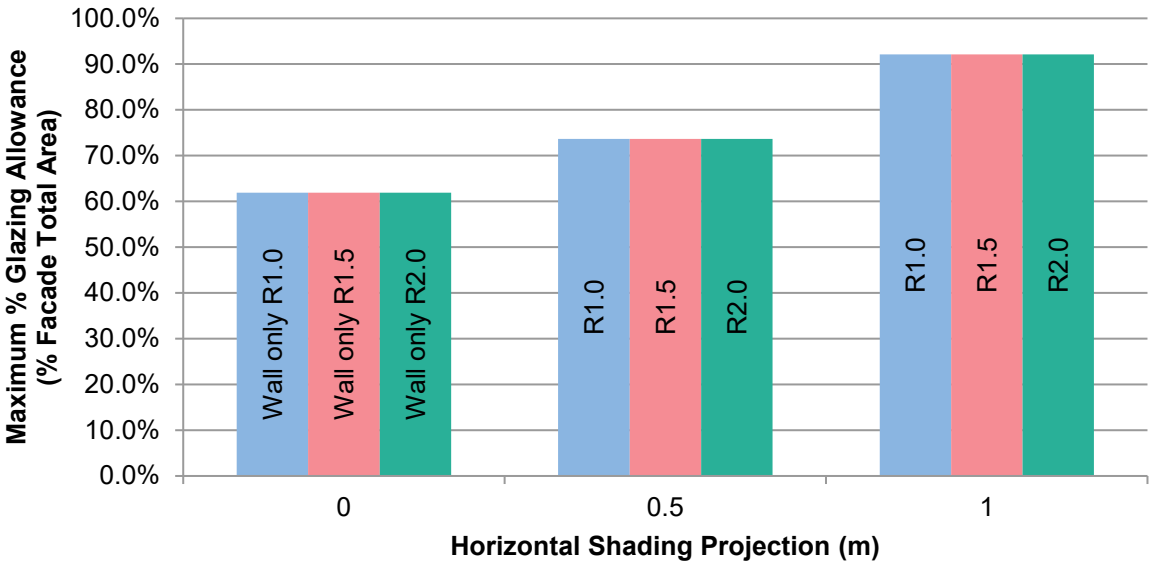
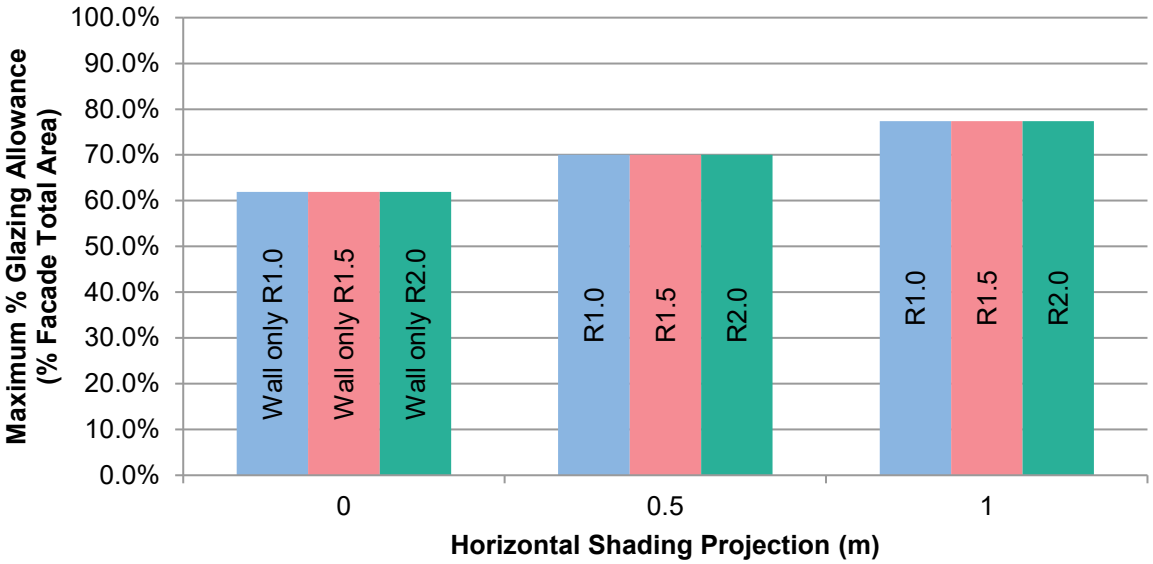


Figure 6 Maximum percentage of glazing allowed on south facades for various horizontal shading projections (Total System U-Value=1.8, SHGC=0.16)



Verification Method Approach

JV3 is a compliance pathway that may be used as an alternative to the DTS Provisions in Section J. It is commonly used if it is advantageous to the building design or cost of the compliance process. JV3 includes a prescribed calculation methodology set out in Specification JVb and modelling profiles for different building profiles set out in Specification JVc. There are also a number of additional DTS Provisions set out in Specification JVa that must be separately complied with.

Using JV3, the designer calculates the total annual GHG emissions that would result if their building was built exactly to the DTS Provisions of Section J. It is then compare to the building as they propose it to be built. If the proposed building overall produces less GHG emissions than the reference building, it is deemed to comply even if individual elements do not comply. More information about JV3 is available in the NCC Volume One Handbook for Energy Efficiency from the ABCB website (abcb.gov.au).

For this part of the case study, a scenario is proposed where the proposed glazing extent is similar to Figure 4 (from the DTS Scenario 5) with a glazed area of 62% of the total façade area. However, the proposed case study building has a non-compliant glazing Total System SHGC with an SHGC of 0.18. To compensate for this, the glazing Total System U-Value is reduced to 2.2 W/m^2.K. Under the DTS

approach, this facade would be deemed non-complaint, therefore JV3 is being used to determine if compliance can be achieved by an alternate pathway. The façade performance of the reference building and the proposed building are summarised in Table 1and Table 2.

The hotel is assumed to have individual Fan Coil Units (FCUs) that are supplied with chilled water and heating hot water from a central natural gas boiler with efficiencies summarised in Table 3 and Table 4.

Table 1 Reference building and proposed building wall performance

Parameter	Reference building	Proposed building
R-Value (m^2.K/W)	1.0	1.0

Table 2 Reference and proposed building glazing performance

Parameter	Reference building	Proposed building
Total System U-Value (W/m^2.K)	2.65	2.2
Total System SHGC	0.16	0.18
Glazed area percentage	62%	62%

Table 3 Reference and proposed building heating performance

Parameter	Reference building	Proposed building
System type	Natural gas boiler	Natural gas boiler
Efficiency	86%	86%

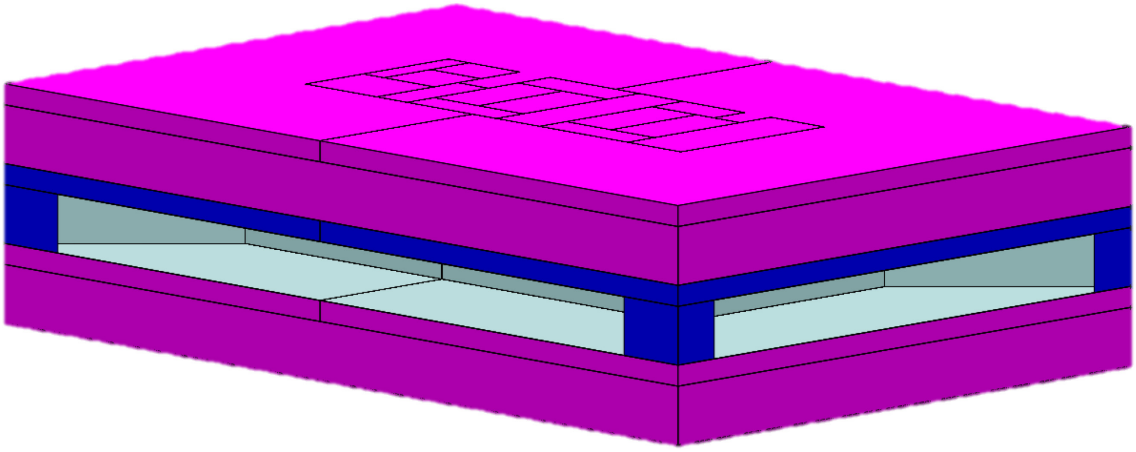
Table 4 Reference and proposed building cooling performance

Parameter	Reference building	Proposed building
System type	Air cooled (<528 kW)	Air cooled (<528 kW)
Energy Efficiency Ratio	4.05	4.05

A representative 3-dimensional model was created using Integrated Environmental Software: Virtual Environment (IES:VE) 2017. The building was created with 3.8 m floor heights with 2.8 m high glazing (Figure 7). The glazing comprises 62% of the total façade area (equivalent to 84% of the floor-to-ceiling façade) without shading. The upper and lower bounding floors were set to adiabatic boundaries to simulate only heat gains and losses through the external walls in line with J1.5.

As per JV3, the proposed building model and reference building model were created based on the modelling methodology described in Specification JVb and JVc. Compliance is demonstrated if the proposed model has lower GHG emissions compared to the reference building model based on the GHG emissions factor of 256 kg CO_2-e/GJ for electricity and 51.53 CO_2-e/GJ for natural gas in New South Wales.

Figure 7 3D model of the Class 3 hotel typical floor



The results of the JV3 modelling are summarised in Table 5. In climate zone 5, the dominant annual energy use and GHG emissions come from cooling, and therefore the benefit of having a low Total System SHGC for the glazing has a significant impact on the energy performance of the hotel façade, especially due to the extent of glazing modelled. Because the glazing Total System U-Value was reduced as a compromise, the heating energy and GHG emissions have been reduced enough to offset the increase in energy and GHG emissions from cooling. This means that the case study model complies using JV3.

Table 5 Reference and proposed building model façade performance

Source	Reference building model	Proposed building model	Reduction
Heating energy (GJ)	77.124	63.423	17.8%
Heating GHG emissions (kg CO_2-e)	3,974	3,268	17.8%
Cooling energy (GJ)	45.858	49.479	-7.9%
Cooling GHG emissions (kg CO_2-e)	11,742	12,667	-7.9%
Total energy (GJ)	122.992	112.902	8.2%
Total GHG emissions (kg CO_2-e)	31,486	28,903	8.2%

Summary

This case study provides a detailed understanding of different approaches to applying the NCC DTS Provisions and JV3 Verification Method for energy efficiency in Volume One of the NCC. It shows how to determine different glazing and wall combinations in designing the façade of a Class 3 hotel building constructed in climate zone 5. Below is a summary of the results.

DTS Approach

- The wall-only R-Value must be at least R1.0. Increasing this will help compliance with the wall-glazing system Total System U-Value, but not with the solar admittance.
- Based on the Façade Calculator, it is possible for the glazed area to reach a maximum of 43.5% of the total façade area within the limits set for the glazing properties (minimum Total System U-Value of 1.8 and minimum Total System SHGC of 0.16).
- For typical double-glazing with aluminium frames and low-tint, the percentage of glazing allowed varies from 28.0% to 39.8% of the total façade area (equivalent to 38.0% to 54.0% of the floor-to-ceiling façade area).
- With a Total System U-Value = 1.8 W/m^2.K and Total System SHGC = 0.16, it is possible to have glazing up to 61.9% of the total façade area (equivalent to 84.0% of the floor-to-ceiling façade area).
- By providing a 0.5 m horizontal shading projection, it is possible to increase the total glazing allowance for the north, east and west facades to 73.7% of the total façade area, and to 70.0% of the total façade area for the south (equivalent to 100.0% and 95.0%, respectively, of the floor-to-ceiling façade area) using a glazing system with a Total System U-Value = 1.8 W/m^2.K and Total System SHGC = 0.16.
- It is possible to increase the total glazing allowance for the north, east and west facades to 92.1% (equivalent to 125.0% of the floor-to-ceiling façade area) of the total façade area by providing a 1.0 m horizontal shading projection and using a glazing system with a Total System U-Value = 1.8 W/m^2.K and Total System SHGC = 0.16.
- Using a 1.0 m horizontal shading and a glazing system with a Total System U-Value = 1.8 W/m^2.K and Total System SHGC = 0.16 will allow the glazed area to be increased to 77.4% of the total façade area (equivalent to 105.0% of the floor-to-ceiling façade area).

Verification Method Approach

- JV3 can be used for building designs that either do not meet all of the DTS Provisions, or that provide other benefits.