BRE
Bucknalls Lane
Watford, Herts
WD25 9XX

+44 (0)333 321 8811

enquiries@bregroup.com
bregroup.com

CLIENT REPORT

# Thermal modelling of CSG secondary glazing solution

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# Prepared by:


| | |
|---|---|
| Name | Dr Caroline Weeks |
| Position | Principal Consultant |
| Date | 11 December 2025 |
| Signature |  |


# Authorised by:


| | |
|---|---|
| Name | Colin Sinclair |
| Position | Associate Director |
| Date | 11 December 2025 |
| Signature |  |

# 1. Introduction and description of work

BRE was commissioned by Conservation Secondary Glazing Ltd (CSG) to estimate the U-value improvement of an example single glazed timber frame window when retrofitted with the CSG secondary glazing system.

Overall, the total heat loss from a window is determined by taking into consideration the following:

- The U-value for the window frame. This is a measure of the quantity of heat that will flow through a unit area of the frame, per unit temperature difference between the internal and external environment. It is expressed in W/m²K.
- The U-value for the centre of the glazing. This is a measure of the quantity of heat that will flow through a unit area of the glass, per unit temperature difference between the internal and external environment (W/m²K.)
- The linear thermal bridge ψ-values for the connecting junctions between the frame and glazing, i.e. at the window head, sill, mullion and jambs. This is a measure of additional heat losses at connections where geometric or constructional effects change the thermal behaviour. Values are multiplied by the length over which they apply and are expressed in W/mK.

The analysis derived a U-value for a single glazed timber frame sash window of 1.2m wide x 1.8m high, which is typical of the size presented by CSG customers. The U-value of the window with the CSG secondary glazing system applied was then assessed to determine the relative improvement (ΔU).

## 1.1 Assessment standards

The assessment was undertaken in compliance with:

- BS EN ISO 10077-1:2017 - Thermal performance of windows, doors and shutters - Calculation of thermal transmittance. Part 1: General. BSI, 2017
- BS EN ISO 10077-2:2017 - Thermal performance of windows, doors and shutters - Calculation of thermal transmittance. Part 2: Numerical method for frames. BSI, 2017
- BS EN 673:2011 – Glass in building – Determination of thermal transmittance (U-value) – Calculation method. BSI, 2011
- BS EN ISO 10211:2017 – Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations. BSI, 2017
- BS EN ISO 10456:2007 – Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values. BSI, 2007
- BR 497 – Conventions for calculating linear thermal transmittance and temperature factors. BRE, 2016

## 1.2 Software

Modelling was undertaken using Physibel's TRISCO thermal modelling software. TRISCO has been validated against the detailed test reference cases contained within Annex A of BS EN ISO 10211.

## 1.3 Construction and geometry

'Base' window assumptions: For the timber frame window, a basic 'block' timber frame was assumed, 45mm wide (visible profile) and 45mm deep, with a 3mm single glass pane.

'CSG' secondary glazing assumptions: Dimensions were taken from CAD drawings provided by the client. Arrangements were as per the drawings in Appendix A with a 4mm glass pane in the secondary glazing.

## 1.4 Temperatures and surface resistances used in models

Internal temperature = 20ºC
External temperature = 0ºC

The surface resistances used for thermal models were as follows:

| | |
|---|---|
| Internal, horizontal heat flow | = 0.13 $m^2K/W$ |
| Internal, downward heat flow | = 0.17 $m^2K/W$ |
| Internal, upward heat flow | = 0.10 $m^2K/W$ |
| External heat flow, exposed areas | = 0.04 $m^2K/W$ |

## 1.5 Thermal conductivities

The representative thermal conductivities used in the models were taken from BS EN ISO 10456:2007 based on materials advised by the client. All air gaps within the construction were calculated according to BS EN ISO 6946.

Table 1: Representative thermal conductivities

| **Material** | **Thermal conductivity** (W/mK) |
|---|---|
| Aluminium | 160.0 |
| Glass | 1.00 |
| Timber | 0.13 |
| Silicone | 0.35 |
| Nylon seal | 0.25 |

# 2. Results

## 2.1 Parameters of the single glazed window without secondary glazing

Separate frame U-value and connection ψ-values have been determined for the windows according to the procedure in BS EN 10077-2, with results given in Table 2.

The U-value of the centre pane of glass is calculated using the BRE U-value calculator, according to the procedure in BS EN 673.

Table 2: U-values and ψ-values for the reference single glazed timber frame window example

| Timber frame section | Glass centre-pane U-value, Ug, W/m²K | Timber frame U-value, Uf, W/m²K | Timber frame-glazing connection ψ-value, ψf, W/m²K |
|---|---|---|---|
| Head | 5.780 | 1.83 | -0.011 |
| Sill | | 1.67 | -0.012 |
| Jamb1 (upper) | | 1.82 | -0.012 |
| Jamb2 (lower) | | 1.67 | -0.012 |
| Mullion | | 2.63 | -0.022 |

## 2.2 Parameters of the single glazed window including CSG secondary glazing

U-values and ψ-values for the example window with the CSG secondary glazing system are given in Table 3.

Table 3: U-values and ψ-values for the reference window with the CSG secondary glazing system

| Timber frame section | Glass centre-pane U-value, Ug, W/m²K | Timber frame U-value, Uf, W/m²K | Timber frame-glazing connection ψ-value, ψf, W/m²K |
|---|---|---|---|
| Head | 2.870 (upper)<br>2.826 (lower) | 0.78 | 0.085 |
| Sill | | 1.47 | 0.006 |
| Jamb1 (upper) | | 0.78 | 0.074 |
| Jamb2 (lower) | | 1.47 | 0.006 |
| Mullion | | 1.60 | 0.002 |

## 2.3 Window U-values with and without the CSG secondary glazing

Table 4 gives the calculated overall window U-values for the example window of 1.2m wide x 1.8m high, with and without the CSG secondary glazing system. The modelling suggests that the inclusion of the CSG system, on this size of window, improves the U-value by approximately 47% compared to the baseline single glazed window. It should however be noted that the U-value improvement will vary by window size as U-values of windows depend on their size and configuration. As a result, calculations will need to be re-run using the approach outlined in section 2.4 below to reflect different window sizes.

For the avoidance of doubt, this review has only considered the U-value of the window and other parameters may need to be assessed to verify the overall suitability of the secondary glazing product, e.g. product durability, strength, fire resistivity, etc.

Table 4: U-values for the example windows (1.2m wide x 1.8m high), without and with the CSG secondary glazing system

| Timber frame window | Window U-value, Uw, W/m²K |
|---|---|
| Single glazed timber frame | 4.91 |
| Single glazed timber frame with CSG system | 2.62 |
| Difference, ΔU | -2.29 |
| % improvement | 47% |

## 2.4 Method for calculating the overall U-value for a window of any size

The U-values presented in Table 4 are based on a window of 1.2m wide x 1.8m high. The overall U-value of a window of other dimensions may be calculated using the following formula, where U-values and ψ-values of the frames are available, and the U-value of the centre pane of glazing is also calculated:

$$Uw = \frac{(Ug \times Ag) + \sum(Uf \times Af) + \sum(\psi f \times lf)}{Aw}$$

$Uw$ = U-value of the whole window

$Ug$ = U-value of the glazing (centre pane)

$Uf$ = U-value of the respective frame components; i.e. the head, sill and jamb

$\psi f$ = ψ-value of the respective frame-glazing connections, i.e. at head, sill and jamb

$Aw$ = Area of the whole window

$Ag$ = Visible area of the glazing

$Af$ = Visible area of the respective frame components, i.e. the head, sill and jamb (based on the larger of the projected widths of the frame as seen from both sides)

$lf$ = Length of the respective frame-glazing connections, i.e. at head, sill and jamb (based on the greatest length of frame edge, as seen from both sides)

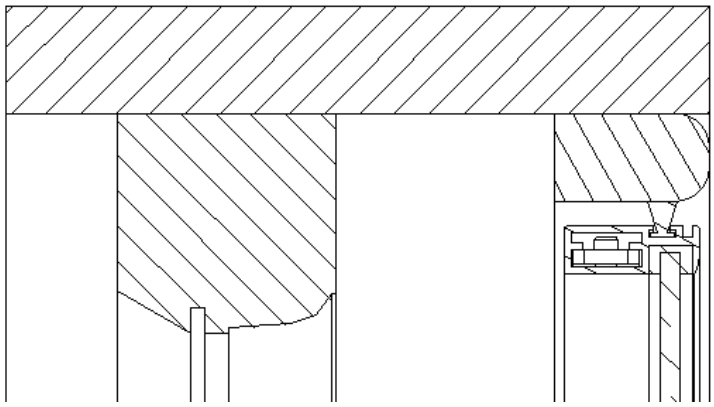
Note that respective Uf and Af values need to first be multiplied together (i.e. $U_{head}$ x $A_{head}$), before the resulting heat losses are summed. The same applies to the ψ-values and their respective lengths.

Graphical outputs from modelling are included in Appendix B.

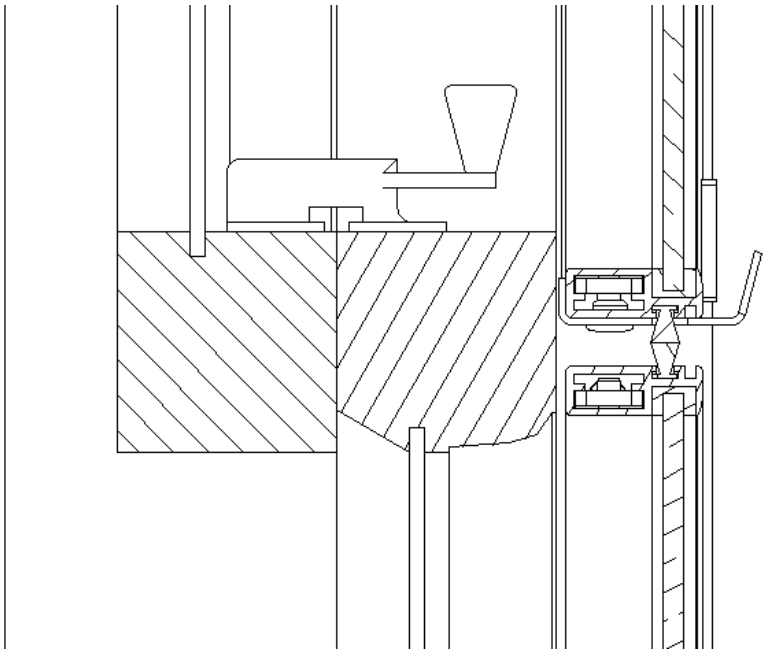
 

# Appendix A: Client drawings

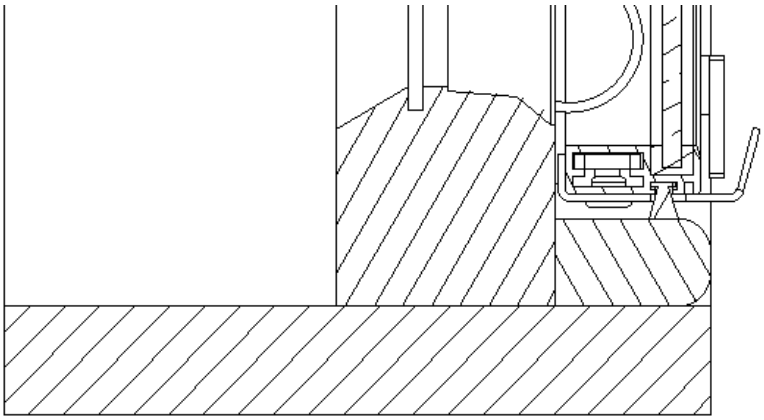
Head (upper jamb is visually equivalent)



Mullion



Sill (lower jamb is visually equivalent)

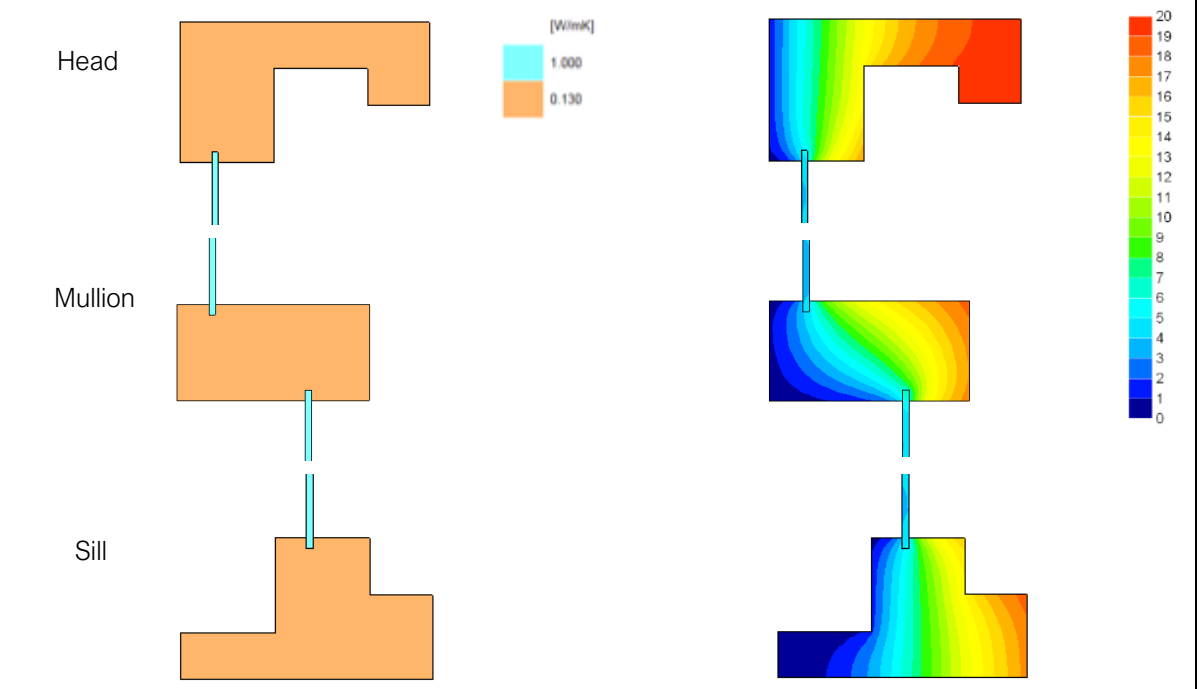


# Appendix B: Graphical representations

Note that upper jambs are visually similar to heads, and lower jambs to sills, hence jamb diagrams have not been included below.

## Window without secondary glazing




## Window with CSG secondary glazing