VELUX®

# IES VE guide for VELUX products

How to correctly insert VELUX products in IES VE program, focus on daylight and indoor climate simulation.

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# Info

## Authors

VELUX A/S

## Contact info

If have any question regarding the guide please contact:

Thorbjørn Færing Asmussen
thorbjorn.asmussen@velux.com

If requires technical data information please contact your local VELUX Sales company.

## Limitations

The guide provides information on how to model a VELUX window product in IES VE, given the available capabilities and limitations of the software and based on the latest software version available at the time of writing, namely VE 2019.

# IES VE guide for VELUX

## About

This document offers guidelines on the simulation of a sloped roof VELUX window in IES VE to carry out thermal, natural ventilation, air quality and daylight assessments.

IES VE is a software developed and licensed by Integrated Environmental Solutions Limited. It is a thermal simulation suite of integrated analysis tools for buildings, including whole building energy simulations and indoor climate analysis. The daylight calculation capability of the software is based on Radiance.

The guide focuses on how to model a sloped VELUX integra Roof Window in IES VE; it is not a general guide on how to use IES VE.

## Slope Roof window

The modelling of a VELUX pivoting sloped Integra Roof Window in IES VE for thermal, natural ventilation, air quality and daylight assessments will be presented in the following sections.

The window characteristics are summarised in Table 1 and the modelling assumptions in Table 2.

Table 1, VELUX window characteristics

| VELUX window characteristics | Values |
|---|---|
| General Properties | |
| Type | Pivoting roof window GGL |
| Size | 780mm x 1398mm (M08) |
| Insulating Glass Unit | 59, Low energy |
| Frame percentage | 36% |
| Thermal & solar properties | |
| Thermal transmittance of glass, Ug | 1.1 W/(m$^2$K) |
| Total window thermal transmittance, Uw | 1.7 W/(m$^2$K) |
| Total solar energy transmittance, g-value | 0.60 |
| Natural ventilation properties | |
| Opening area definition | Fully open position corresponds to 19.4 cm distance from bottom of frame to bottom of sash (refer to figur 5, page 9) [1] |
| Free open area | 0.27 m$^2$ |

Table 2, Modelling example assumptions

| Modelling assumptions | |
|---|---|
| Natural ventilation control to avoid overheating | Open when Tair,in>24°C between 07:00-20:00 |
| Natural ventilation control for air quality | Open 10 mins morning and evening when Tair,out>0°C |

[1] The opening area is based on VELUX Roof Window, GGL Integra V21. The area is the minimum value for all Integra VELUX Roof Windows. Manual (pivot and top hung) will have a higher opening area, but can use this value as a minimum opening area.

# Modelling the sloped roof VELUX window in IES VE

## Dynamic thermal simulation using Apache

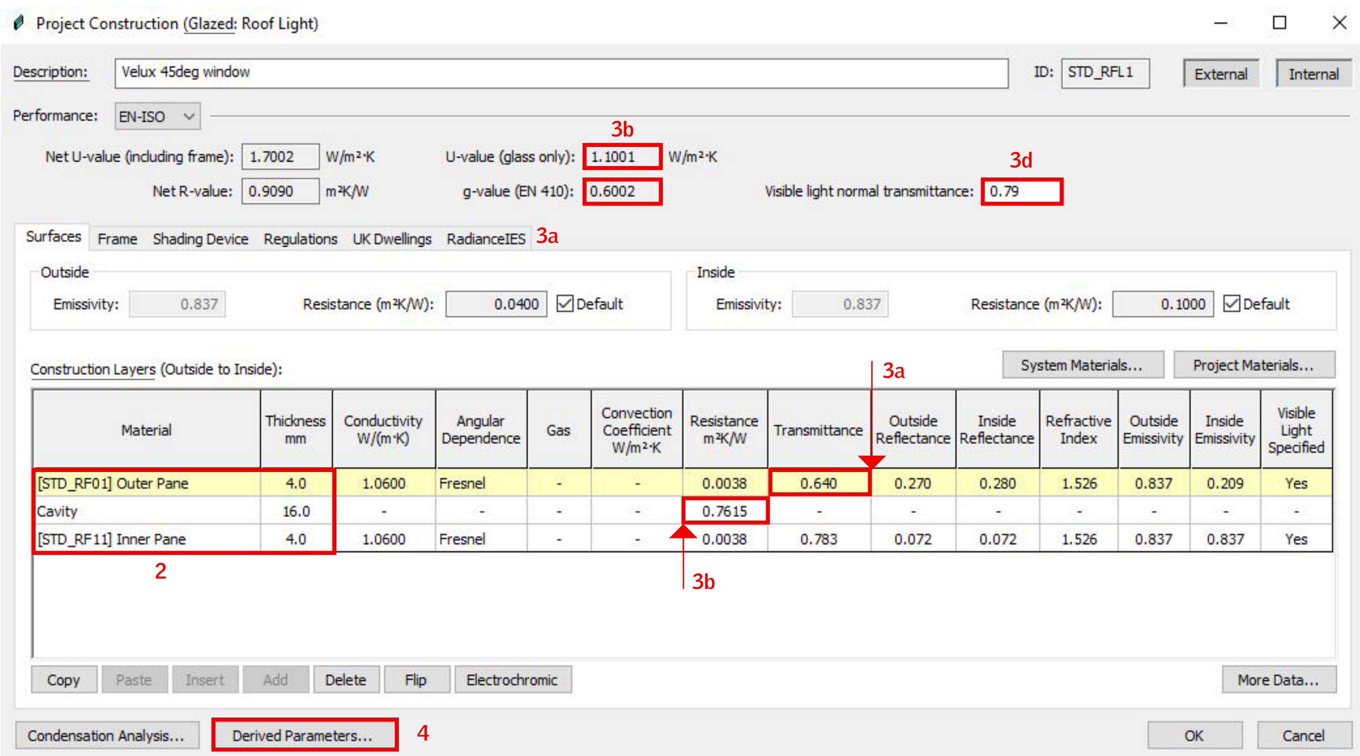
1 Create a new project or open an existing one in IES VE. Once the geometry is complete (including all the windows), either through creating it in ModelIT or importing it using the IES interoperability, set up your model as usual, ensuring to include the location and climatic data, building fabric, thermal templates and energy systems.

To set up the sloped roof VELUX window go to the Apache module and open the Apache Construction Database Manager (APcdb).

2 In the Glazed tab add a new construction and set it to Roof Light under the Category column. Open the construction and give it an appropriate name in the Description field.

Make sure to adjust the Construction Layers (figure 1) so that the window composition matches the construction.

Figure 1, APcdb Glazed construction – setting up the sloped roof VELUX window



VELUX®

# Dynamic thermal simulation using Apache

3 The glazing properties of the VELUX product need to be reflected in the APcdb construction as figures 1 (on page 5) and figure 2 show, with each step highlighted in red.

a Edit the Transmittance of the outer pane to get the correct g-value, shown in the field g-value (EN 410). (figure 1)

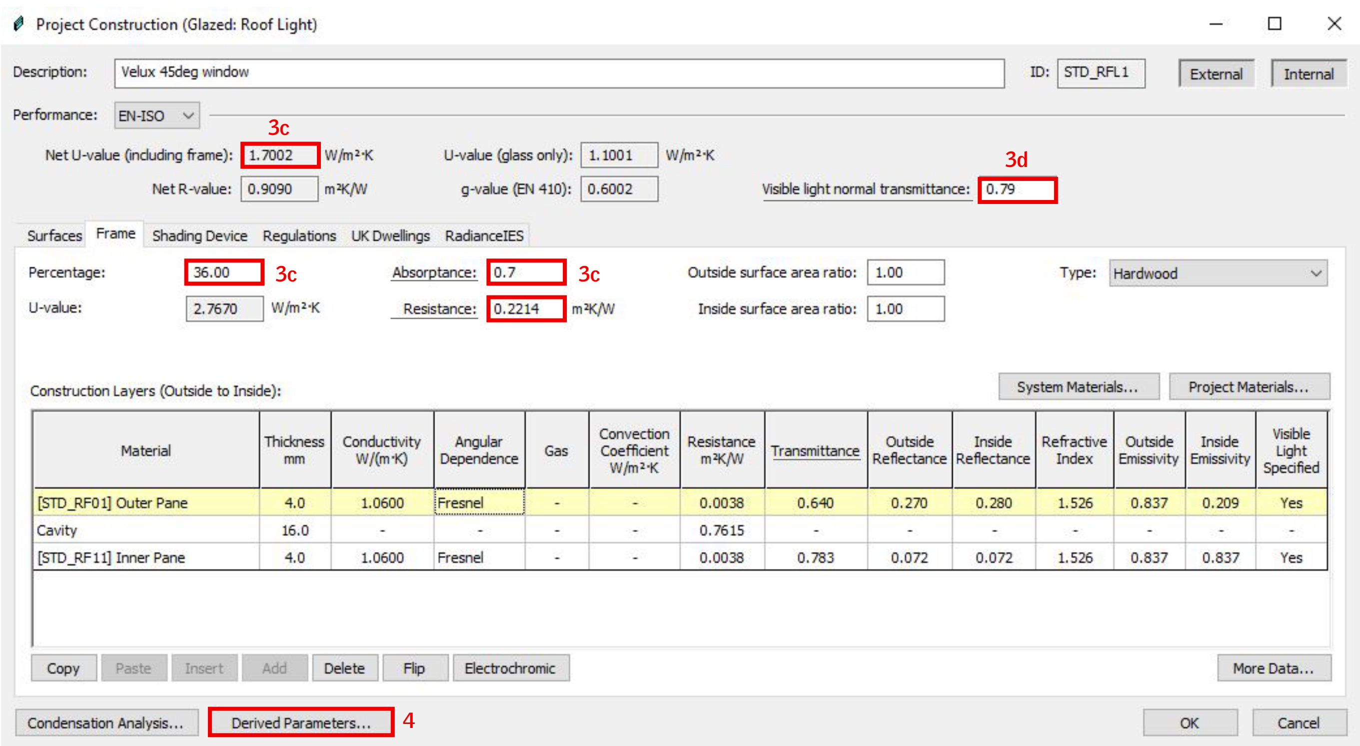
b To achieve the product's glass U-value edit the Resistance of the cavity. (figure 1)

c Then go to the Frame tab (figure 2) and adjust the frame percentage (and Absorptance if known) as per the product specifications.

Edit the frame Resistance to get the specified frame U-value (if known) and total window U-value, shown in the field Net U-value (including frame). (figure 2)

d Set the Visible light normal transmittance in the corresponding field (figure 1 or 2), in case you are planning to carry out Radiance calculations for a daylight assessment; the APcdb construction will be used in Radiance (see "Daylight calculations using RadianceIES").

Figure 2, APcdb Glazed construction, Frame tab – setting up the sloped roof VELUX window frame



4 To see the calculated values for the Total shading coefficient, open the Derived Parameters (figures 1 on page 5 and figure 3) .

5 Once your VELUX construction is complete exit the APcdb dialogue and in the 3D model interface of Apache apply the construction to the appropriate windows, using the Assign constructions button.

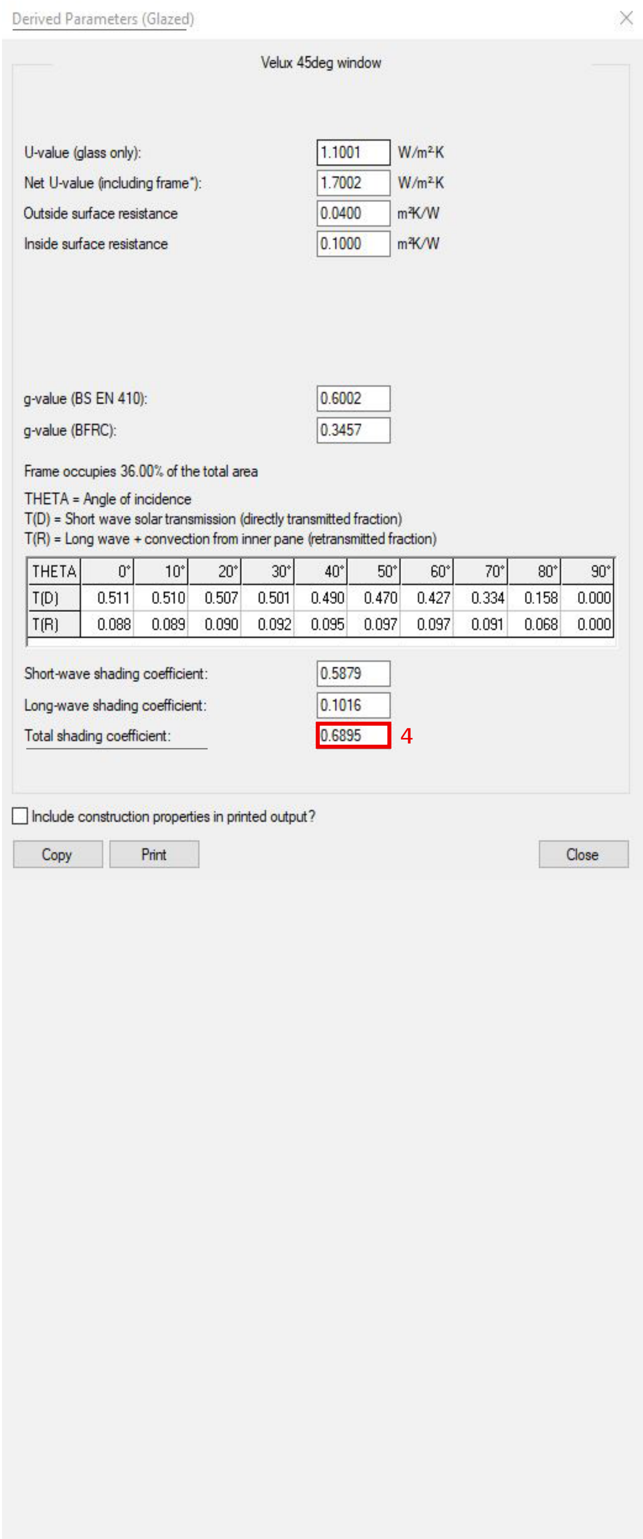
You can do this by selecting the openings at room level (to apply the construction on all windows of the room) or at surface level (to apply the construction on specific windows of the room).

The VELUX window is now ready for use in thermal simulations

6 Click the ApacheSim (Dynamic Simulation) button in Apache to run a dynamic thermal analysis.

Enable the Suncast Link in the Apache Simulation window that will appear to allow for tracking direct beam radiation based on the model's geometry and click Simulate to run the analysis.

Figure 3, APcdb Glazed construction - Derived parameters window



# Natural ventilation using MacroFlo

1 Once the set-up of the dynamic thermal simulation is complete, the opening of a VELUX window can be defined under the MacroFlo module of IES. By clicking on the MacroFlo openings database manager button the user can create a new MacroFlo Opening Type (figure 4). After giving the opening an appropriate name in the field Description, the Opening Category should be defined first, as this will dictate the available input options. For the example pivoting VELUX window the Window-centre hung category is appropriate. For details on the opening types please visit the IES help page on MacroFlo Opening Types.

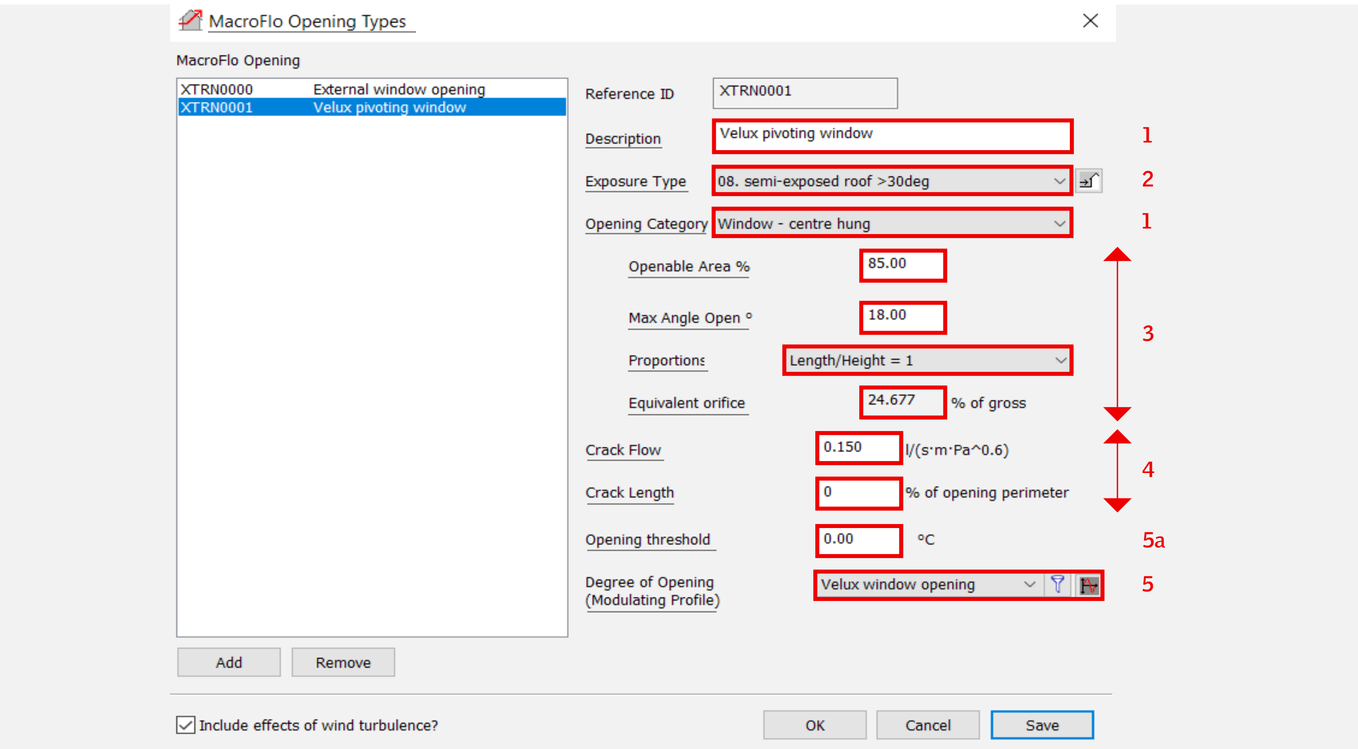
2 The Exposure Type will define the wind pressure coefficients and needs to be selected based on the intended application of the window. In this example a semi-exposed roof >30deg is representative. For details on the exposure type characteristics and the calculation methods please refer to the MacroFlo Methods Manual and the Wind Pressure Coefficients section of the IES help page.

3 The Openable Area %, the Max Angle Open° and the Proportions of the window will define the Equivalent orifice area as a percentage of the gross opening area drawn in the model (figure 4).

As figure 6 (on page 9) explains, the Openable Area % is set to 85 % to account for the immovable frame of the window. The Max Angle Open° is calculated to 18.0° based on the given distance of 19.4 cm between the bottom of the frame and the bottom of the sash (figure 5, on page 9). (For Max angle Open for all Roof Window, (V21 & V22) and Flat Roof Window, see Appendix A, B and C).

The appropriate Length/Height Proportions is selected from the drop-down menu. Based on these inputs, the Equivalent Orifice Area calculated by IES is 24.7% of the gross window area (0.78 m x 1.398 m), which is equal to the 0.27 m2 free open area given in Table 1, on page 4.

Figure 4, MacroFlo Opening Types window – setting up the sloped roof VELUX window as an opening



## Natural ventilation using MacroFlo

4 The Crack Flow and Crack Length (figure 4, on page 8) represent the leakage properties of the crack around the opening. If these properties are known they can be inserted in the respective fields.

Alternatively the user can decide to account for the crackage of the windows when assigning the infiltration rate of the building in the Thermal templates. In that case, the crack length should be set to zero.

Typical values and further information on the crackage characteristics can be found in the Flow Characteristics of the IES help page.

Figure 5, Pivoting sloped roof VELUX window opening characteristics

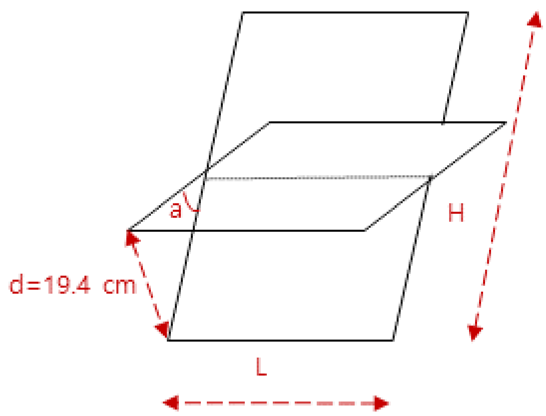
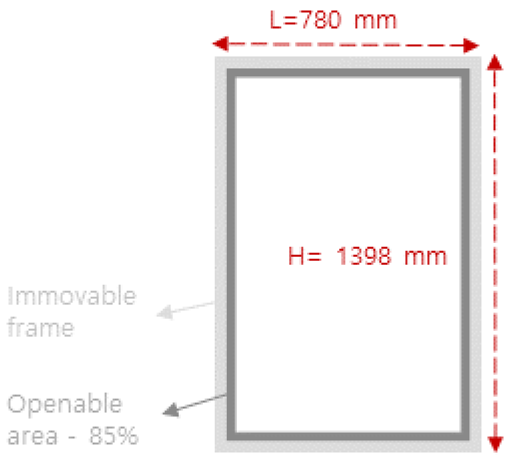



Figure 6, Pivoting sloped roof VELUX window sash and frame



# Natural ventilation using MacroFlo

5 In order to set up the control of the opening the recommended way is to set up a Modulating profile and apply it in the Degree of Opening drop-down menu (figure 4, on page 8).

This way the user may select different control variables (e.g. temperature and/or $CO^2$ levels) and specific times to apply the control.

The Opening Threshold should be set to zero to ensure it does not override the modulating profile control. (Figure 4, on page 8)

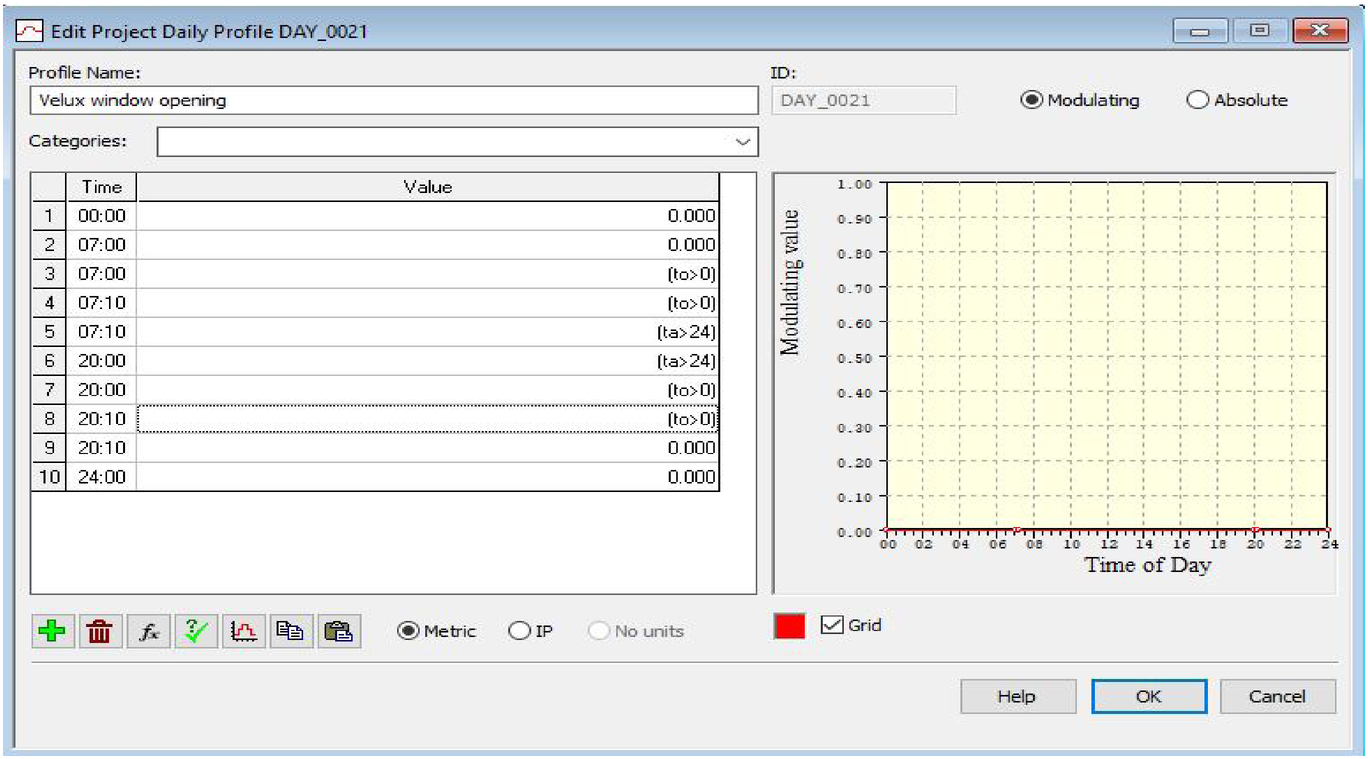
Figure 7, shows the modulating profile applied for the sloped roof VELUX window based on the control assumption described in table 2, on page 4.

6 When all the inputs are defined click OK to close the MacroFlo Opening Types window and save. (figure 4, on page 4)

In the 3D geometry interface select the windows to which you would like to apply the VELUX opening type and assign the opening by clicking on the Assign Opening Types button, where you can replace the default opening assigned with the VELUX opening you just created.

7 Go to the Apache module and click on the ApacheSim (Dynamic Simulation button). Make sure to tick MacroFlo under Model Links in the Apache Simulation window that will open and click Simulate.

Figure 7, Example modulating profile for control of window opening



# Air quality

The available calculated variable for air quality assessments is the Room $CO^2$ concentration. Once the dynamic thermal model is set up, by running an ApacheSim (Dynamic Simulation) in Apache, IES will calculate the Room $CO^2$ concentration amongst its room output variables that can be reviewed in the VistaPro module when the simulation is complete.

The calculation will be based on the external $CO^2$ levels (assuming a fixed outside air concentration of 360 ppm), any air exchanges defined by MacroFlo or ApacheHVAC and the occupancy settings.

For more information on the calculation method please refer to the IES help page > Carbon Dioxide Balance section.

# Daylight calculations using RadianceIES

The RadianceIES module supports both Climate Based Daylight Modelling under the Advanced calculation type as well as static daylight calculations, under the Luminance or Illuminance calculation types.

1 Once the geometry (including all windows), location and climatic data are defined, go to the RadianceIES module to carry out a daylight calculation using the sloped roof VELUX window.

2 The next step is about defining the daylight properties of the VELUX glazing and the other model constructions. This is done using the APcdb menu, which can be accessed either through Apache or directly through.

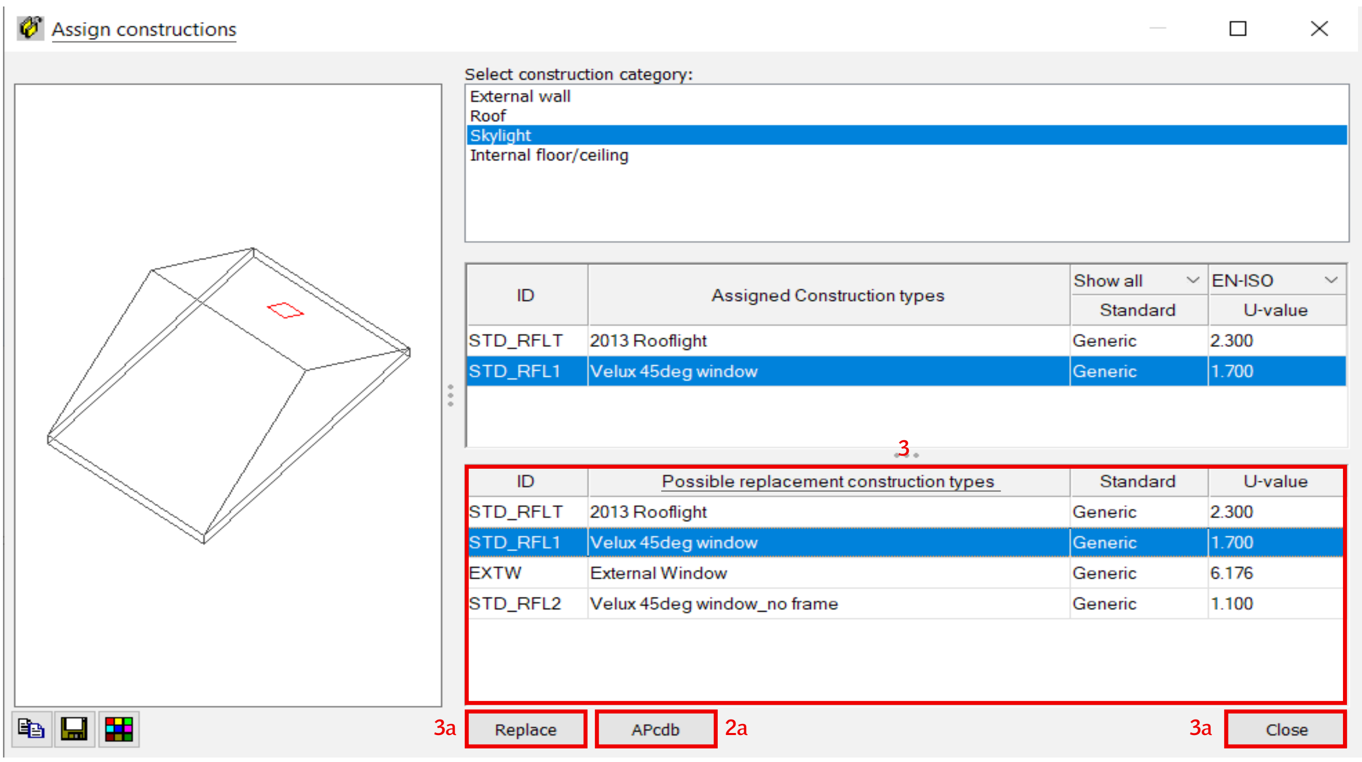
RadianceIES by using the Assign constructions button. To define the glass Radiance properties follow the next steps.

a In the 3D model interface select the windows to which you would like to apply the VELUX glazed construction. Click the Assign constructions button and in the window that will open (figure 8), click the APcdb button to create the VELUX window construction.

If you have already created a VELUX window construction in Apache and you now need to set its Radiance properties go directly to step 2c.

b In the Glazed tab add a new construction and set it to Roof Light under the Category column. Open the construction and give it an appropriate name in the Description field. (Figure 8)

Figure 8, RadianceIES Assign constructions window



c Within the Glazed construction APcdb window (figure 9), there are two ways to define the glass properties for the Radiance calculations.

The first option is to insert the Visible light normal transmittance and then go to the RadianceIES tab and Glazed Surface sub-tab of the construction and tick the box Derive from Visible light normal transmittance (figure 9). IES will calculate the transmissivity of the glass automatically.

Alternatively this can be done by using the Calculate transmissivity button, which will prompt you to insert the transmittance (i.e. visible light transmittance). (Figure 10, on page 14).

By clicking OK, IES will calculate the transmissivity.

d To define the frame reflectance go to the Frame sub-tab of the RadianceIES tab of the glazed construction (figure 11, on page 14) and set the Red, Blue and Green reflectance to get the desired Reflectance (generic value of 0.80 used in example). Click OK to save and exit the dialogue.

3 By visiting the Assign constructions window now you will see the VELUX construction you created under Possible replacement construction types (figure 8, on page 12).

a Apply the VELUX APcdb construction to the appropriate windows or skylights by using the Replace button and Close

4 Define the rest of the materials' reflectance properties in the RadianceIES tab of each APcdb construction element (i.e. walls, floor, roof, ceiling, etc), as you normally would.

Figure 9, APcdb glazed construction window RadianceIES tab – Glazed surface sub-tab

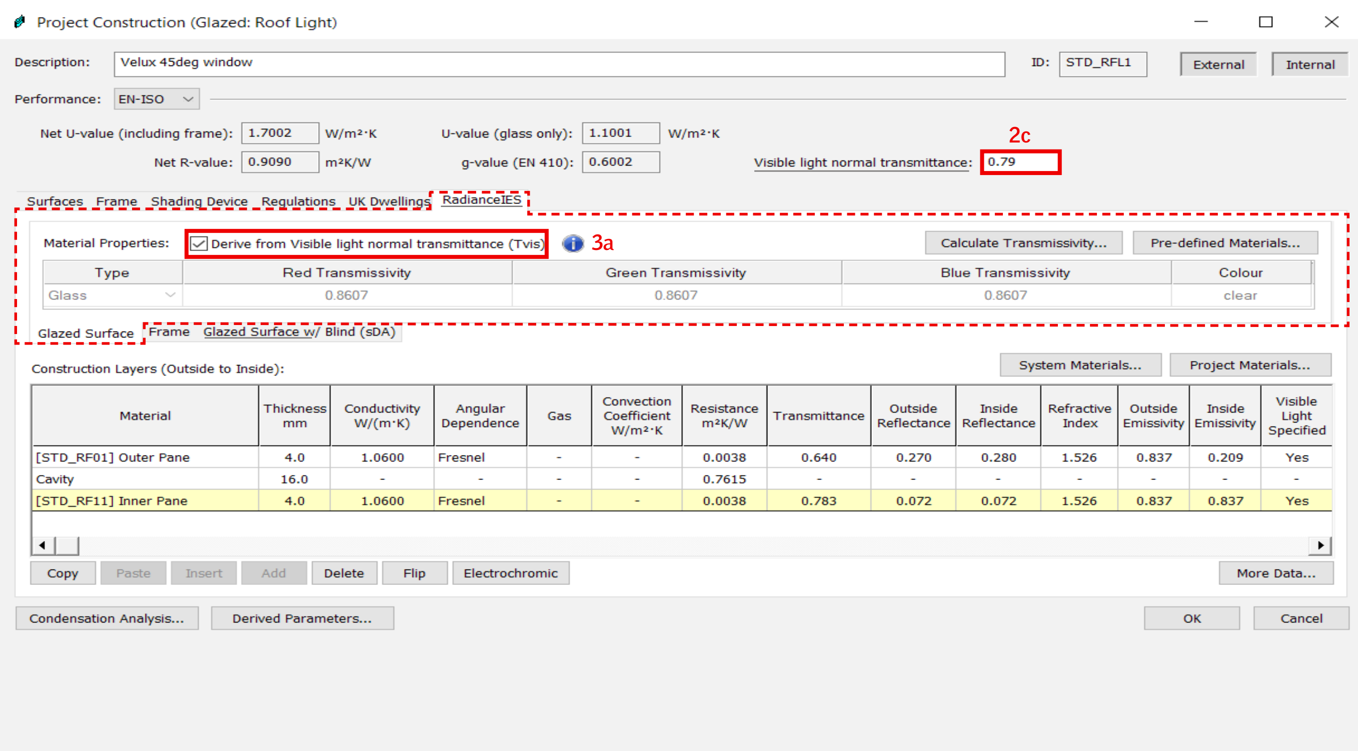


Figure 10, APcdb glazed construction window RadianceIES transmissivity calculation dialogue

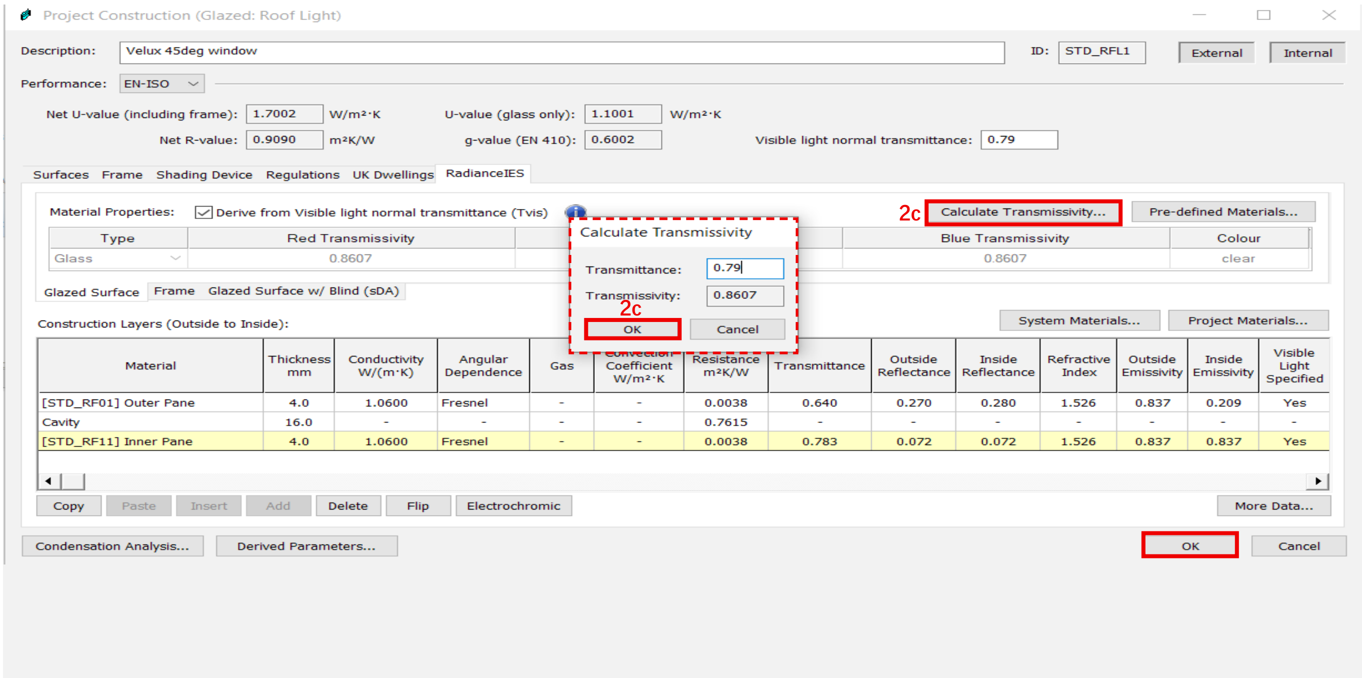
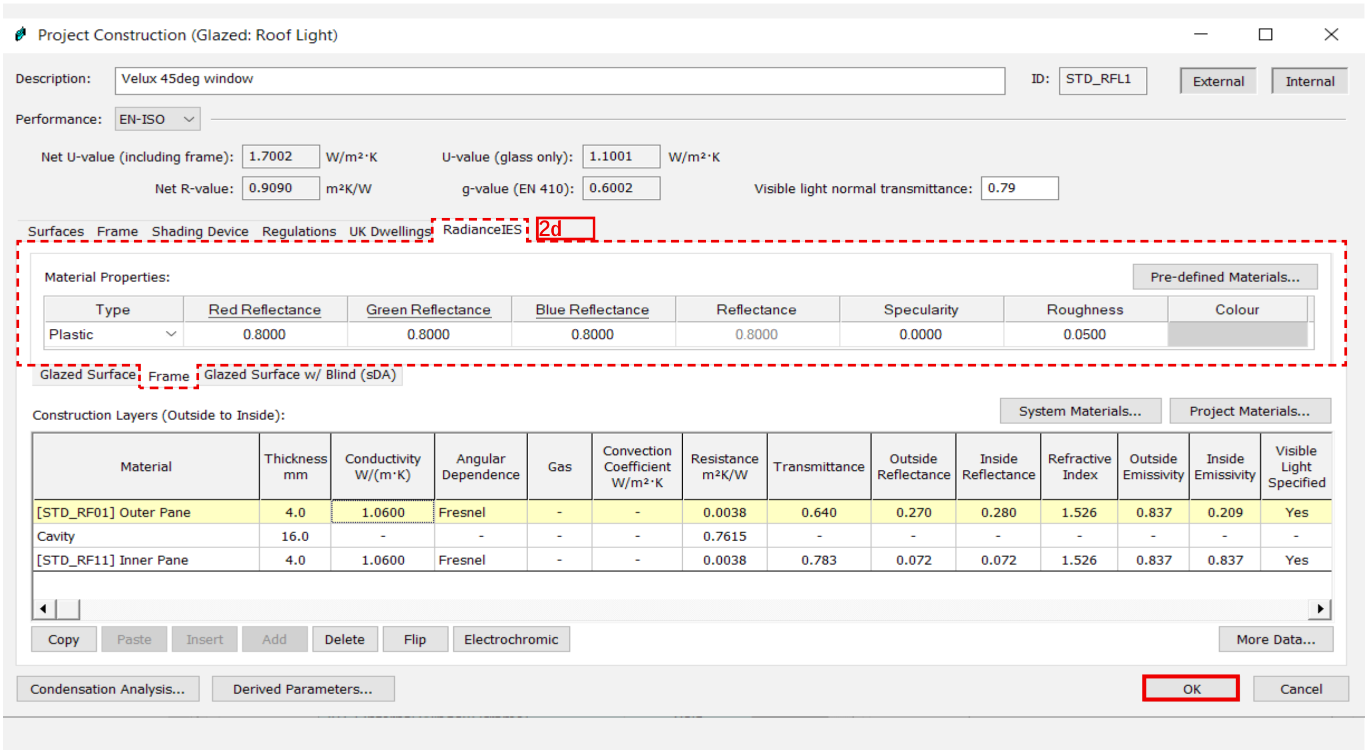



Figure 11, APcdb glazed construction window RadianceIES tab - Frame sub-tab

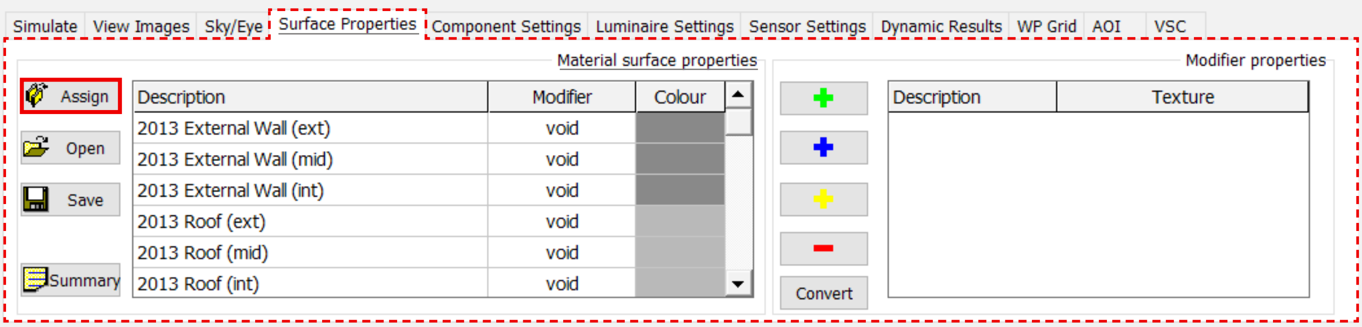


# Alternative route  to edit the Radiance properties

You can also edit the Radiance properties of the model constructions using the Surface Properties tab on the bottom menu of Radiance (figure 12).

By scrolling down in the Material surface properties you will find all the surface types available in the model and you can double-click on any of them to amend their properties. You can then use the Assign button on the left hand-side to apply them in the model. Please note that you cannot create new surfaces through this utility.

Figure 12, RadianceIES Surface Properties tab



# Daylight calculations using RadianceIES

5 In the RadianceIES menu go to Simulation Options and set up the Working Plane, Maintenance Factor, Area of Interest, Ground Reflectance, Sky Resolution and Window Frames under each respective tab (figure 13).

It is noted that the frame width will form part of the total window area drawn in the ModelIT geometry, i.e. the window area drawn must account for the frame.

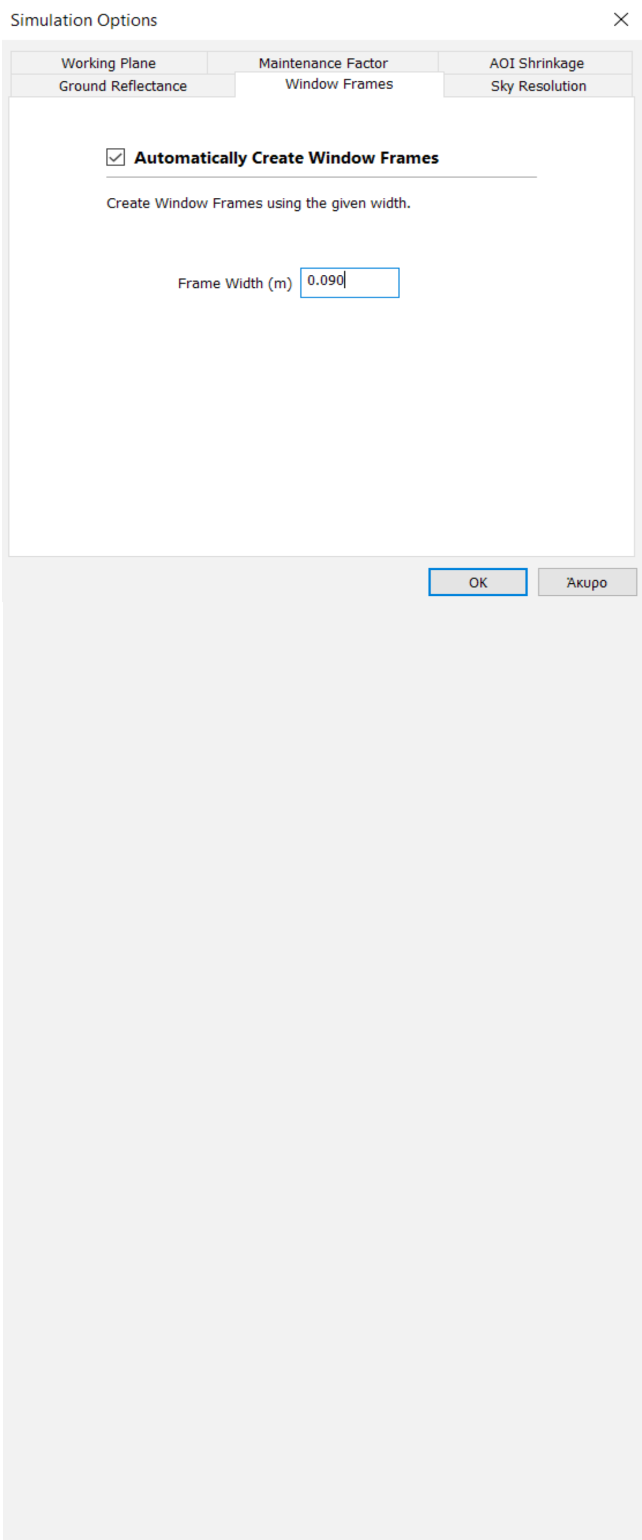
6 According to the type of analysis the user wishes to simulate, the rest of the RadianceIES modelling inputs need to be defined as appropriate. In this example an illuminance simulation is described.

Once the Sky/Eye tab settings are set, Illuminance is selected under the Simulate tab. Choose the type of output you want to extract (e.g. working plane image). You can choose the simulation quality from the relevant drop down options.

When selecting Custom you will be prompted to customise the simulation settings. The simulation is commenced by clicking on the Simulate button.

For further details on the RadianceIES modelling inputs please visit the Radiance section of the IES help page and refer to the Notes & Design Tips for Upgrading pre-VE 2019 models, if relevant.

Figure 13, Setting up Simulation Options for daylight calculations



# Appendix A - VELUX product information

## VELUX Roof Windows V22 (for all manual/ integra pivot and tophung)

| Frame percentage VELUX roof windows V22 (GGL,GGU, GPL,GPU etc. | | | |
|---|---|---|---|
| Size | External frame width [mm] | External frame height [mm] | Frame percent-age [%] |
| BK04 | 472 | 978 | 50 |
| CK01 | 550 | 698 | 51 |
| CK02 | 550 | 778 | 49 |
| CK04 | 550 | 978 | 46 |
| CK06 | 550 | 1178 | 44 |
| FK04 | 660 | 978 | 42 |
| FK06 | 660 | 1178 | 39 |
| FK08 | 660 | 1398 | 37 |
| MK27 | 780 | 624 | 47 |
| MK04 | 780 | 978 | 47 |
| MK06 | 780 | 1178 | 36 |
| MK08 | 780 | 1398 | 34 |
| MK10 | 780 | 1600 | 32 |
| MK12 | 780 | 1800 | 31 |
| PK25 | 942 | 550 | 48 |
| PK04 | 942 | 978 | 35 |
| PK06 | 942 | 1178 | 32 |
| PK08 | 942 | 1398 | 30 |
| PK10 | 942 | 1600 | 29 |
| SK06 | 1140 | 1178 | 30 |
| SK08 | 1140 | 1398 | 27 |
| SK10 | 1140 | 1600 | 26 |
| UK04 | 1140 | 978 | 31 |
| UK08 | 1140 | 1398 | 25 |
| UK10 | 1140 | 1600 | 24 |

| Free exit height, VELUX Roof Window | | | |
|---|---|---|---|
| Size | Window height [mm] | Free exit height [mm] | Max angle open [degree] |
| K02 | 778 | 38 | 7 |
| K04 | 978 | 198 | 28 |
| K06 | 1178 | 195 | 22 |
| K08 | 1398 | 194 | 18 |
| K10 | 1600 | 194 | 15 |

# Appendix B - VELUX product information

## VELUX Roof Windows V21 (for all manual/ integra pivot and tophung)

| Frame percentage VELUX roof windows V22 (GGL,GGU, GPL,GPU etc. | | | |
|---|---|---|---|
| Size | External frame width [mm] | External frame height [mm] | Frame percent-age [%] |
| C02 | 550 | 778 | 54 |
| C04 | 550 | 978 | 49 |
| C06 | 550 | 1178 | 46 |
| F04 | 660 | 978 | 45 |
| F06 | 660 | 1178 | 42 |
| F08 | 660 | 1398 | 40 |
| M04 | 780 | 978 | 42 |
| M06 | 780 | 1178 | 39 |
| M08 | 780 | 1398 | 36 |
| M10 | 780 | 1600 | 35 |
| P04 | 942 | 978 | 39 |
| P06 | 942 | 1178 | 36 |
| P08 | 942 | 1398 | 33 |
| P10 | 942 | 1600 | 31 |
| S06 | 1140 | 1178 | 33 |
| S08 | 1140 | 1398 | 31 |
| S10 | 1140 | 1600 | 29 |
| U04 | 1140 | 978 | 35 |
| U08 | 1140 | 1398 | 29 |

# Appendix C - VELUX product information

## VELUX Flat Roof, CFP ISD

| Frame percentage VELUX roof windows V22 (GGL,GGU, GPL,GPU etc. | | | |
|---|---|---|---|
| **Size** | External frame width [mm] | External frame height [mm] | Frame percent-age [%] |
| **60060** | 790 | 790 | 70 |
| **60090** | 790 | 1090 | 63 |
| **80080** | 990 | 990 | 59 |
| **90090** | 1090 | 1090 | 55 |
| **90120** | 1090 | 1390 | 50 |
| **100100** | 1190 | 1190 | 51 |
| **100150** | 1190 | 1690 | 45 |
| **120120** | 1390 | 1390 | 45 |
| **150150** | 1690 | 1690 | 38 |

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CONTACT INFO

Thorbjørn Færing Asmussen
Thorbjorn.f.asmussen@velux.com
VELUX A/S
www.velux.dk