Natural Ventilation Guide

The Natural Ventilation Guide is also available within the Simergy Help CHM file that is available within Simergy , and is located in the Introduction chapter.

Additional Resources for EnergyPlus Natural Ventilation information:

- The EnergyPlus Input Output Reference (also available within Simergy Help)
- The EnergyPlus Engineering Reference
- On-line versions of both documents mentioned above (http://bigladdersoftware.com/epx/docs/)

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Simergy Natural Ventilation Guide

Natural ventilation involves the modeling of operable windows to introduce outdoor air into a space to provide both cooling and ventilation. Simergy provides two options for modeling natural ventilation: simple and detailed.

Note that a simulation cannot contain both simple and detailed natural ventilation objects.

The Natural Ventilation Guide goes through a series of NatVent Design Scenarios to explain the capabilities and provide examples/tutorials that will assist you to set up and simulate your own Natural Ventilations models.

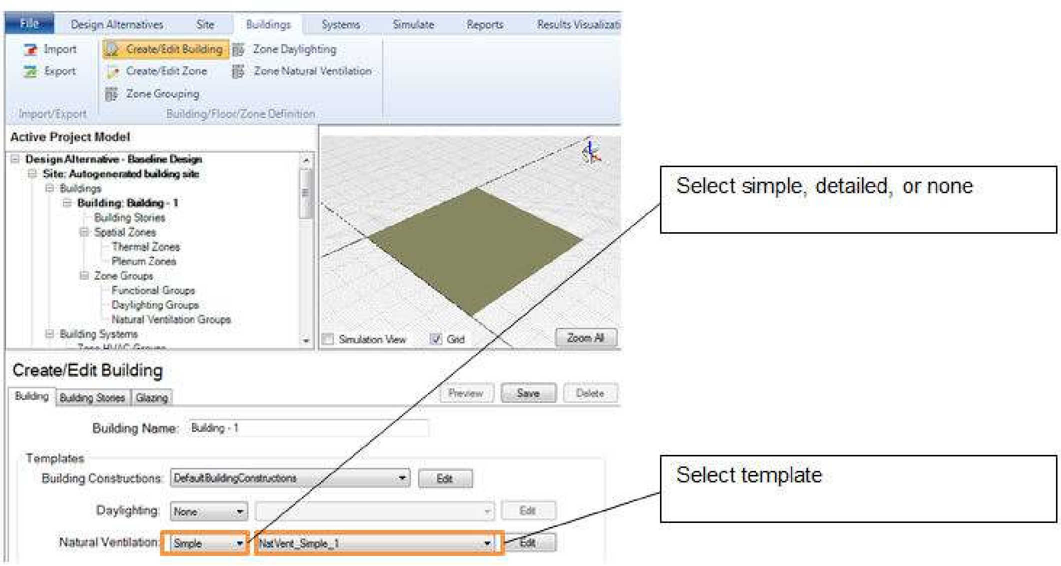
1. Simple Natural Ventilation for Overall Building

First Step = Select Simple

Workspace = Buildings > Create/Edit Building > Building Section

You must select *Simple* (options = Simple or *Detailed*) under the *Buildings* tab. Then you will select a template that contains various parameters for the natural ventilation scheme.

Note: A set of Natural Ventilation Templates are installed with Simergy or they can be defined within the Templates tab.



Simple Natural Ventilation

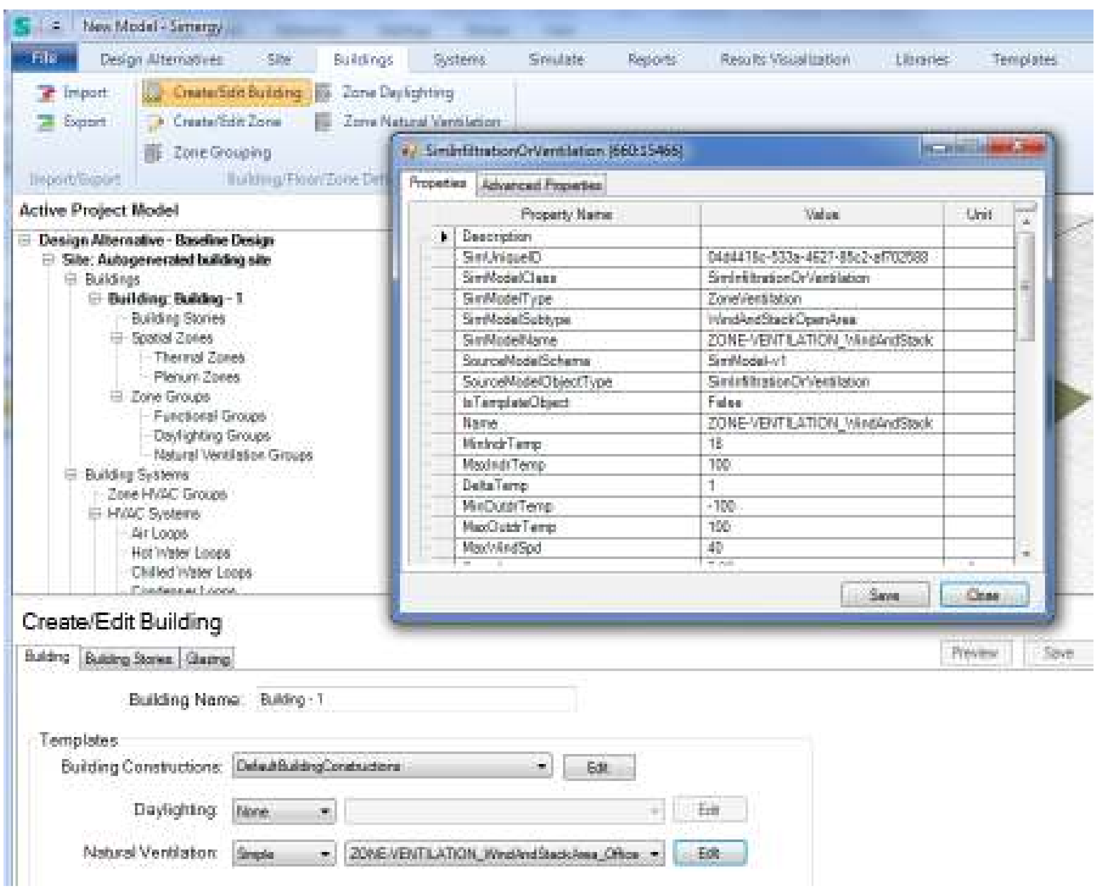
The simple natural ventilation option employs the EnergyPlus object *ZoneVentilation:WindandStackOpenArea (More information on this object can be found in the EnergyPlus Input/Output reference),* which, with simplified equations, calculates wind and buoyancy driven flows at the zone level based on the wind direction, indoor-outdoor temperature difference, and several user-input values (opening area, opening effectiveness, height difference, etc).

In the most basic **Simple** natural ventilation scenario, all you need to do is the steps that were described above:

1. Select Simple from the first drop down list on the Natural Ventilation row
2. Select a Simple Natural Ventilation Template from the second drop down list. The drop down list source is actually from Libraries: Infiltration/Vent. Selecting the natural ventilation template at the Buildings level will apply this template to every thermal zone in the building.
3. Select a Operable Window Simple type when creating the building geometry and glazing. See Assigning Operable Window Types.

Editing a Natural Ventilation Template Selection

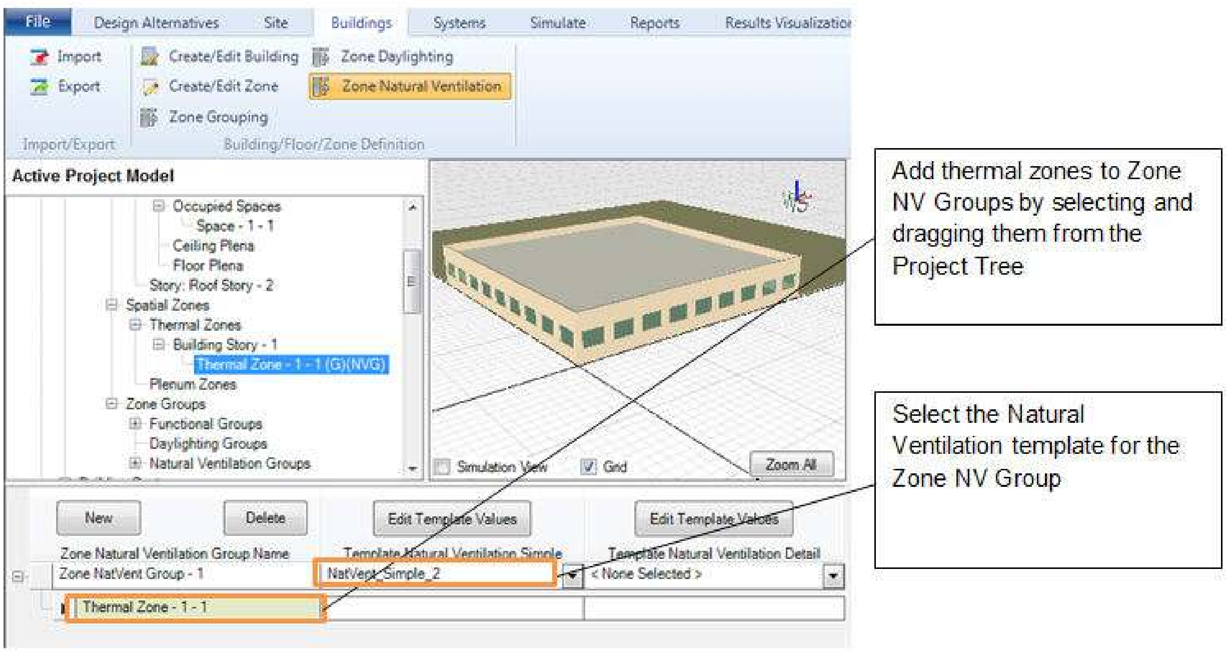
You can view and make changes to the Simple Natural Ventilation Template by selecting Edit, which will open a pop-up dialog box, which provides the same capability as if you were working in the Templates > Natural Ventilation workspace.



2. Simple Natural Ventilation for portions of the building

The user can also assign different simple NV templates to a single or multiple set of Zone Natural Ventilation Groups. This is achieved through the *Zone Natural Ventilation* tab. Steps are as follows:

1. Click New to create a new Zone Natural Ventilation Group.
2. Select and drag thermal zones to add them to the Zone Natural Ventilation Group that was just created.
3. Select a Operable Window Simple type when creating the building geometry and glazing. See Assigning Operable Window Types.
4. Select a Natural Ventilation Simple Template from the drop down menu.



Similar to the "Edit" button on the Building Tab, the Edit Templates Values can be selected which will open a pop-up dialog box, providing the same capability to make changes to the Natural Ventilation Template as if you were working in the Templates > Natural Ventilation workspace.

For explanation of the next column see "Detailed Natural Ventilation"

Note: You can define "Simple" Natural Ventilation at the whole building level as well as define "Simple" Natural Ventilation for Zone Natural Ventilation Groups. In this case the Natural Ventilation Template selected at the whole building level will be applied to every zone in the model except those zones that are part of a Zone Natural Ventilation Group. The Natural Ventilation Template selected for the Zone Natural Ventilation Group will override the template selected at the whole building level for the zones included in the Zone Natural Ventilation Group. This type of model approach is more likely when using "Detailed" Natural Ventilation and is described in greater detail here.

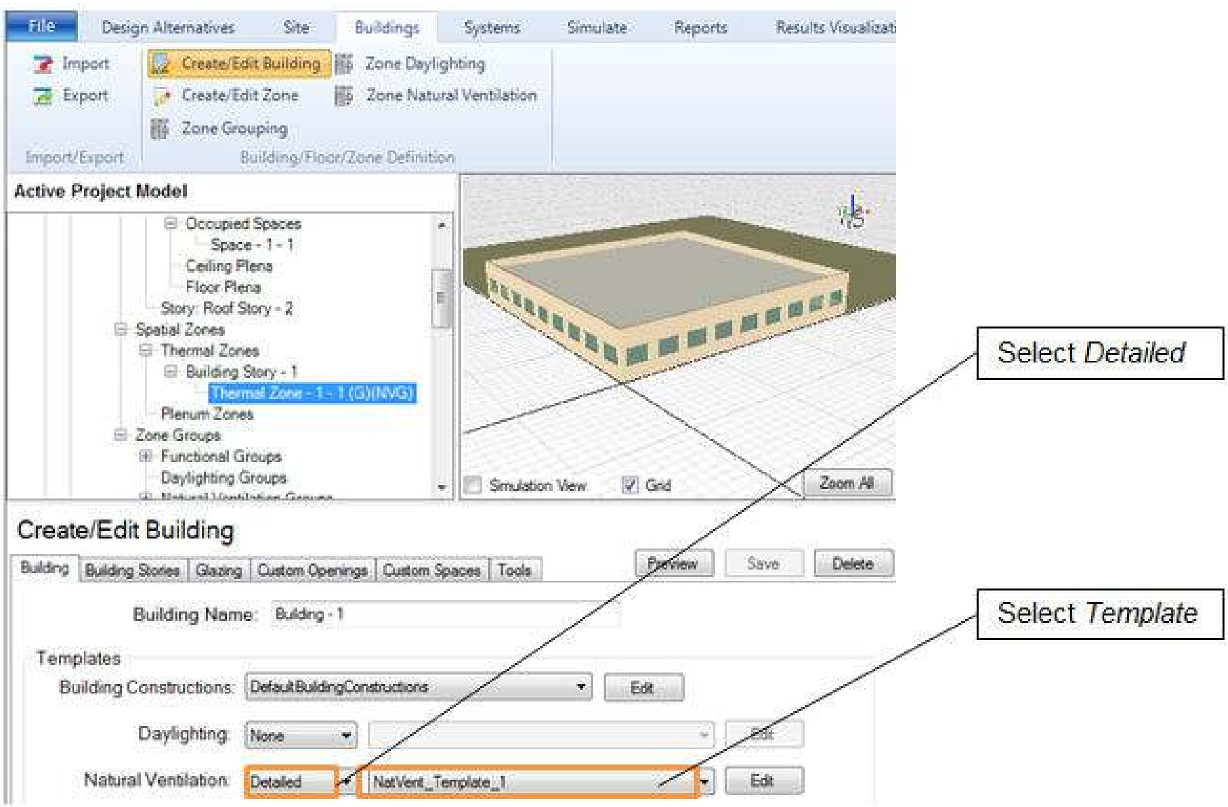
3. Detailed Natural Ventilation for Overall Building

The detailed natural ventilation option employs the Airflow Network, a bulk airflow model built in to the EnergyPlus interface. It is a nodal model that treats each zone as a node and each opening as a linkage.

Wind and buoyancy pressures are calculated at each opening and used to establish the airflow rate between adjacent zones and between zones and the outdoors.

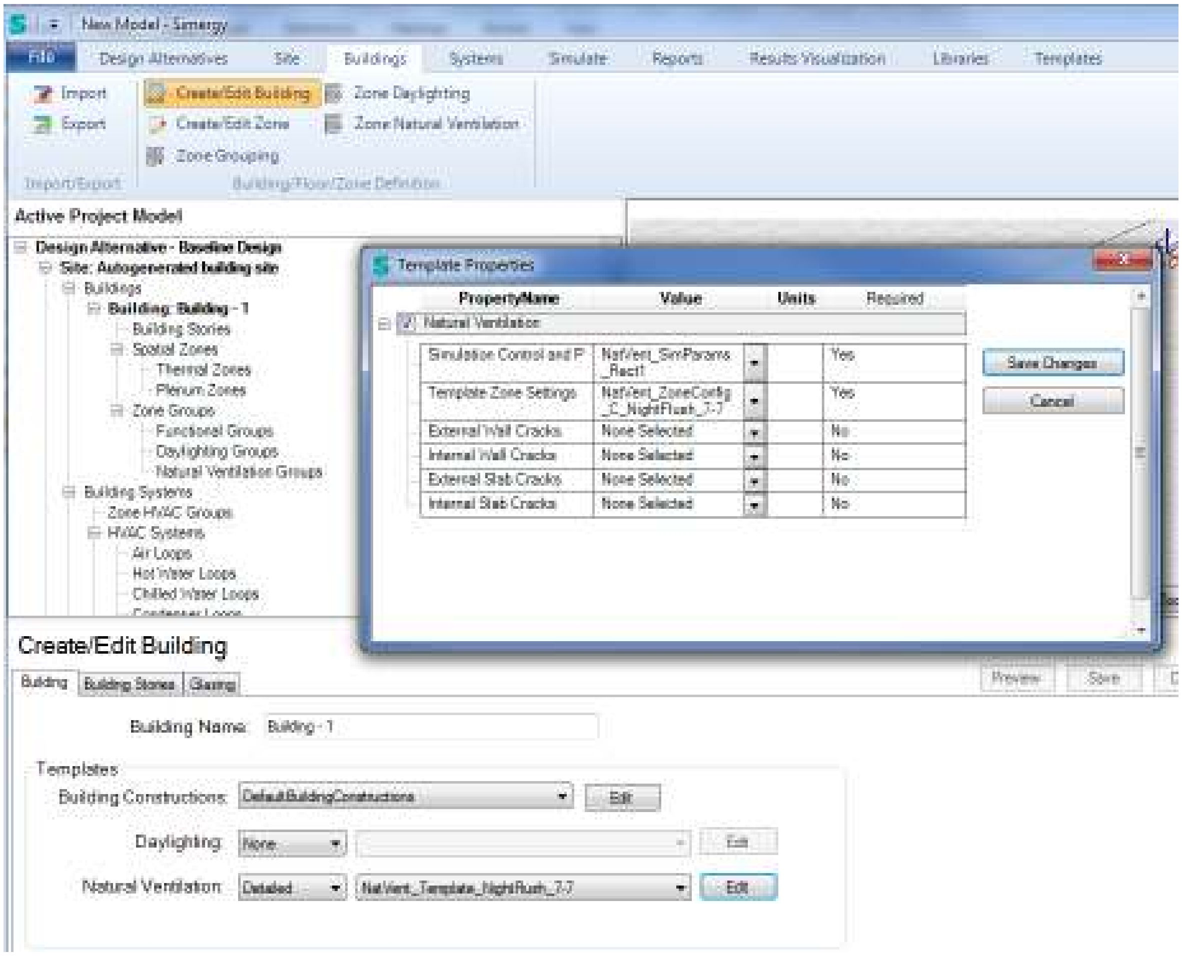
Like the simple natural ventilation option, the user has the ability to define a single template for a whole building on the *Buildings* tab. Selecting a template at the building level applies that template to every thermal zone in the building. In the most basic **Detailed** natural ventilation scenario, all you need to do is the steps that were described above:

1. Select Detailed from the first drop down list on the Natural Ventilation row
2. Select a Detailed Natural Ventilation Template from the second drop down list. Selecting the natural ventilation template at the Buildings level will apply this template to every thermal zone in the building. Source for the drop down list is Templates: Natural Ventilation.
3. Select a Operable Window Detailed type when creating the building geometry and glazing. See Assigning Operable Window Types.



Editing Detailed Natural Ventilation Template Selection

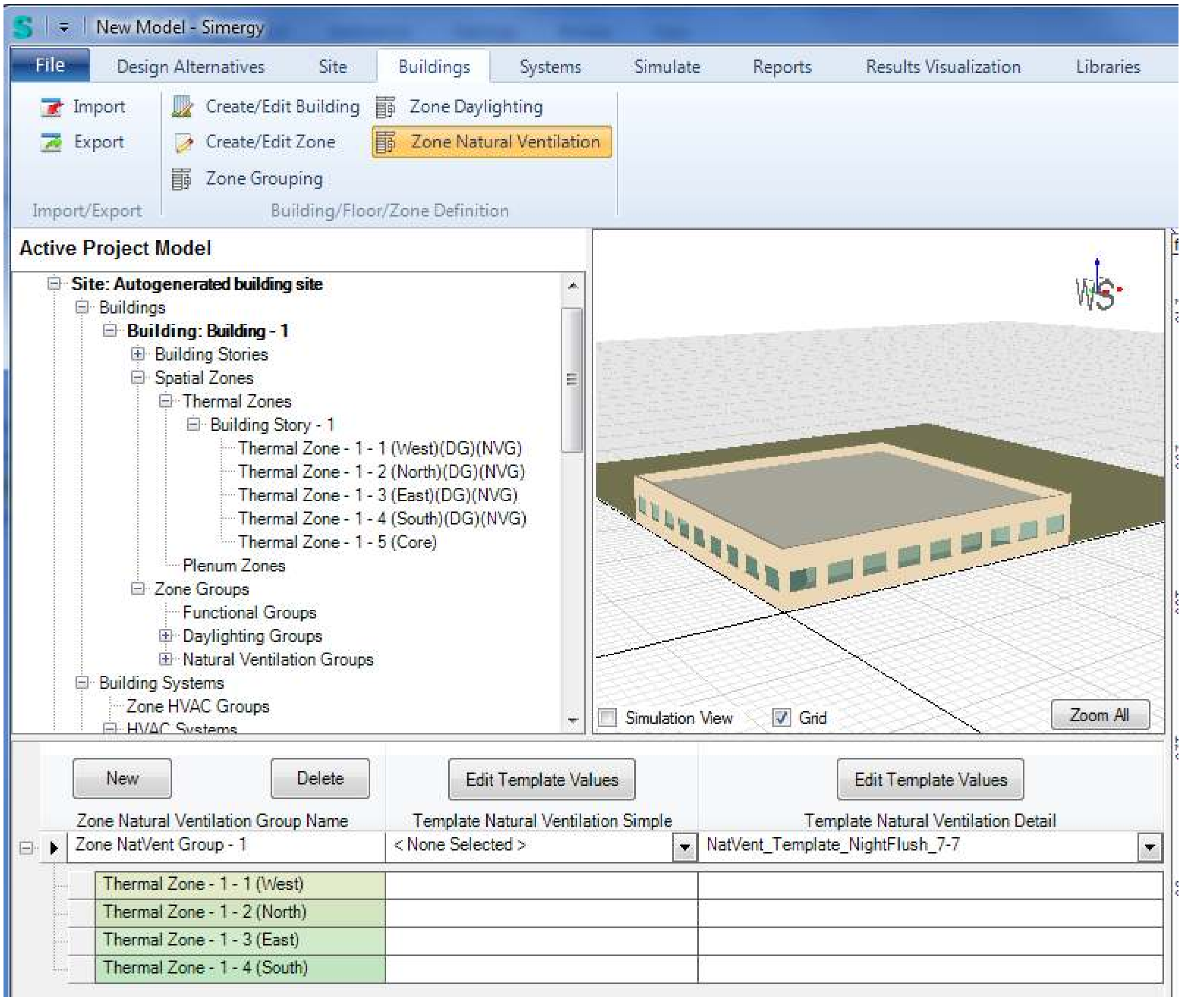
You can view and make changes to the Detailed Natural Ventilation Template by selecting Edit, which will open a pop-up dialog box, which provides the same capability as if you were working in the Templates > Natural Ventilation workspace. Each drop down list in the value column of the table is linked to a Libraries category that is the source for the list. You can either select a library entry from the available set packaged with the Simergy installation or create your own within the Libraries category. The Detailed Natural Ventilation Template topic identifies the drop down list source for each row and provides links to descriptions.



4. Detailed Natural Ventilation for portions of the building

The user can also assign different detailed NV templates to single or multiple Zone Natural Ventilation Groups. This is achieved through the *Zone Natural Ventilation* tab. Steps are as follows:

1. Click New to create a new Zone Natural Ventilation Group.
2. Select and drag thermal zones into the group.
3. Select a Natural Ventilation Detailed Template from the drop down menu.

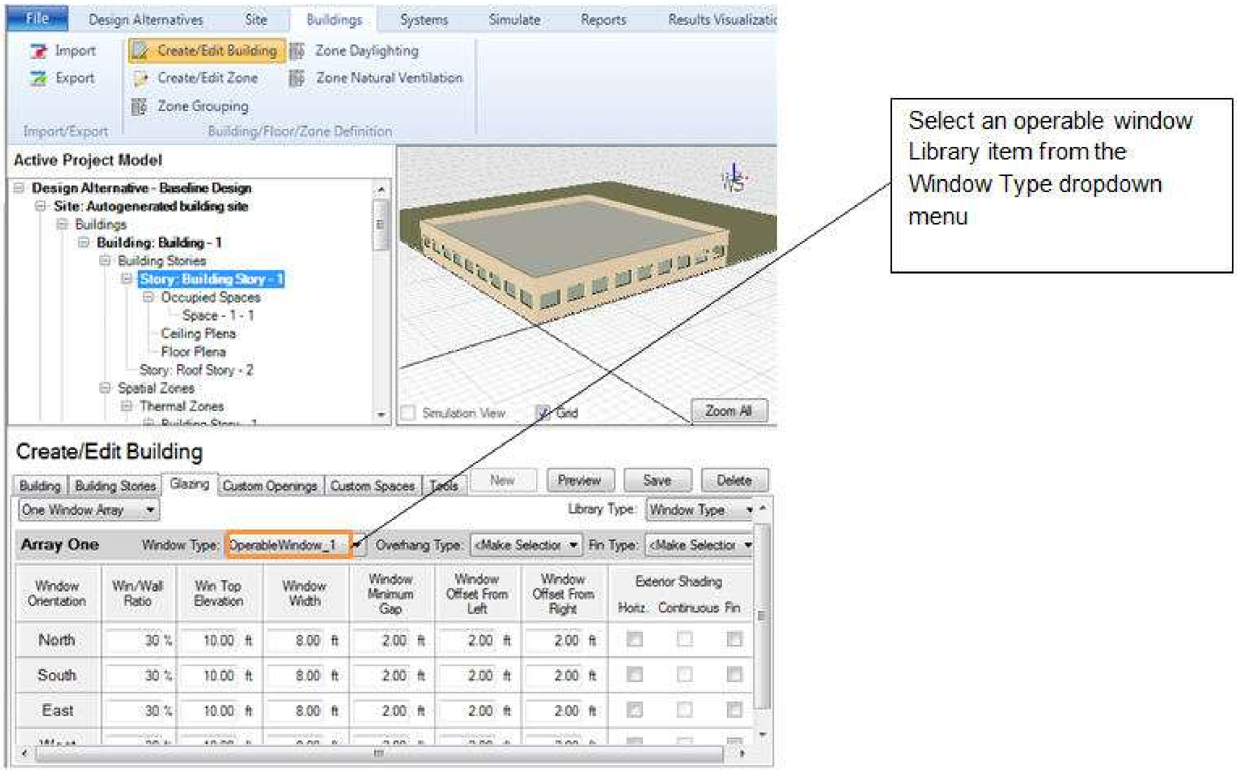


Note: Just as on the Building tab, you can select Edit Template Values, it will open a pop-up dialog box, which provides the same capability as if you were working in the Templates > Natural Ventilation workspace.

Assigning Operable Window Types

Next, the user selects which windows are operable and defines various opening parameters for each window opening. This is done through the *Glazing* and/or *Custom Openings* tab(s).

To select and apply one operable window type to all the windows in the building, use the *Glazing* tab and select an operable window Library item from the Window Type drop down menu, then click preview and save.



5. Detailed Natural Ventilation for the overall building and for portions of the building using Zone Natural Ventilation Groups

As you start to develop more complex Natural Ventilation models, you might find the need to have a "Detailed" Natural Ventilation Setting (Natural Ventilation Template) at the overall building level and also "Detailed" Natural Ventilation Settings (Natural Ventilation Template) at a Zone Ventilation Group(s) level. The model can be set up in the same manner as described in Scenario 3 and Scenario 4. The main thing to keep in mind is:

When a Natural Ventilation Template is selected at the whole building level it will be applied to every zone in the model except those zones that are part of a Zone Natural Ventilation Group. The Natural Ventilation Template selected for the Zone Natural Ventilation Group will override the template selected at the whole building level for the zones included in the Zone Natural Ventilation Group.

6. Setting up a Mixed Mode system for your model

When considering natural ventilation as a design strategy for different climates, a Mixed-Mode ventilation system might be the best approach to integrate natural ventilation into the design. A Mixed-Mode ventilation system is a hybrid ventilation approach (natural ventilation + mechanical) that uses a combination of natural ventilation from operable windows and mechanical systems that include air distribution equipment, and air conditioning equipment. The approach to set up a mixed mode system differs based on the type of HVAC System you are working with. If you are working with a system that doesn't have an explicit Air Loop set up then mixed mode capability is introduced at the Zone HVAC Group level via the Hybrid Availability Manager. If the HVAC system does have an air loop associated with it then the mixed mode capability is introduced in the Loop Level Controls via the Hybrid Availability Manager. Let's take a closer look at some examples.

Mixed Mode Example - ASHRAE Baseline System 1 (PTAC system)

Note: PTAC = Packaged Terminal Air Conditioner

If you wanted to take the ASHRAE Baseline System 1 and transform it into a Mixed Mode System, you would need to do a couple of things:

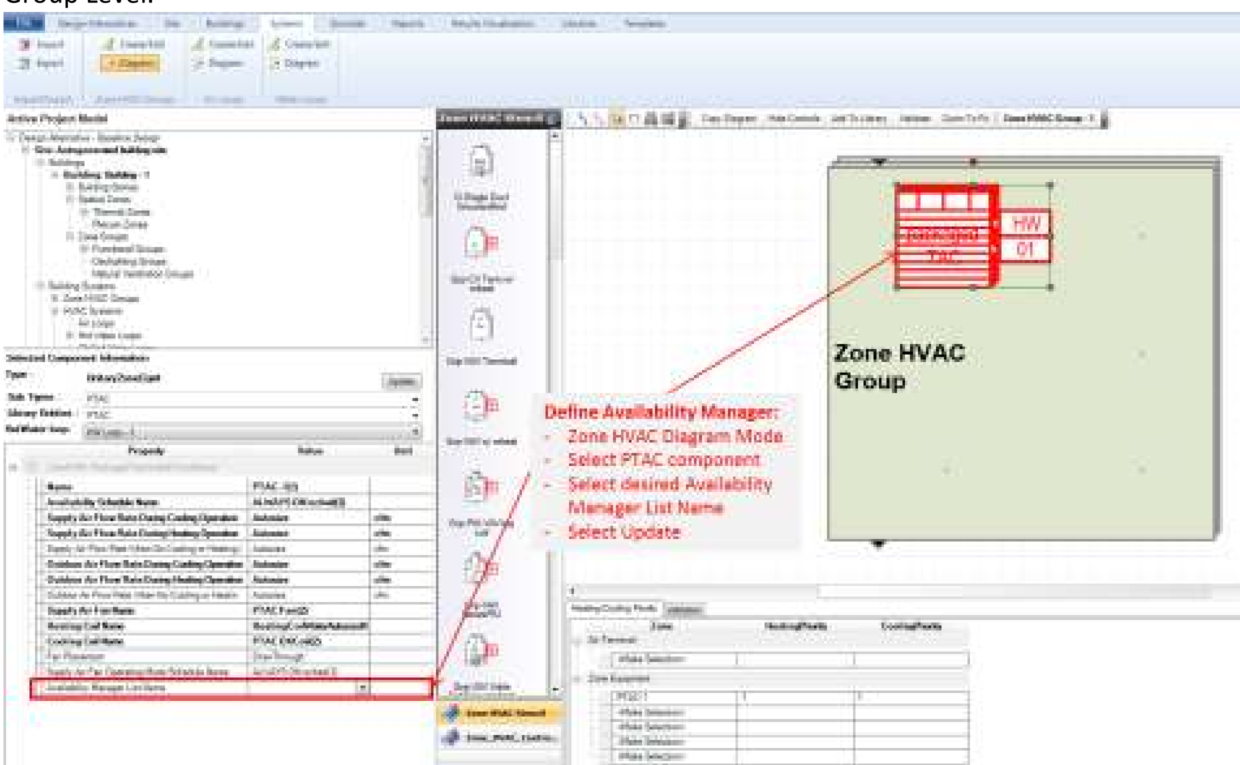
Activate Natural Ventilation

This can be accomplished in either of the following ways:

- Whole Building - Select Detailed and select Natural Ventilation Template. Applies to all of the thermal zones in the model, unless the thermal zones are part of a Zone Natural Ventilation Group that have a Natural Ventilation Template assigned to them.
- Zone Natural Ventilation Groups - set up a single or multiple groups with desired sets of thermal zones included. Assign Natural Ventilation Templates to each of the Zone Natural Ventilation Groups.
- A combination of the previous two...

Introduce Mixed Mode capability at the Zone HVAC Group Level

ASHRAE System 1 contains a packaged terminal air conditioning unit, which is self-contained and does not need an air loop set up. Therefore the mixed mode capabilities need to be added at the Zone HVAC Group Level.



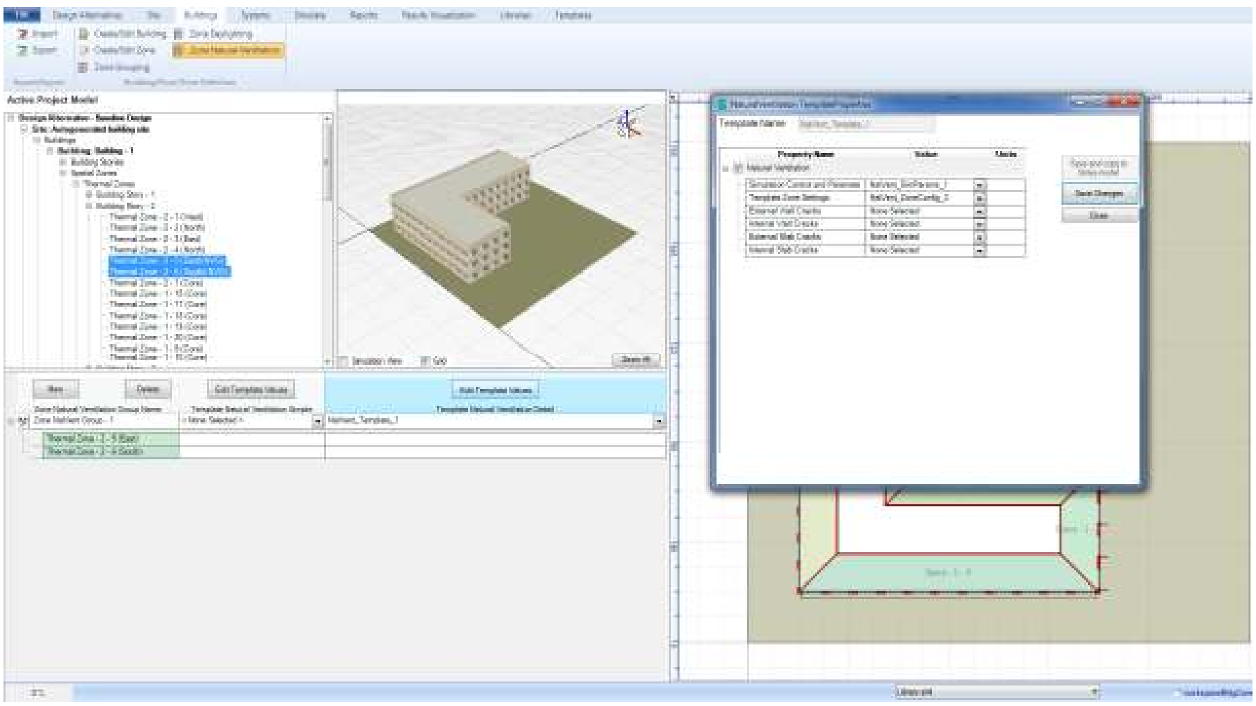
The image shows the Zone HVAC Diagram Mode for System 1, where the PTAC object has been selected and the properties are displayed on the lower left.

Mixed Mode Example - ASHRAE Baseline System 3 Packaged Rooftop Air Conditioner

Zone Natural Ventilation

Workspace: Buildings-Building/Floor/Zone Definition-Create/Zone Natural Ventilation
Workspace Areas: Active Project Model Tree - 3d view - 2d view
Related Workspaces: Zone Daylighting - Zone Grouping

The strategy is to allow the user to set up different Zone Natural Ventilation Groups within the model to assign either a Natural Ventilation Simple or Detailed Template to a group of zones, so that they do not have to be input individually. The user can also access and edit the templates selected directly from this workspace, versus having to go to the templates and/or libraries tabs.
Note: A user could have the same thermal zone within a Zone Group, a Zone Daylighting Group and a Zone Natural Ventilation Group. A thermal zone can only be in one Group within a type. This provides the user substantial flexibility in how thermal zones can be grouped and input values assigned.



When a user has assigned a thermal zone to a Zone Natural Ventilation Group, the letters (NVG) will appear at the end of the thermal zone listing on the Project Tree.

Zone Natural Ventilation Table

At a basic level, the table contains three columns. Once a Zone Group has been created (New) the user can then select single or multiple thermal zones from the Project Tree and drag and drop them into the table and associate them with a specific Zone Group.
Tip: When dragging and dropping thermal zones from the Project Tree, make sure to drop them on the Zone Group name.

Zone Natural Ventilation Group Name

The unique name that is assigned by default or is entered by the user. The name entered is the one that will appear in the Project Tree under Zone Groups/Natural Ventilation Groups.

Note: The user can select within the cell and edit the text directly to create a new name and/or edit the existing.

Template Natural Ventilation Simple

[drop down list] The user can select a Libraries Infiltration/Vent library entry from the drop down list. The options available are dependent upon the Source Library that is active. The Libraries Infiltration/Vent contains input properties for Equipment, People and Lighting.

Template Natural Ventilation Detail

[drop down list] The user can select a Natural Ventilation Template from the drop down list. The options available are dependent upon the Source Library that is active. The Natural Ventilation Template contains inputs for the property categories of Simulation Controls and parameters, template zone settings and crack properties.

New

Creates a new row in the table, and provides a default unique (sequential) name in the Zone Natural Ventilation Group Name column.

Delete

The user can select a Zone Group and then by selecting delete they can remove that Zone Natural Ventilation Group from the model.

Edit Library Entry Values - Natural Ventilation Simple

By selecting the user can directly access the selected Libraries Infiltration/Vent Library Entry via a pop-up window as shown in the image above. Within the pop-up window the user can make changes to the library entry just as they would if they went to the Libraries/Controls and Performance Data/Infiltration-Vent workspace. Within the pop-up dialog, if the user makes changes they have two "save options"

> ***Save Changes***
>
> Saves the Library Entry changes to the Project Model Source Library associated with the project.
>
> ***Save and Copy to Library Model***
>
> Saves the Library Entry changes to the source library that the Library Entry was created/is currently associated with.

Tip: If just reviewing the Templates content and no changes have been made, just select the red X in the upper right of the pop-up dialog to close it.

Edit Template Values - Natural Ventilation Detail

By selecting the user can directly access the selected Natural Ventilation Template via a pop-up window as shown in the image above. Within the pop-up window the user can make changes to the template just as they would if they went to the Templates/Data Templates/Natural Ventilation workspace. Within the pop-up dialog, if the user makes changes they have two "save options", as described above.

Natural Ventilation

Location = Libraries/Controls and Performance Data/Natural Ventilation

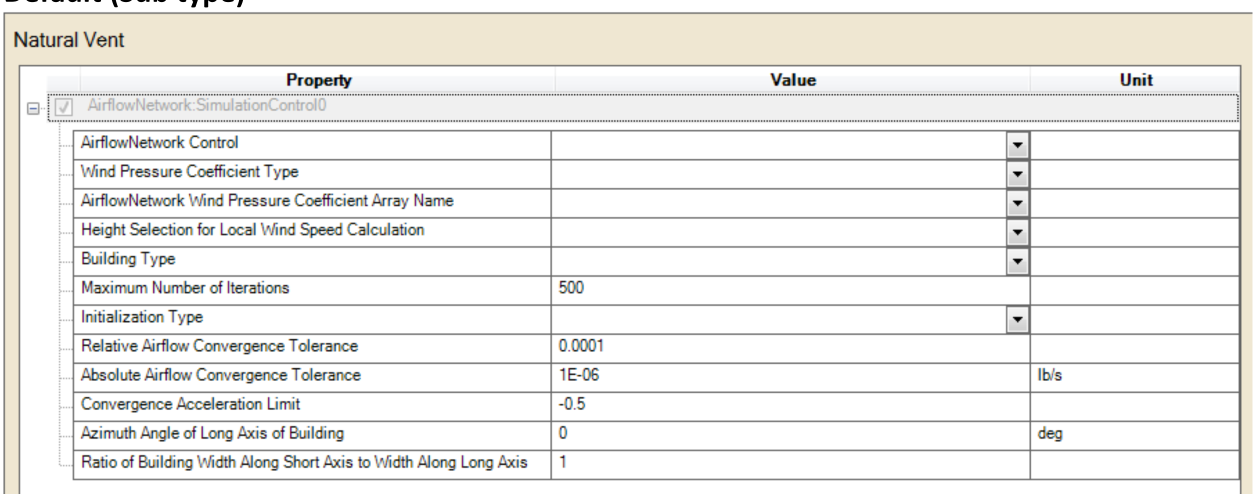
Type and Sub Type Mapping

The Type and Sub Type options that can be selected from the drop down lists in that area of the workspace, which filter the Source Library to display the variables the user can select to include, along with a value, in a Library Entry.

Type Options	Sub Type Options	EnergyPlus Objects (IO Reference links)
Air Flow Network	default	AirFlowNetwork:SimulationControl
Zone	default	AirFlowNetwork:Multizone:Zone
Surface Crack	default	AirFlowNetwork:Multizone:Surface:Crack AirFlowNetwork:Multizone:Surface:ReferenceCrackConditions

Air Flow Network (Type)

Default (Sub type)


Natural Vent

Property	Value	Unit
AirflowNetwork:SimulationControl0		
AirflowNetwork Control		
Wind Pressure Coefficient Type		
AirflowNetwork Wind Pressure Coefficient Array Name		
Height Selection for Local Wind Speed Calculation		
Building Type		
Maximum Number of Iterations	500	
Initialization Type		
Relative Airflow Convergence Tolerance	0.0001	
Absolute Airflow Convergence Tolerance	1E-06	lb/s
Convergence Acceleration Limit	-0.5	
Azimuth Angle of Long Axis of Building	0	deg
Ratio of Building Width Along Short Axis to Width Along Long Axis	1	

Field: AirflowNetwork Control

The following selections are available to control the Airflow Network simulation:

- **MultizoneWithDistribution:** Multizone air flow calculations are performed during all simulation timesteps, including the impacts of the air distribution system when a HVAC system fan is operating. Any **ZoneInfiltration:***, **ZoneVentilation:***, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are not simulated.
- **MultizoneWithoutDistribution**: Multizone air flow calculations are performed during all simulation timesteps, but the air distribution system portion of the network is not modeled even if it is specified in the input data file. Any **ZoneInfiltration:***, **ZoneVentilation:***, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are not simulated.
- **MultizoneWithDistributionOnlyDuringFanOperation:** Multizone air flow calculations, including the impacts of the air distribution system, are only performed when the HVAC system fan is operating. Any **ZoneInfiltration:***, **ZoneVentilation:***, **ZoneMixing** and **ZoneCrossMixing** objects

specified in the input data file are used when the HVAC system fan is OFF (if none are specified, then no air flow calculations are performed when the fan is OFF).

- **NoMultizoneOrDistribution:** No multizone air flow calculations (with or without the air distribution system portion of the network) are performed during the simulation. Any **ZoneInfiltration:***, **ZoneVentilation:***, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are simulated (if none are specified, then no air flow calculations are performed). Note: Having an input data file with no AirflowNetwork:SimulationControl objects gives the same impact – no multizone air flow calculations. However, this choice is provided as a convenience to the user to easily disable the multizone air flow calculations for an input data file that already contains AirflowNetwork objects.

> **Note:** A **ZoneInfiltration:*** object indicates any one of **ZoneInfiltration:DesignFlowRate**, **ZoneInfiltration:EffectiveLeakageArea**,and **ZoneInfiltration:FlowCoefficient** objects. A object of **ZoneVentilation:*** indicates any one of **ZoneVentilation:DesignFlowRate** and **ZoneVentilation:WindandStackOpenArea** objects**.**

Field: Wind Pressure Coefficient Type

Determines whether the wind pressure coefficients are input by the user or calculated. The choices are **Input** or **SurfaceAverageCalculation**, with the default being SurfaceAverageCalculation.

- If **INPUT**, user must enter an AirflowNetwork:MultiZone:WindPressureCoefficientArray object, one or more AirflowNetwork:MultiZone:ExternalNode objects, and one or more AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.
- If **SurfaceAverageCalculation**, it should only be used for **rectangular** buildings. In this case surface-average wind pressure coefficients vs. wind direction are calculated by the program for the four vertical facades and the roof based on user entries for "Building Type," "Azimuth Angle of Long Axis of Building," and "Ratio of Building Width Along Short Axis to Width Along Long Axis" (see description of these fields below). With this choice you do **not** have to enter any of the following objects: AirflowNetwork:MultiZone: Wind Pressure Coefficient Array, AirflowNetwork:MultiZone:ExternalNode and AirflowNetwork:MultiZone:WindPressureCoefficientValues.

Field: AirflowNetwork Wind Pressure Coefficient Array Name

This is the name of the AirflowNetwork:MultiZone:WindPressureCoefficientArray object that contains wind directions corresponding to the wind pressure coefficients given in the AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.

Field: Height Selection for Local Wind Speed Calculation

Determines whether the local wind speed is calculated based on either given external node heights or surface opening heights. The choices are **ExternalNode** or **OpeningHeight**, with the default being OpeningHeight. The local outdoor wind speed calculation procedure is given in the section of "Local Wind Speed Calculation" in the Engineering Reference. The calculation procedure requires the height input.

- If **ExternalNode**, the heights given in the AirflowNetwork:MultiZone:ExternalNode objects are used to calculate local wind speeds. Used only if Wind Pressure Coefficient Type = INPUT (see description of previous field).

- If **OpeningHeight**, the number of the AirflowNetwork:MultiZone:ExternalNode objects has to be equal to the number of external surfaces defined in the AirflowNetwork:MultiZone:Surface objects. The centroids in the z direction of the AirflowNetwork:MultiZone:Surface objects are the heights used in the local wind speed calculation. The input is required if Wind Pressure Coefficient Type = INPUT (see description of previous field).

If Wind Pressure Coefficient Type = **SurfaceAverageCalculation**, a value in this field is not required and a blank may be entered. The default choice is used internally to generate the AirflowNetwork:MultiZone:ExternalNode objects

Field: Building Type

Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The choices for Building Type are LowRise and HighRise, with the default being LowRise.

LowRise corresponds to a rectangular building whose height is less than three times the width of the footprint (w_{short} in Figure 80) and is less than three times the length of the footprint (w_{long} in the same figure).

HighRise corresponds to a rectangular building whose height is more than three times the width of the footprint (w_{short} in Figure 80) or is more than three times the length of the footprint (w_{long} in the same figure).

Field: Maximum Number of Iterations

The maximum number of iterations allowed in finding an AirflowNetwork solution. If the number of iterations at each simulation timestep is above the maximum number of iterations defined by this field, the program could not find the solution and a Severe error is issued and the program is aborted. The default value is 500.

Field: Initialization Type

Designates which method is used for AirflowNetwork initialization. The choices for Initialization Type are LinearInitializationMethod and ZeroNodePressures, with the default being ZeroNodePressures.

Field: Relative Airflow Convergence Tolerance

The solution is assumed to have converged when is less than the value specified for this input field. This convergence criteria is equivalent to the ratio of the absolute value of the sum of all network airflows ( ) to the sum of network airflow magnitudes ( ). The default value is 1.0×10^{-4}.

Field: Absolute Airflow Convergence Tolerance

The solution is assumed to have converged when the summation of the absolute value of all network airflows ( ) is less than the value specified for this input field. The default value is 1.0×10^{-6}.

Field: Convergence Acceleration Limit

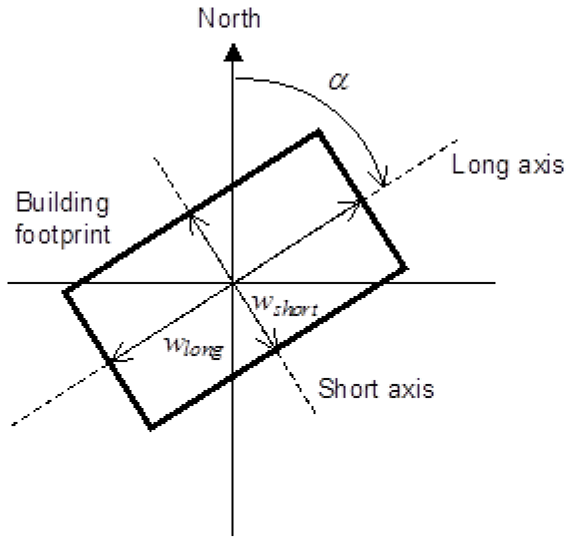
If the ratio of successive pressure corrections is less than this limit, use Steffensen acceleration algorithm (Ref. AirflowNetwork Model in the EnergyPlus Engineering Reference). The range for this field is -1 to 1, with the default value being -0.5.

Field: Azimuth Angle of Long Axis of Building

Gives the orientation of a rectangular building for calculating wind pressure coefficients. This is the smaller of the angles, measured clockwise, between North and the long axis of the building (see Figure 80). Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The range for this input is 0 to 180, with the default value being 0.

Field: Ratio of Building Width Along Short Axis to Width Along Long Axis

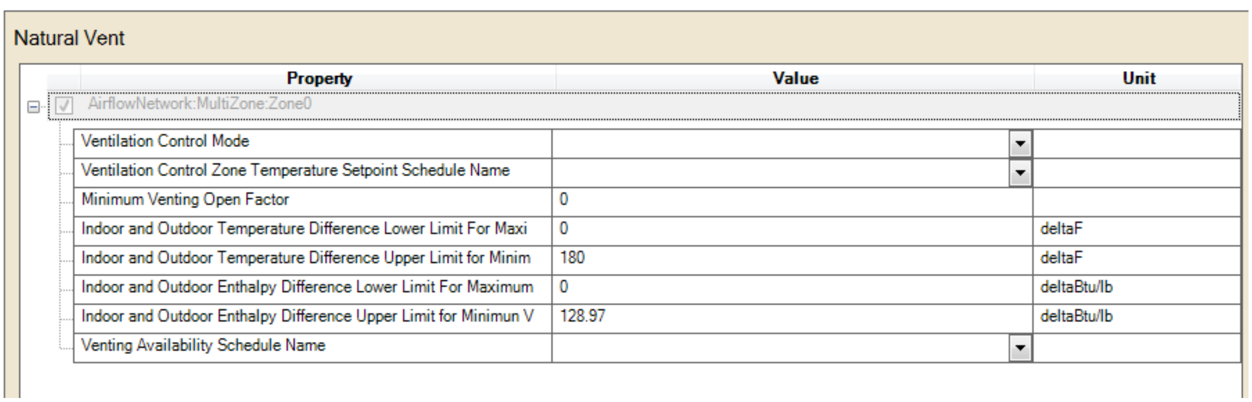
This is the aspect ratio of a rectangular footprint. It is given by the width of the footprint along its short axis divided by the width along the long axis (see Figure 80). If the footprint is square, the value of this field is 1.0. Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The range for this input is > 0 to 1, with the default value being 1.



Source: EnergyPlus IO Reference - Footprint of a rectangular building showing variables used by the program to calculate surface-average wind pressure coefficients. The angle □ is the "Azimuth Angle of Long Axis of Building." w_{short}/w_{long} is the "Ratio of Building Width Along Short Axis to Width Along Long Axis."

Zone (Type)

Default (Sub type)



Natural Vent

Property	Value	Unit
AirflowNetwork:MultiZone:Zone0		
Ventilation Control Mode		
Ventilation Control Zone Temperature Setpoint Schedule Name		
Minimum Venting Open Factor	0	
Indoor and Outdoor Temperature Difference Lower Limit For Maxi	0	deltaF
Indoor and Outdoor Temperature Difference Upper Limit for Minim	180	deltaF
Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum	0	deltaBtu/lb
Indoor and Outdoor Enthalpy Difference Upper Limit for Minimun V	128.97	deltaBtu/lb
Venting Availability Schedule Name		

This object allows control of natural ventilation through exterior and interior openings in a zone, where "opening" is defined as an openable window or door, and it is required to perform Airflow Network calculations.

Field: Ventilation Control Mode

Specifies the type of zone-level natural ventilation control.

Let T_{out} equal the outdoor air temperature, T_{zone} equal the previous timestep's zone air temperature, T_{set} equal the Vent Temperature Schedule value, H_{zone} equal the specific enthalpy of zone air from the previous timestep, and H_{out} equal the specific enthalpy of outdoor air. Then the four allowed choices for Ventilation Control Mode are:

- **NoVent**: All of the zone's openable windows and doors are closed at all times independent of indoor or outdoor conditions. The Venting Availability Schedule is ignored in this case. This is the default value for this field.
- **Temperature**: All of the zone's openable windows and doors are opened if $T_{zone} > T_{out}$ **and** $T_{zone} > T_{set}$ **and** Venting Availability Schedule (see below) allows venting.
- **Enthalpy:** All of the zone's openable windows and doors are opened if $H_{zone} > H_{out}$ **and** $T_{zone} > T_{set}$ **and** Venting Availability Schedule allows venting.
- **Constant**: Whenever this object's Venting Availability Schedule allows venting, all of the zone's openable windows and doors are open, independent of indoor or outdoor conditions. Note that "Constant" here means that the size of each opening is fixed while venting; the air flow through each opening can, of course, vary from timestep to timestep**.**
- **ASHRAE55AdaptiveComfort**: All of the zone's operable windows and doors are opened if the operative temperature is greater than the comfort temperature (central line) calculated from the ASHRAE Standard 55-2010 adaptive comfort model and Venting Availability Schedule allows venting.
- **CEN15251AdaptiveComfort:** All of the zone's operable windows and doors are opened if the operative temperature is greater than the comfort temperature (central line) calculated from the CEN15251 adaptive comfort model and Venting Availability Schedule allows venting.

Field: Ventilation Control Zone Temperature Setpoint Schedule Name

The name of a schedule of zone air temperature set points that controls the opening of windows and doors in the thermal zone to provide natural ventilation. This setpoint is the temperature above which all the openable windows and doors in the zone will be opened if the conditions described in the previous field Ventilation Control Mode are met. The Ventilation Control Zone Temperature Setpoint Schedule Name applies only to windows and doors in the zone that are specified.

Field: Minimum Venting Open Factor

See Figure 1 or Figure 2. This field applies only if Ventilation Control Mode = Temperature or Enthalpy. This value may be from zero to 1.0, with the default being 0.0.

Field: Indoor and Outdoor Temperature Difference Lower Limit For Maximum Venting Open Factor

See Figure 1. This field applies only if Ventilation Control Mode = Temperature. This value may be from zero to less than 100˚C, with the default being 0˚C. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Temperature Difference Upper Limit for Minimun Venting Open Factor

See Figure 1. This field applies only if Ventilation Control Mode = Temperature. This value must be greater than 0˚C, with the default being 100˚C. The value for this field must be greater than the value specified for the previous field..

Field: Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum Venting Open Factor

See Figure 2. This field applies only if Ventilation Control Mode = Enthalpy. This value may be from zero to less than 300,000 J/kg, with the default being 0 J/kg. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Enthalpy Difference Upper Limit for Minimun Venting Open Factor

See Figure 2. This field applies only if Ventilation Control Mode = Enthalpy. This value must be greater than zero, with the default being 300,000 J/kg. The value for this field must be greater than the value specified for the previous field.

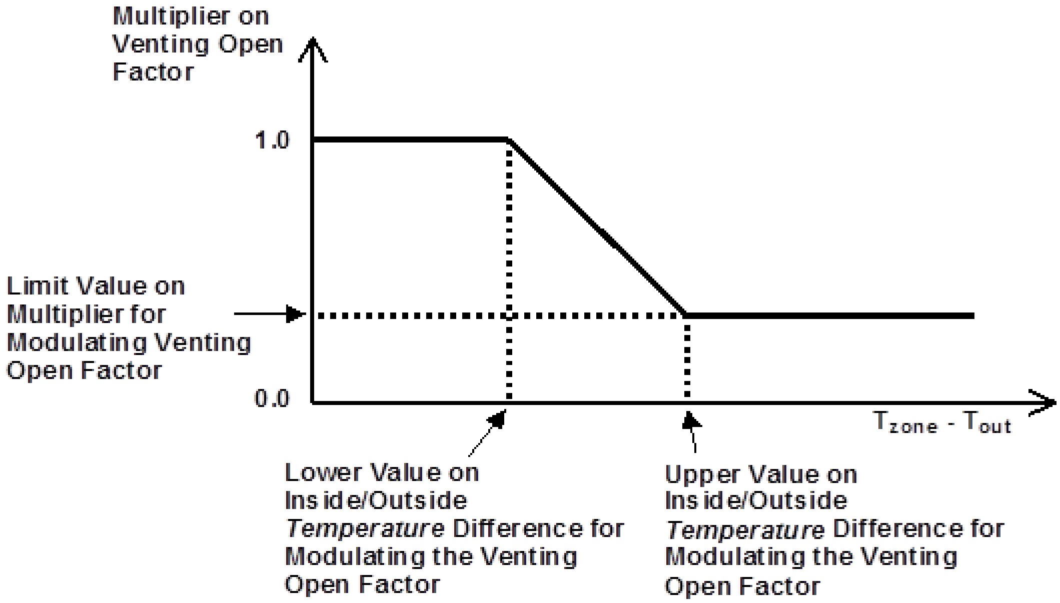


Figure 1: Modulation of venting area according to inside-outside temperature difference (Source: EnergyPlus IO Reference, Figure 81)

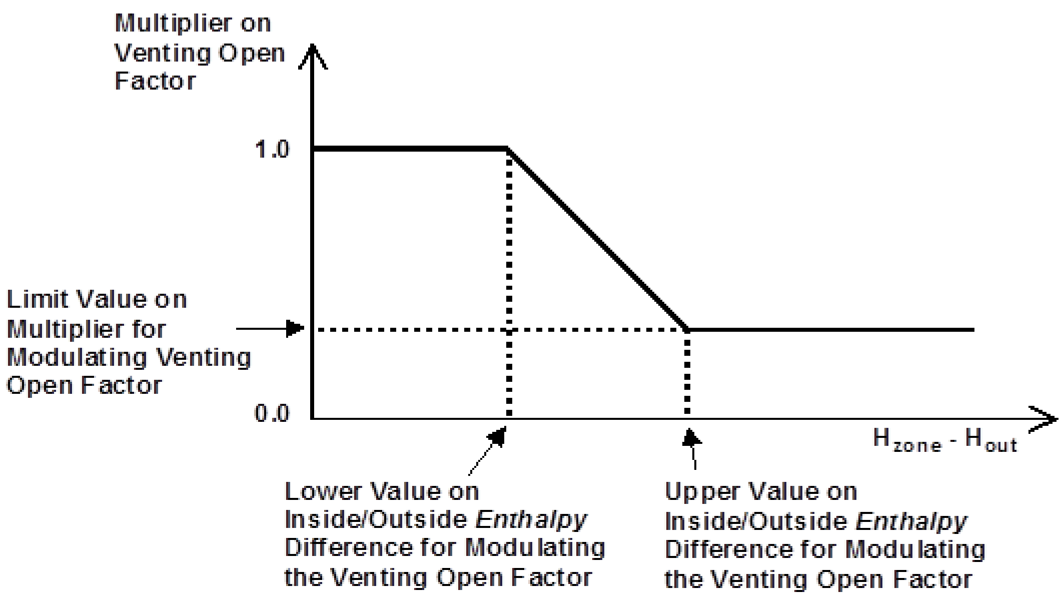


Figure 2: Modulation of venting area according to inside-outside enthalpy difference (Source: EnergyPlus IO Reference, Figure 82)

Note: In order to establish an airflow network, there must be at least two surfaces defined, so that air can flow from one zone into other zones (or to outdoors) through the network (air mass flow conserved).

Field: Venting Availability Schedule Name

The name of a schedule that specifies when venting is available. A zero or negative schedule value means venting is not allowed. A value greater than zero means venting can occur if other venting control conditions are satisfied.

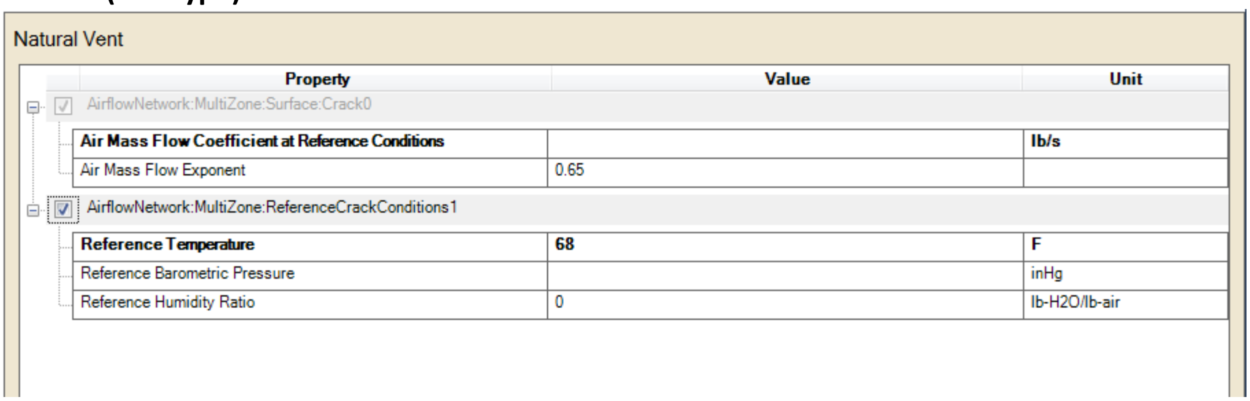
Tip: If a Venting Availability Schedule Name is not specified, it is assumed that venting is always available.

Using Venting Availability Schedule allows you to turn off venting at certain times of the day (at night, for example), of the week (on weekends, for example), or of the year (during the winter, for example).

If used with Ventilation Control Mode = Constant, the ventilation rate is constant only when this schedule allows venting; otherwise the ventilation rate is set to zero.
If Ventilation Control Mode = NoVent, this schedule has no effect.

Surface Crack (Type)

Default (Sub type)



Specifies the properties of air flow through a crack and the associated measurement conditions. The following power law form is used that gives air flow through the crack as a function of the pressure difference across the crack:

Where
Q = air mass flow (kg/s)
C_Q = air mass flow coefficient (kg/s-Pa^n @ 1 Pa)
C_T = reference condition temperature correction factor (dimensionless)
= pressure difference across crack (Pa)
n = air flow exponent (dimensionless)

where
ρ = Air density at the specific air temperature and humidity ratio conditions [kg/m^3]
ν = Air kinetic viscosity at the specific air temperature condition [m^2/s]
ρ_o = Air density at the reference air conditions provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [kg/m^3]

ν_o = Air kinetic viscosity at the reference air temperature provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [m^2/s]

AirFlowNetwork:Multizone:Surface:Crack

Field: Air Mass Flow Coefficient at Reference Conditions

The value of the air mass flow coefficient, , in the crack air flow equation. It has units of kg/s at 1Pa. This value must be greater than zero.

Field: Air Mass Flow Exponent

The value of the exponent, n, in the crack air flow equation. The valid range is 0.5 to 1.0, with the default value being 0.65.

AirFlowNetwork:Multizone:Surface:ReferenceCrackConditions

Specifies the reference conditions for temperature, humidity, and pressure..

Field: Reference Temperature

The reference temperature in °C under which the Surface Crack Data were obtained. The default value is 20°C.

Field: Reference Barometric Pressure

The reference barometric pressure in Pa under which the Surface Crack Data were obtained. The default value is 101325 Pa.

Field: Reference Humidity Ratio

The reference humidity ratio in kg/kg under which the Surface Crack Data were obtained. The default value is 0 kg/kg.

Infiltration/Ventilation

Location = Libraries/Controls and Performance Data/Infiltration-Ventilation

Each Type in the Type and Sub Type table contains a section that displays a screenshot of the Property Values Table showing the properties associated with the Type and Sub Type. In the case where the Sub Types have the same properties only one example of the Property Values table is shown. See Property Values Table to learn about how to interact with the table.
Note: *Although not yet fully implemented the intent is that for each section there will be links directly to the EnergyPlus Input Output Reference. In addition the links will also be included in the Type and Sub Type Mapping Table.*

Type and Sub Type Mapping

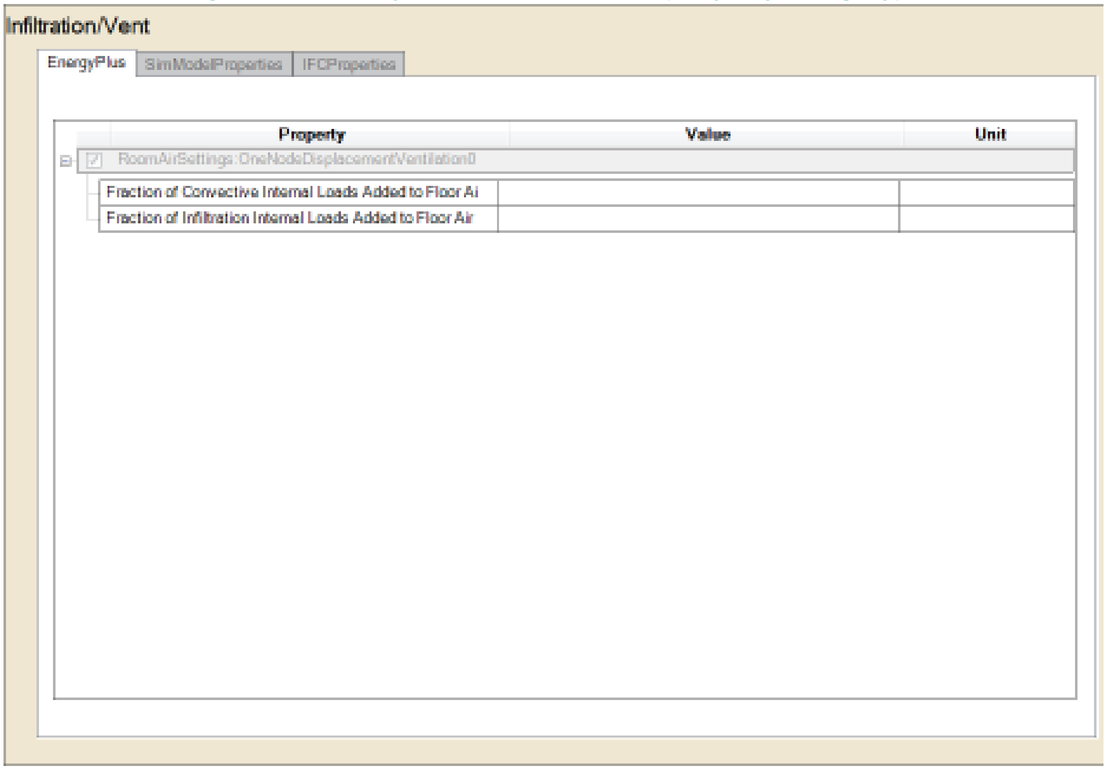
The Infiltration/Ventilation Type and Sub Type options that can be selected from the drop down lists in that area of the workspace, which filter the Source Library to display the variables the user can select to include, along with a value, in a Library Entry.

Type Options	Sub Type Options	EnergyPlus Objects (IO Reference links)
Room Air Settings	One Node Displacement Ventilation Three Node Displacement Ventilation Cross Ventilation Under Floor Air Distribution Interior Under Floor Air Distribution Exterior	RoomAirSettings:OneNodeDisplacementVentila RoomAirSettings:ThreeNodeDisplacementVenti RoomAirSettings:CrossVentilation RoomAirSettings:UnderFloorAirDistributionInteri RoomAirSettings:UnderFloorAirDistributionExte
Zone Infiltration	Design Flow Rate Effective Leakage Area Flow Coefficient	ZoneInfiltration:DesignFlowRate ZoneInfiltration:EffectiveLeakageArea ZoneInfiltration:FlowCoefficient
Zone Ventilation	Design Flow Rate Wind and Stack Open Area	ZoneVentilation:DesignFlowRate ZoneVentilation:WindandStackOpenArea

Room Air Settings (Type)

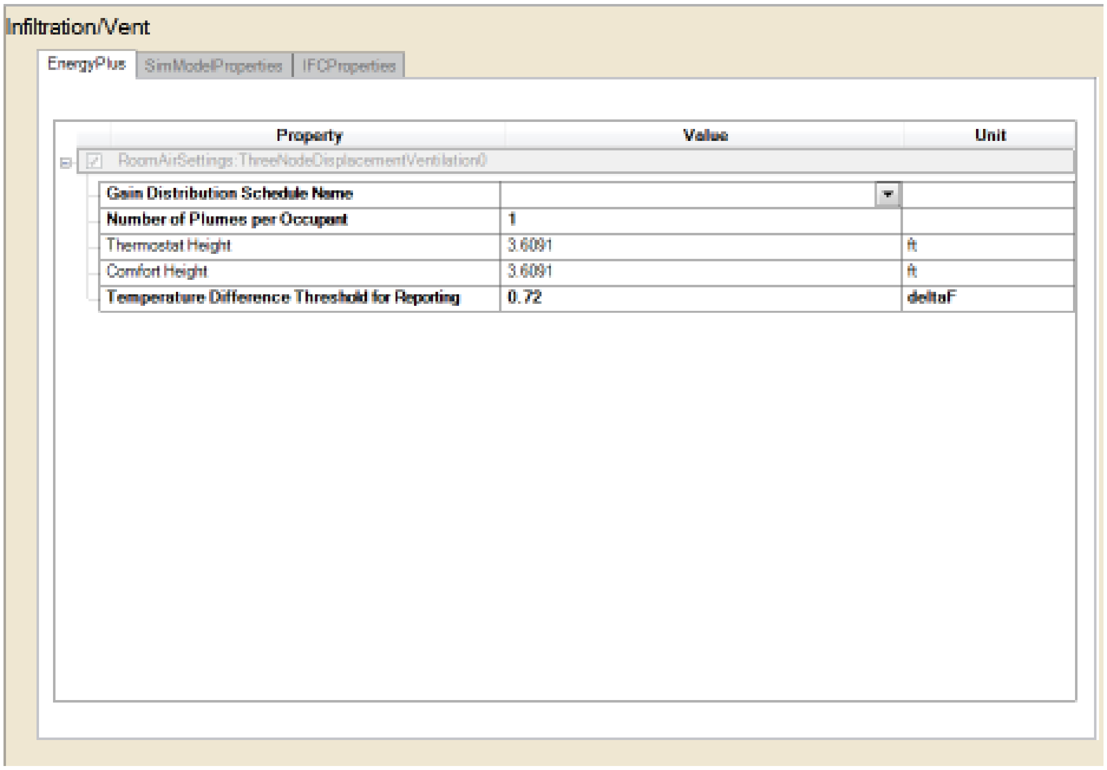
One Node Displacement Ventilation (Sub Type)

RoomFloorSettings:OneNodeDisplacementVentilation (Property Category)



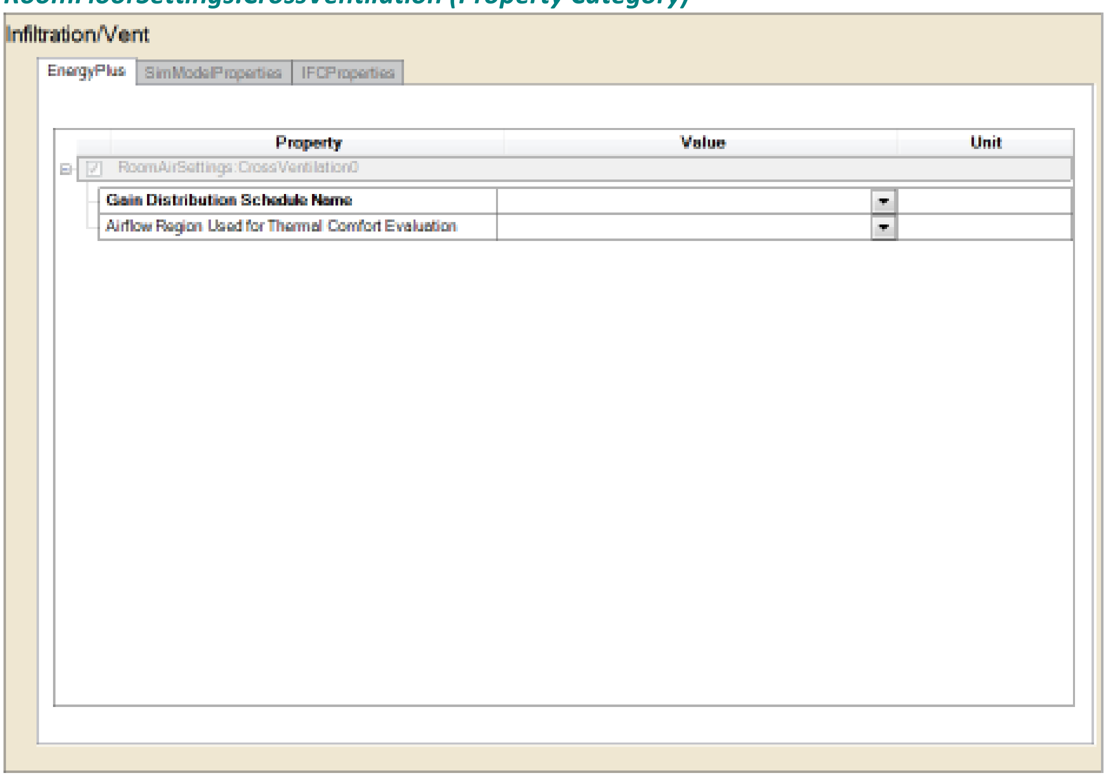
Three Node Displacement Ventilation (Sub Type)

RoomFloorSettings:ThreeNodeDisplacementVentilation (Property Category)



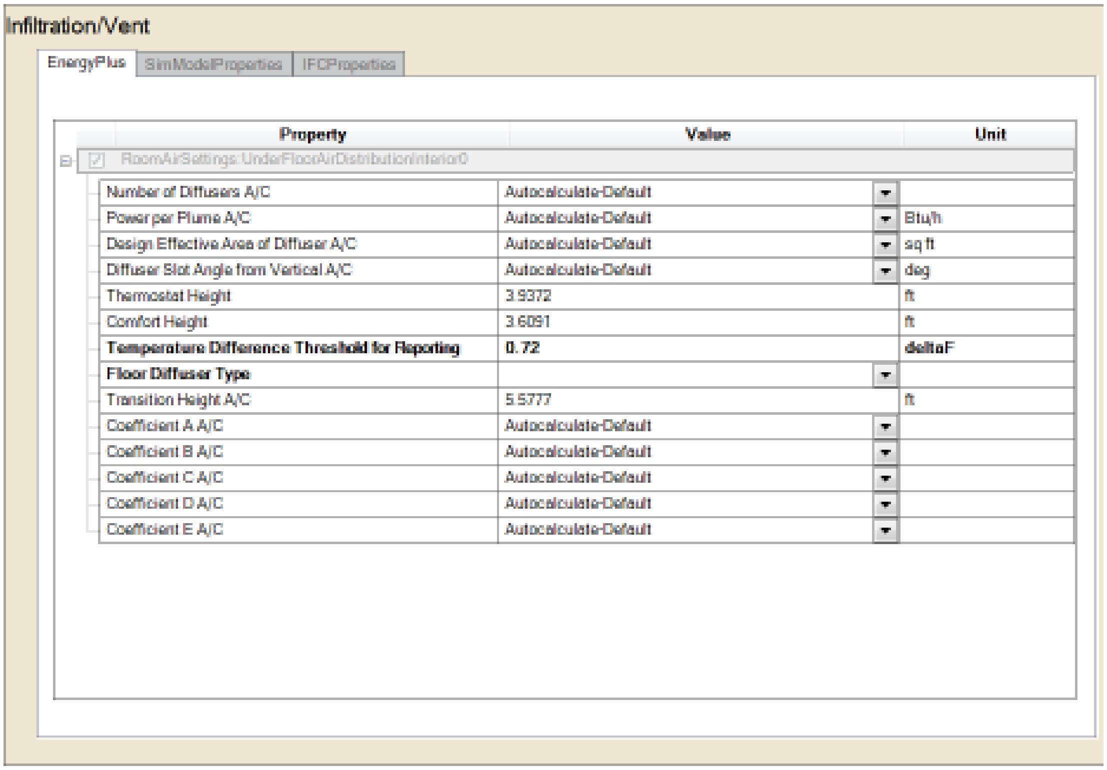
Cross Ventilation (Sub Type)

RoomFloorSettings:CrossVentilation (Property Category)



Under Floor Air Distribution Interior (Sub Type)

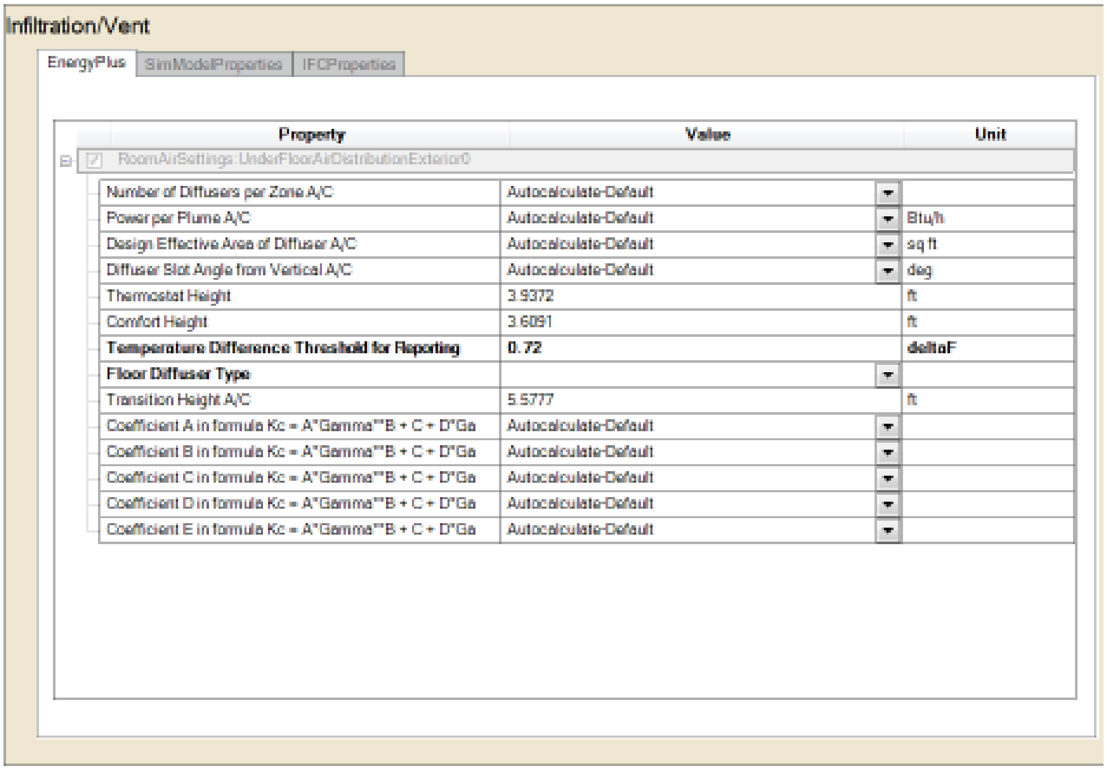
RoomFloorSettings:UnderFloorAirDistribution:Interior (Property Category)



Property	Value	Unit
Number of Diffusers A/C	Autocalculate-Default	
Power per Plume A/C	Autocalculate-Default	Btu/h
Design Effective Area of Diffuser A/C	Autocalculate-Default	sq ft
Diffuser Slot Angle from Vertical A/C	Autocalculate-Default	deg
Thermostat Height	3.9372	ft
Comfort Height	3.6091	ft
Temperature Difference Threshold for Reporting	**0.72**	**deltaF**
Floor Diffuser Type		
Transition Height A/C	5.5777	ft
Coefficient A A/C	Autocalculate-Default	
Coefficient B A/C	Autocalculate-Default	
Coefficient C A/C	Autocalculate-Default	
Coefficient D A/C	Autocalculate-Default	
Coefficient E A/C	Autocalculate-Default	

Under Floor Air Distribution Exterior (Sub Type)

RoomFloorSettings:UnderFloorAirDistribution:Exterior (Property Category)

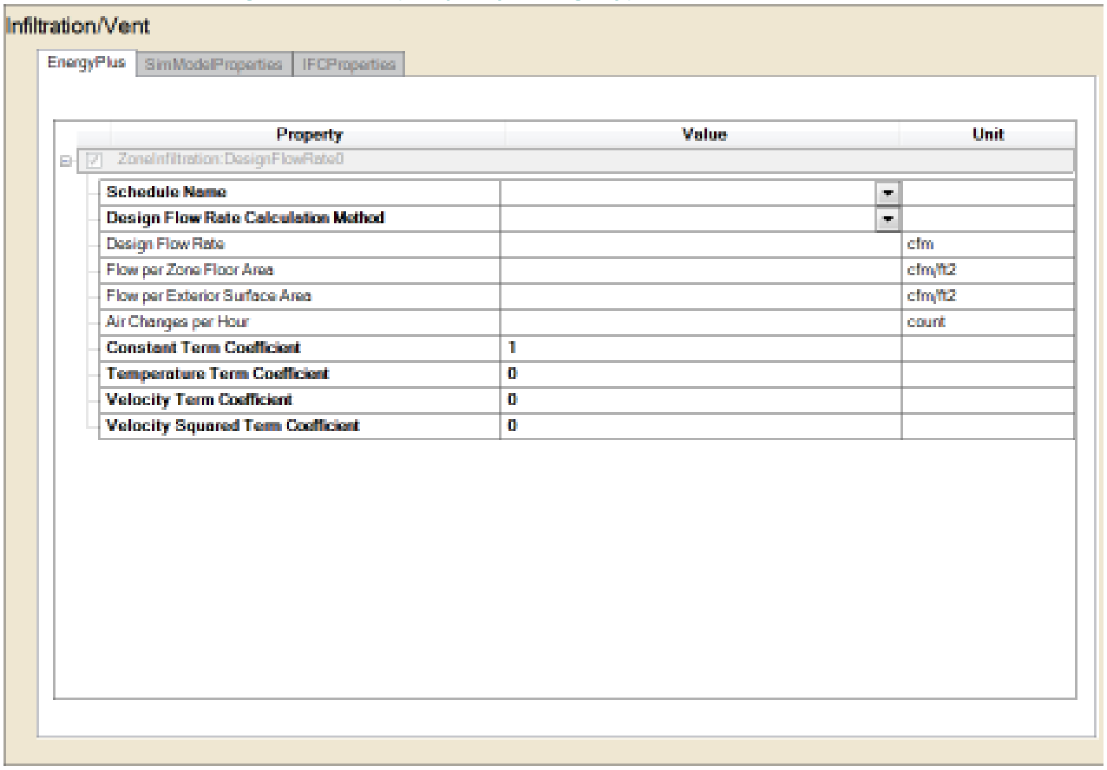


Property	Value	Unit
Number of Diffusers per Zone A/C	Autocalculate-Default	
Power per Plume A/C	Autocalculate-Default	Btu/h
Design Effective Area of Diffuser A/C	Autocalculate-Default	sq ft
Diffuser Slot Angle from Vertical A/C	Autocalculate-Default	deg
Thermostat Height	3.9372	ft
Comfort Height	3.6091	ft
Temperature Difference Threshold for Reporting	**0.72**	**deltaF**
Floor Diffuser Type		
Transition Height A/C	5.5777	ft
Coefficient A in formula Kc = A*Gamma**B + C + D*Ga	Autocalculate-Default	
Coefficient B in formula Kc = A*Gamma**B + C + D*Ga	Autocalculate-Default	
Coefficient C in formula Kc = A*Gamma**B + C + D*Ga	Autocalculate-Default	
Coefficient D in formula Kc = A*Gamma**B + C + D*Ga	Autocalculate-Default	
Coefficient E in formula Kc = A*Gamma**B + C + D*Ga	Autocalculate-Default	

Zone Infiltration (Type)

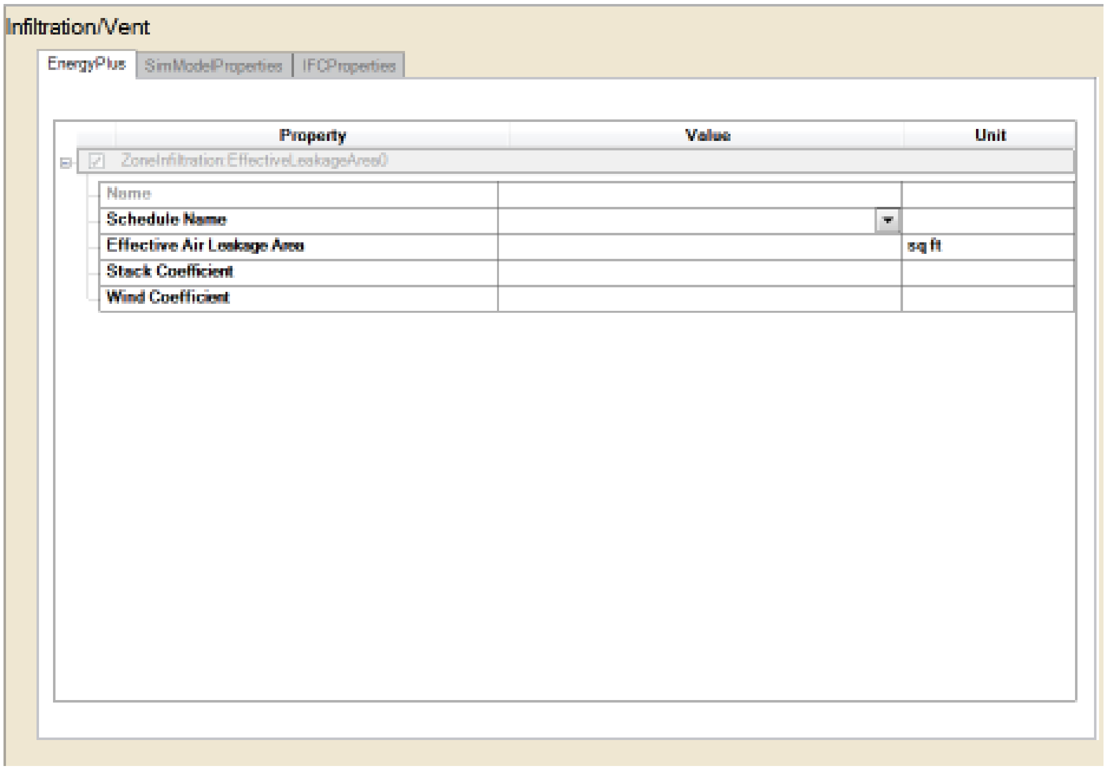
Design Flow Rate (Sub Type)

oneVentilation:DesignFlowRate (Property Category)



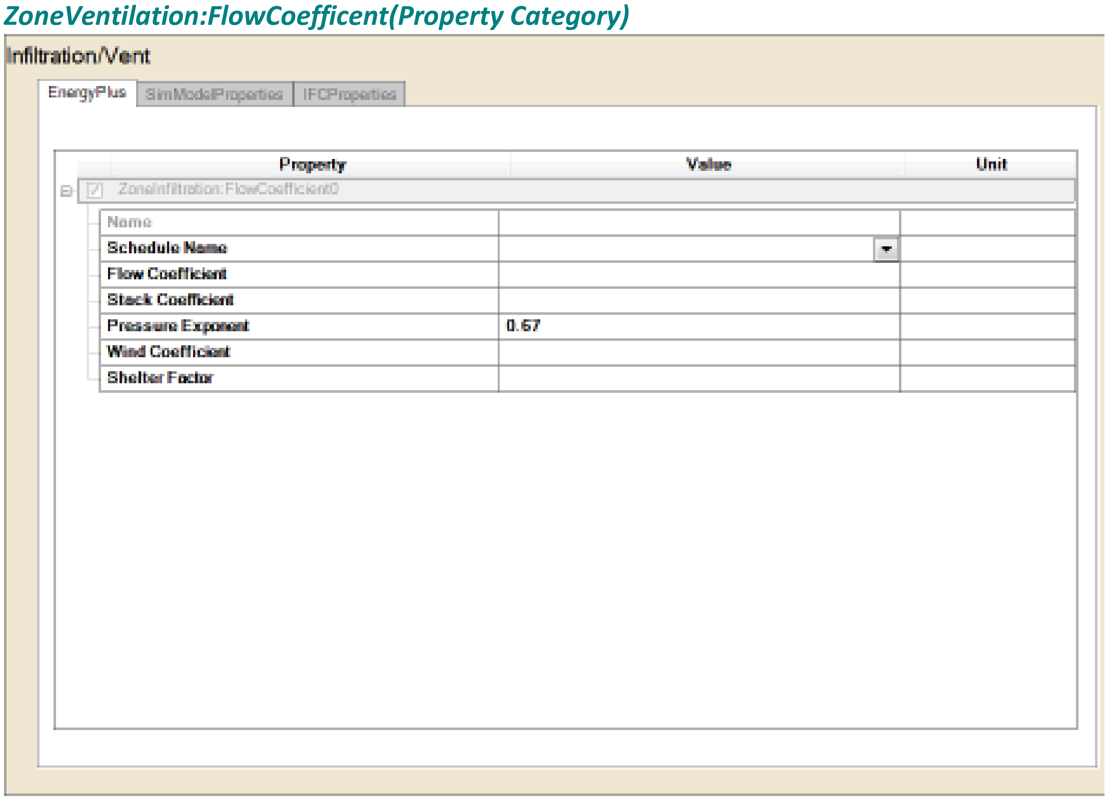
Effective Leakage Area (Sub Type)

ZoneVentilation:EffectiveLeakageArea (Property Category)



Flow Coefficient (Sub Type)

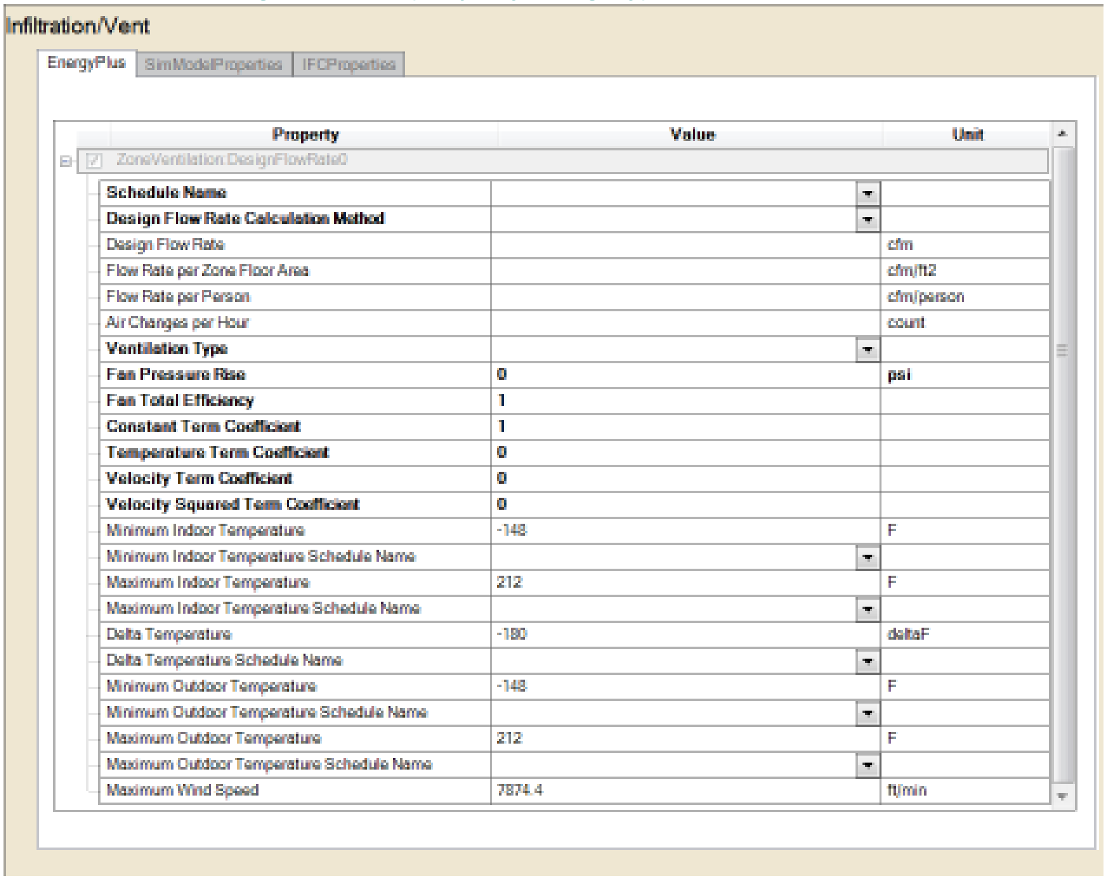
ZoneVentilation:FlowCoefficent(Property Category)



Zone Ventilation (Type)

Design Flow Rate (Sub Type)

ZoneVentilation:DesignFlowRate (Property Category)



Infiltration/Vent

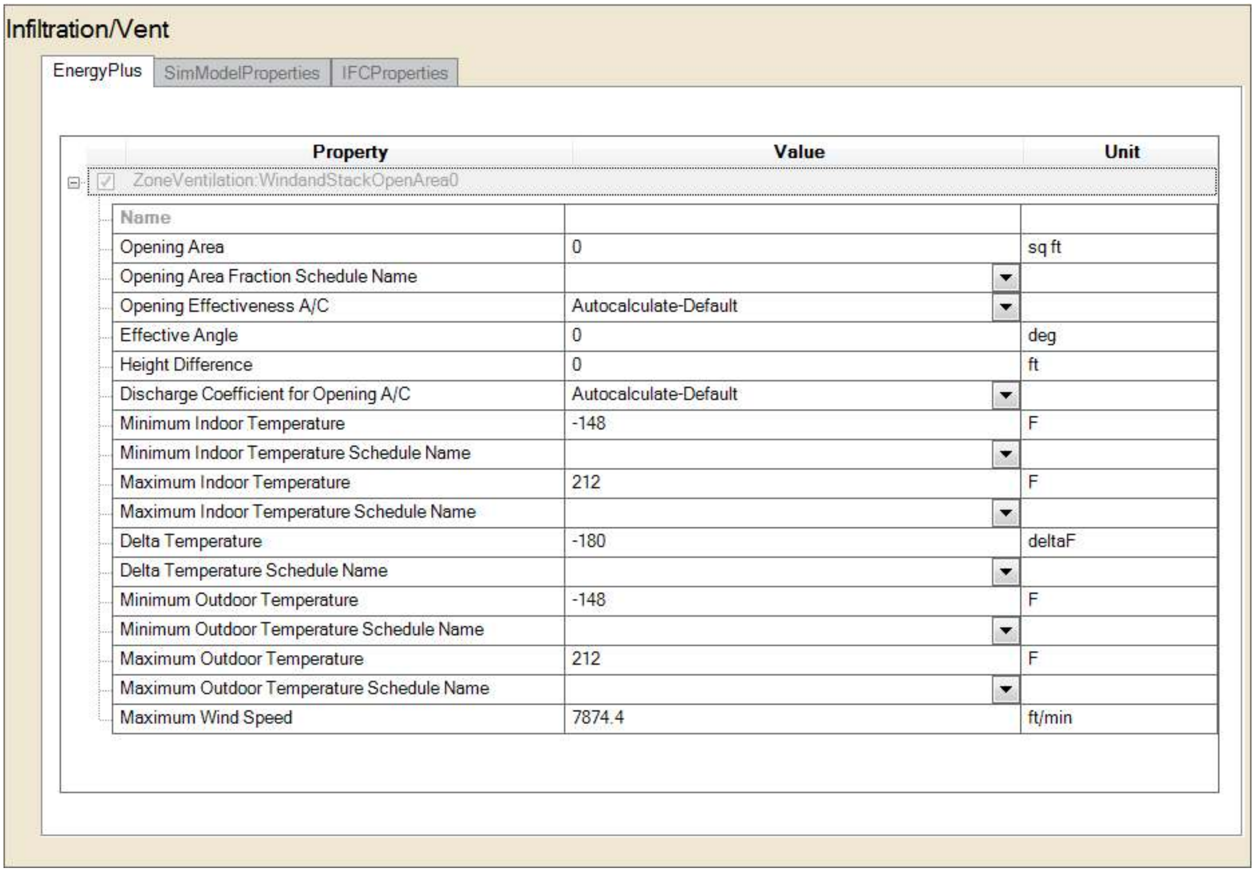
EnergyPlus | SimModelProperties | IFCProperties

ZoneVentilation:DesignFlowRate0

Property	Value	Unit
Schedule Name		
Design Flow Rate Calculation Method		
Design Flow Rate		cfm
Flow Rate per Zone Floor Area		cfm/ft2
Flow Rate per Person		cfm/person
Air Changes per Hour		count
Ventilation Type		
Fan Pressure Rise	**0**	**psi**
Fan Total Efficiency	**1**	
Constant Term Coefficient	**1**	
Temperature Term Coefficient	**0**	
Velocity Term Coefficient	**0**	
Velocity Squared Term Coefficient	**0**	
Minimum Indoor Temperature	-148	F
Minimum Indoor Temperature Schedule Name		
Maximum Indoor Temperature	212	F
Maximum Indoor Temperature Schedule Name		
Delta Temperature	-180	deltaF
Delta Temperature Schedule Name		
Minimum Outdoor Temperature	-148	F
Minimum Outdoor Temperature Schedule Name		
Maximum Outdoor Temperature	212	F
Maximum Outdoor Temperature Schedule Name		
Maximum Wind Speed	7874.4	ft/min

Wind and Stack Open Area (Sub Type)

ZoneVentilation:WindandStackOpenArea(Property Category)



Infiltration/Vent

EnergyPlus | SimModelProperties | IFCProperties

ZoneVentilation:WindandStackOpenArea0

Property	Value	Unit
Name		
Opening Area	0	sq ft
Opening Area Fraction Schedule Name		
Opening Effectiveness A/C	Autocalculate-Default	
Effective Angle	0	deg
Height Difference	0	ft
Discharge Coefficient for Opening A/C	Autocalculate-Default	
Minimum Indoor Temperature	-148	F
Minimum Indoor Temperature Schedule Name		
Maximum Indoor Temperature	212	F
Maximum Indoor Temperature Schedule Name		
Delta Temperature	-180	deltaF
Delta Temperature Schedule Name		
Minimum Outdoor Temperature	-148	F
Minimum Outdoor Temperature Schedule Name		
Maximum Outdoor Temperature	212	F
Maximum Outdoor Temperature Schedule Name		
Maximum Wind Speed	7874.4	ft/min

The ventilation air flow rate is a function of wind speed and thermal stack effect, along with the area of the opening being modeled. This object can be used alone or in combination with ZoneVentilation:DesignFlowRate objects. **This model is intended for simplified ventilation calculations as opposed to the more detailed ventilation investigations that can be performed with the AirflowNetwork model.** Using the “Wind and Stack with Open Area” model, the natural ventilation flow rate can be controlled by a multiplier fraction schedule applied to the user-defined opening area and through the specification of minimum, maximum and delta temperatures. The temperatures can be either single constant values for the entire simulation or schedules which can vary over time. The equation used to calculate the ventilation rate driven by wind is:

where,

Q_w = Volumetric air flow rate driven by wind [m^3/s]

C_w = Opening effectiveness [dimensionless]

$A_{opening}$ = Opening area [m^2]

$F_{schedule}$ = Open area fraction [user-defined schedule value, dimensionless]

V = Local wind speed [m/s]

The equation used to calculate the ventilation rate due to stack effect is:

where,

Q_s = Volumetric air flow rate due to stack effect [m^3/s]

C_D = Discharge coefficient for opening [dimensionless]

$A_{opening}$ = Opening area [m^2]
$F_{schedule}$ = Open area fraction [user-defined schedule value, dimensionless]
ΔH_{NPL} = Height from midpoint of lower opening to the neutral pressure level [m]. Estimation of this value is difficult; refer to Chapter 16 of the 2009 ASHRAE Handbook of Fundamentals for guidance.
T_{zone} = Zone air dry-bulb temperature [K]
T_{odb} = Local outdoor air dry-bulb temperature [K]

The total ventilation rate calculated by this model is the quadrature sum of the wind and stack air flow components:

The local outdoor air dry-bulb temperature used in the stack effect equation (T_{odb}) is typically a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor air dry-bulb temperature calculation procedure is described in the "Local Outdoor Air Temperature Calculation" section of the Engineering Reference.
The local outdoor wind speed used in the above wind-driven equation (V) is also a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor wind speed calculation procedure is described in the "Local Wind Speed Calculation" section of the Engineering Reference.

Field: Opening Area

This is the opening area exposed to outdoors in a zone.

Field: Opening Area Fraction Schedule Name

This field is the name of the schedule (ref: Schedule) which modifies the Opening Area value (see previous field). The schedule values must be any positive number between 0 and 1 as a fraction. The actual opening area in a zone for a particular simulation time step is defined as the product of the Opening Area input field and the value specified by the schedule named in this input field.

Field: Opening Effectiveness

This field is the opening effectiveness (C_w). The value must be between 0.0 and 1.0 or the value can be autocalculated. If a real value is input, that constant value will be used in the calculations. Otherwise, this field can be left blank (default = Autocalculate) or the user can input **Autocalculate.** Based on recommended values provided in Chapter 16 of the 2009 ASHRAE Handbook of Fundamentals, C_w = 0.55 for perpendicular winds and C_w = 0.3 for diagonal winds. For Autocalculate, any angles between perpendicular and diagonal are linearly interpolated between 0.3 and 0.55 by the model.

Field: Effective Angle

This is the angle in degrees counting from the North clockwise to the opening outward normal. The value must be between 0 and 360, with the default being 0 if this input field is left blank. The Effective Angle is 0 if the opening outward normal faces North, 90 if faces East, 180 if faces South, and 270 if faces West. The value is fixed and independent of coordinate system defined in the GlobalGeometryRules object. This input field value is used to calculate the angle between the wind direction and the opening outward normal to determine the opening effectiveness values when the input field Opening Effectiveness = Autocalculate.

Field: Height Difference

This is the height difference between the midpoint of the lower opening and the neutral pressure level in meters. This value is a required user input.

> Note: Estimation of the height difference is difficult for natural ventilated buildings. Chapter 16 of the 2009 ASHRAE Handbook of Fundamentals may provide guidance for estimating the height difference.

Field: Discharge Coefficient for Opening

This is the discharge coefficient for the opening (C_D). The value must be between 0.0 and 1.0, or the value can be autocalculated. If a real value is input, that constant value will be used in the calculations. Otherwise, this field can be left blank (default = Autocalculate) or the user can input **Autocalculate.**

Field: Minimum Indoor Temperature

This is the indoor temperature below which ventilation is shutoff. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is -100.0°C if the field is left blank. This lower temperature limit is intended to avoid overcooling a space and thus result in a heating load. For example, if the user specifies a minimum temperature of 20°C, ventilation is assumed to be available if the zone air temperature is above 20°C. If the zone air temperature drops below 20°C, then ventilation is automatically turned off.

Field: Minimum Indoor Temperature Schedule Name

This alpha field defines the name of a schedule (ref. Schedule) which contains the minimum indoor temperature (in Celsius) below which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Minimum Indoor Temperature field. If the user enters a valid schedule name, the minimum temperature values specified in this schedule will override the constant value specified in the Minimum Indoor Temperature field.

Field: Maximum Indoor Temperature

This is the indoor temperature (in Celsius) above which ventilation is shutoff. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is 100.0°C if the field is left blank. This upper temperature limit is intended to avoid overheating a space and thus result in a cooling load. For example, if the user specifies a maximum temperature of 28°C, ventilation is assumed to be available if the zone air temperature is below 28°C. If the zone air temperature increases to 28°C, then ventilation is automatically turned off.

Field: Maximum Indoor Temperature Schedule Name

This alpha field defines the name of a schedule (ref. Schedule) which contains the maximum indoor temperature (in Celsius) above which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Maximum Indoor Temperature field. If the user enters a valid schedule name, the maximum temperature values specified in this schedule will override the constant value specified in the Maximum Indoor Temperature field.

Field: Delta Temperature

This is the temperature difference between the indoor and outdoor air dry-bulb temperatures below which ventilation is shutoff. The minimum value for this field is -100.0°C and the default value is also -100.0°C if the field is left blank. This field allows ventilation to be stopped if the temperature outside is too warm and could potentially heat the space. For example, if the user specifies a delta temperature of 2°C, ventilation is assumed to be available if the outside air temperature is at least 2°C cooler than the zone air temperature. If the outside air dry-bulb temperature is less than 2°C cooler than the indoor dry-bulb temperature, then ventilation is automatically turned off.

The values for this field can include negative numbers. This allows ventilation to occur even if the outdoor temperature is above the indoor temperature. The Delta Temperature is used in the code in the following way:

```
IF ((IndoorTemp - OutdoorTemp) < DeltaTemperature) Then ventilation is not allowed.
```

Thus, if a large negative number is input for DeltaTemperature, the ventilation can be kept on even if the outdoor temperature is greater than the indoor temperature. This is useful for uncontrolled natural ventilation (open windows) or as a way to estimate the effect of required ventilation air for load calculations.

Field: Delta Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the temperature difference (in Celsius) between the indoor and outdoor air dry-bulb temperatures below which ventilation is shutoff as a function of time. The minimum temperature difference value in the schedule can be -100°C. This field is an optional field and has the same functionality as the Delta Temperature field. If the user enters a valid schedule name, the delta temperature values specified in this schedule will override the constant value specified in the Delta Temperature field.

Field: Minimum Outdoor Temperature

This is the outdoor temperature (in Celsius) below which ventilation is shut off. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is -100.0°C if the field is left blank. This lower temperature limit is intended to avoid overcooling a space, which could result in a heating load.

Field: Minimum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) below which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Minimum Outdoor Temperature field. If the user enters a valid schedule name, the temperature values in this schedule will override the constant value specified in the Minimum Outdoor Temperature field.

Field: Maximum Outdoor Temperature

This is the outdoor temperature (in Celsius) above which ventilation is shut off. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is 100.0°C if the field is left blank. This upper temperature limit is intended to avoid overheating a space, which could result in a cooling load.

Field: Maximum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) above which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Maximum Outdoor Temperature field. If the user enters a valid schedule name, the temperature values in this schedule will override the constant value specified in the Maximum Outdoor Temperature field.

Field: Maximum Wind Speed

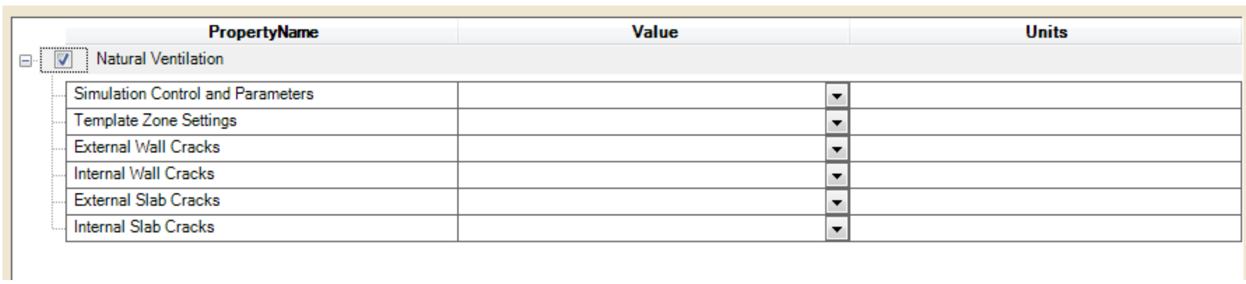
This is the wind speed (m/s) above which ventilation is shut off. This can help simulate conditions where one would normally close windows to avoid chaos in a space (papers blowing around, etc.).

Natural Ventilation

Location = Templates/Data Templates/Natural Ventilation

Workspace Area 1: Data Template Naming/Selection
Workspace Area 2: Data Template Property Table

Property Values Table



The image displays the Natural Ventilation Properties table.

Property Values Table Value Sources

The table below maps the drop down list sources for each row of the Value column in the property table that is displayed in the image below. It addresses two questions; 1) Where does the list shown come from? 2) What does the user need to go to add to the list or edit library entries? The hyperlinks in the Value Sources column go to the description of the library category.

Tip: If a value source is not included it means the field is predefined selections determined by EnergyPlus, and cannot be edited by the user in Simergy.

Property Category	Property Name	Value Source
Natural Ventilation	Simulation Control and Parameters	AirFlowNetwork/Default
	Template Zone Settings	Zone/Default
	External Wall Cracks	SurfaceCrack/Default
	Internal Wall Cracks	SurfaceCrack/Default
	External Slab Cracks	SurfaceCrack/Default
	Internal Slab Cracks	SurfaceCrack/Default

Libraries - Windows

Location = Libraries/Materials and Assemblies/Windows

Type and Sub Type Mapping

The Type and Sub Type options that can be selected from the drop down lists in that area of the workspace, which filter the Source Library to display the variables the user can select to include, along with a value, in a Library Entry.
Note: *The links within the table are to the EnergyPlus Input Output Reference providing additional detailed explanation of the EnergyPlus objects.*

Type Options	Sub Type Options	EnergyPlus Objects (IO Reference links)
Typical Window	ExteriorDetailed	FenestrationSurface:Detailed AirflowNetwork:MultiZone:Component:DetailedOpening AirflowNetwork:MultiZone:Component:SimpleOpening WindowProperty:AirflowControl WindowProperty:StormWindow Daylighting:DELight:ComplexFenestration
	Exterior	Window AirflowNetwork:MultiZone:Component:DetailedOpening AirflowNetwork:MultiZone:Component:SimpleOpening
	Interior	Window:Interzone AirflowNetwork:MultiZone:Component:DetailedOpening AirflowNetwork:MultiZone:Component:SimpleOpening
	FrameAndDivider	WindowProperty:FrameAndDivider

Typical Window (Type)

Property Set - AirflowNetwork:MultiZone:Component:DetailedOpening

Property Set - AirflowNetwork:MultiZone:Component:Simple Opening

ExteriorDetailed (Sub Type)

Property Set - Fenestration Surface Detailed

This surface class is used for subsurfaces, which can be of five different types: Windows, Doors, GlassDoors, TubularDaylightDomes, and TubularDaylightDiffusers. A subsurface (such as a window) of a base surface (such as a wall) inherits several of the properties (such as Outside Boundary Condition, Sun Exposure, etc.) of the base surface. Windows, GlassDoors, TubularDaylightDomes, and TubularDaylightDiffusers are considered to have one or more glass layers and so transmit solar radiation. Doors are considered to be opaque.

Field: Surface Type

The choices for Surface Type are Window, Door, GlassDoor, TubularDaylightDome, and TubularDaylightDiffuser. Doors are assumed to be opaque (do not transmit solar radiation) whereas the other surface types do transmit solar radiation. Windows and Glass Doors are treated identically in the calculation of conduction heat transfer, solar gain, daylighting, etc. A Window or GlassDoor, but not a Door, can have a movable interior, exterior or between-glass shading device, such as blinds (ref: WindowMaterial:Blind), and can have a frame and/or a divider (ref: WindowProperty:FrameAndDivider). TubularDaylightDomes and TubularDaylightDomes are specialized subsurfaces for use with the DaylightingDevice:Tubular object to simulate Tubular Daylighting Devices (TDDs). TubularDaylightDomes and TubularDaylightDomes cannot have shades, screens or blinds. In the following, the term "window" applies to Window, GlassDoor, TubularDaylightDome, and TubularDaylightDome, if not otherwise explicitly mentioned.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction [for Window, GlassDoor and Door] and Construction:WindowDataFile [for Window and GlassDoor]).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Shading Control Name

This field, if not blank, is the name of the window shading control (ref: WindowProperty:ShadingControl) for this subsurface. It is used for Surface Type = Window and GlassDoor. To assign a shade to a window or glass door, see WindowMaterial: Shade. To assign a screen, see WindowMaterial:Screen. To assign a blind, see WindowMaterial:Blind. To assign switchable glazing, such as electrochromic glazing, see WindowProperty:ShadingControl.

Field: Frame and Divider Name

This field, if not blank, can be used to specify window frame, divider and reveal-surface data (ref: WindowProperty:FrameAndDivider). It is used only for exterior GlassDoors and rectangular exterior Windows, i.e., those with OutsideFaceEnvironment = Outdoors.

This field should be blank for triangular windows.

Property Set - AirflowNetwork:MultiZone:Component:DetailedOpening

Property Set - AirflowNetwork:MultiZone:Component:Simple Opening

Property Set - WindowProperty:Airflow Control

This object is used to specify the control mechanism for windows in which forced air flows in the gap between adjacent layers of glass. Such windows are called "airflow windows." They are also known as "heat-extract windows" or "climate windows."

A common application is to reduce the zone load by exhausting indoor air through the window. In the cooling season this picks up and expels some of the solar heat absorbed by the window glass (and by the between-glass shade or blind, if present). In the heating season this warms the window, reducing the heat loss from the window. A side benefit is increased thermal comfort. This is because the inside surface of the window will generally be cooler in summer and warmer in winter.

Field: Airflow Source

The source of the gap airflow. The choices are:

IndoorAir: Indoor air from the window's zone is passed through the window.

OutdoorAir: Outdoor air is passed through the window.

Field: Airflow Destination

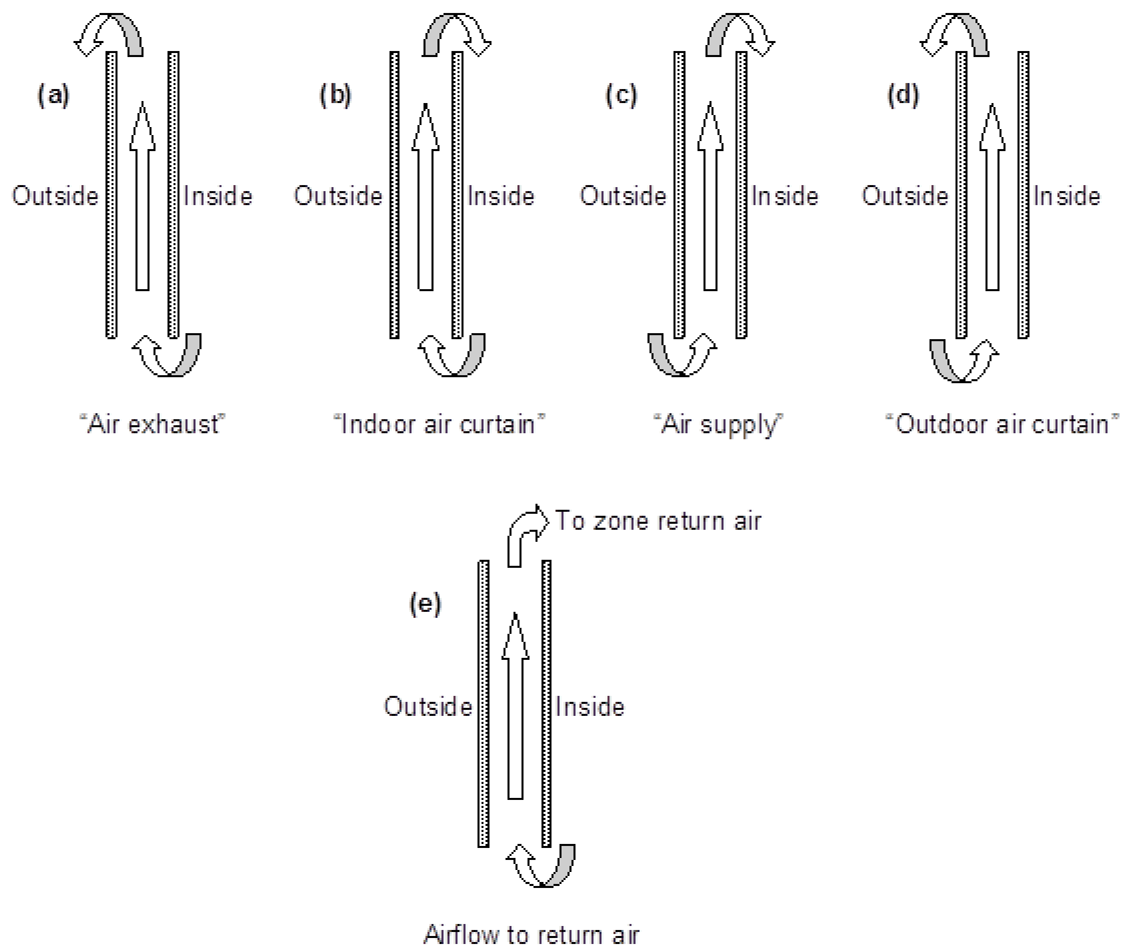
This is where the gap air goes after passing through the window. The choices are:

IndoorAir: The gap air goes to the indoor air of the window's zone.
OutdoorAir: The gap air goes to the outside air.

ReturnAir. The gap air goes to the return air for the window's zone. This choice is allowed only if Airflow Source = InsideAir. If the return air flow is zero, the gap air goes to the indoor air of the window's zone. If the sum of the gap airflow for all of the windows in a zone with Airflow Destination = ReturnAir exceeds the return airflow, then the difference between this sum and the return airflow goes to the indoor air.

The allowed combinations of Airflow Source and Airflow Destination as shown in the diagram below are:

IndoorAir → OutdoorAir
IndoorAir → IndoorAir
IndoorAir → ReturnAir
OutdoorAir → IndoorAir
OutdoorAir → OutdoorAir



Source: EnergyPlus Input Output Reference

Field: Maximum Flow Rate

The maximum value of the airflow, in m^3/s per m of glazing width. The value is typically 0.006 to 0.009 m^3/s-m (4 to 6 cfm/ft).

The airflow can be modulated by specifying Airflow Has Multiplier Schedule = Yes and giving the name of the Airflow Multiplier Schedule (see below).
The fan energy used to move the air through the gap is generally very small and so is ignored.

Field: Airflow Control Type

Specifies how the airflow is controlled. The choices are:

AlwaysOnAtMaximumFlow. The airflow is always equal to Maximum Airflow.
AlwaysOff. The airflow is always zero.
ScheduledOnly. The airflow in a particular timestep equals Maximum Airflow times the value of the Airflow Multiplier Schedule for that timestep.

Field: Airflow Is Scheduled

Specifies if the airflow is scheduled. The choices are:

Yes. The airflow is scheduled.
No. The airflow is not scheduled.

If Yes, Airflow Multiplier Schedule Name is required.

Field: Airflow Multiplier Schedule Name

The name of a schedule with values between 0.0 and 1.0. The timestep value of the airflow is Maximum Airflow times the schedule value. Required if Airflow Is Scheduled = Yes. Unused if Airflow Is Scheduled = No. This schedule should have a ScheduleType with Numeric Type = Continuous and Range = 0.0 : 1.0

Property Set - WindowProperty:StormWindow

This object allows you to assign a movable exterior glass layer (“storm window” or “storm glass”) that is usually applied to a window in the winter to reduce heat loss and removed in the summer. A WindowProperty:StormWindow object is required for each window that has an associated storm window. It is assumed that:

- When the storm glass is in place it is the outermost layer of the window, it covers only the glazed part of the window and not the frame, and it forms a tight seal. See Figure 30.
- When the storm glass is not in place it is completely removed and has no effect on window heat transfer.
- The gap between the storm glass and rest of the glazing is filled with air.

With the addition of a storm window, single glazing effectively becomes double glazing, double glazing becomes triple glazing, etc.

Field: Storm Glass Layer Name

This is the name of a window glass material. Storm windows are assumed to consist of a single layer of glass. A storm window frame, if present, is ignored.

Field: Distance Between Storm Glass Layer and Adjacent Glass

The separation between the storm glass and the rest of the window. It is measured from the inside of the storm glass layer to the outside of the adjacent glass layer.

Field: Month that Storm Glass Layer Is Put On

The number of the month (January = 1, February = 2, etc.) during which the storm window is put in place.

Field: Day of Month that Storm Glass Layer Is Put On

The day of the month that the storm window is put in place. It is assumed that the storm window is put in place at the beginning of this day, i.e., during the first simulation timestep of the day, and remains in place until that month and day given by the following two fields.

Field: Month that Storm Glass Layer Is Taken Off

The number of the month (January = 1, February = 2, etc.) during which the storm window is removed.

Field: Day of Month that Storm Glass Layer Is Taken Off

The day of the month that the storm window is removed. It is assumed that the storm window is removed at the beginning of this day, i.e., during the first simulation timestep of the day, and stays off until the month and day given by Month that Storm Glass Layer Is Put On, Day of Month that Storm Glass Layer Is Put On.

In the northern hemisphere, the month the storm window is put on is generally greater than the month it is taken off (for example put on in month 10, when it starts to get cold, and taken off in month 5, when it starts to warm up). In the southern hemisphere this is reversed: month on is less than month off.

Property Set - Daylighting:DELight:Complex

The DElight daylighting analysis method can be applied to daylighting zones that contain only simple fenestration systems such as windows and skylights that are standard EnergyPlus sub-surfaces. In this situation, no Daylighting:DElight: Complex Fenestration object would be input.

In addition to analyzing simple fenestration systems, DElight includes the capability of analyzing complex fenestration systems such as geometrically complicated static shading systems (e.g., roof monitors) and/or optically complicated glazings (e.g., prismatic or holographic glass). This capability is based on characterizing these complex fenestration systems (CFS) using bidirectional transmittance distribution functions (BTDF). In general, BTDF data for a specific CFS must be either measured or simulated (e.g., using ray-tracing techniques) prior to employing DElight to analyze it within EnergyPlus. The current implementation of DElight CFS calculations within EnergyPlus supports two approaches to the input of BTDF, an analytical approach and a file-based approach. The details of inputting these two approaches are described below under the User Complex Fenestration Type field.

Two analytical CFS BTDF types are currently supported, window and light shelf. The file-based approach requires that a user has access to a data file containing raw BTDF data that DElight reads as additional input during its analysis calculations. BTDF data files are described separately since it is anticipated that individual EnergyPlus users will not create these data files themselves.

The methods related to characterizing and analyzing CFS using BTDF are still evolving. DElight is an early implementation of CFS analysis methods. These methods, and the input associated with them here, will likely change in the future.

Field: Complex Fenestration Type

Type name of the DElight daylighting Complex Fenestration system to be analyzed. This type name must take one of the following two forms.

```
BTDF^GEN^Analytical Type^Normal Visible Transmittance^Dispersion Angle

BTDF^FILE^Filename
```

The first form above is for supported analytical CFS types which currently include WINDOW and LIGHTSHELF. While these analytical types are relatively simple, they represent flexible ways to explore diffusing CFS systems and the impact of light shelves in redirecting light through an aperture. Each of these types also requires the visible transmittance of the CFS at normal incidence angle, and a dispersion angle (in degrees) that represents the "spread" of transmitted light. A small dispersion angle of 10 corresponds to clear glazing while a large angle of 90 corresponds to perfectly diffusing glazing. The "^" symbol must be used as a delimiter between sub-fields within this Complex Fenestration type name string as shown in the IDF example for WINDOW below, and in the DElight sample input data files.

The second form above is for CFS types for which there is pre-measured or pre-simulated BTDF data. In this case the Filename sub-field must be a valid data file name that is associated with an existing BTDF dataset that DElight can use in its calculations.

Field: Fenestration Rotation
The in-plane counter-clockwise rotation angle between the Complex Fenestration optical reference direction and the base edge of the Doppelganger Surface geometry. The Complex Fenestration optical reference direction is the direction of the zero azimuth angle for the BDTF dataset. This Rotation angle will typically be zero when the Doppelganger surface is rectangular and its width edge is aligned with the Complex Fenestration optical reference direction.

Exterior (Sub Type)

Property Set - AirflowNetwork:MultiZone:Component:DetailedOpening

Property Set - AirflowNetwork:MultiZone:Component:Simple Opening

Property Set - Window
The Window object is used to place windows on surfaces that can have windows, including exterior walls, interior walls, interzone walls, roofs, floors that are exposed to outdoor conditions, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects.

Field: Shading Control Name
This field, if not blank, is the name of the window shading control (ref: WindowProperty:ShadingControl) for this subsurface. It is used for Surface Type = Window and GlassDoor. To assign a shade to a window or glass door, see WindowMaterial: Shade. To assign a screen, see WindowMaterial:Screen. To assign a blind, see WindowMaterial:Blind. To assign switchable glazing, such as electrochromic glazing, see WindowProperty:ShadingControl
Simergy source for drop down list = **Libraries/Controllers/ShadingControl/<collection from Sub Types>**

Field: Frame and Divider Name
This field, if not blank, can be used to specify window frame, divider and reveal-surface data (ref: WindowProperty:FrameAndDivider). It is used only for exterior GlassDoors and rectangular exterior Windows, i.e., those with OutsideFaceEnvironment = Outdoors.
This field should be blank for triangular windows.
Simergy source for drop down list = **Libraries/Windows/TypicalWindow/FrameAndDivider**

Interior (Sub Type)

Property Set - AirflowNetwork:MultiZone:Component:DetailedOpening

Property Set - AirflowNetwork:MultiZone:Component:Simple Opening

Property Set - Window Interzone
The Window:Interzone object is used to place windows on surfaces that can have windows, including interzone walls, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction and Construction:WindowDataFile). For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (default Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Note:The source for the drop down list is - ***Libraries/Material/<collection of entries from Types>/<collection of entries across possible sub types>***

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a window in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent ceiling is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

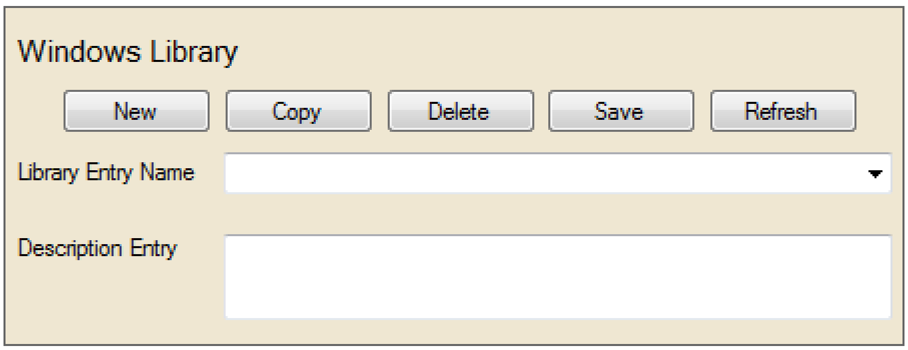
Note:The source for the drop down list is - Libraries/Windows or Doors/<collection of entries from Types>/<collection of entries across possible sub types>

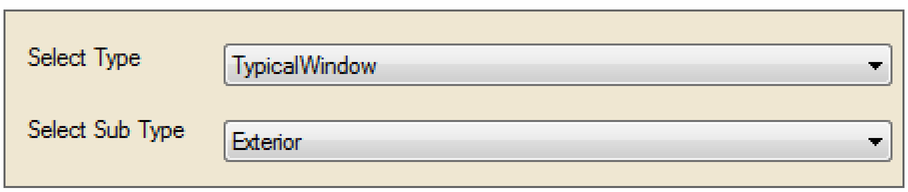
Example - Creating an Operable Window - "Simple" Library Entry

Workspace: Libraries/Materials and Assemblies/Windows
Workspace Areas: Libraries Controls - Property Values Table
Related Examples - Creating an Operable Window - "Detailed" Library Entry

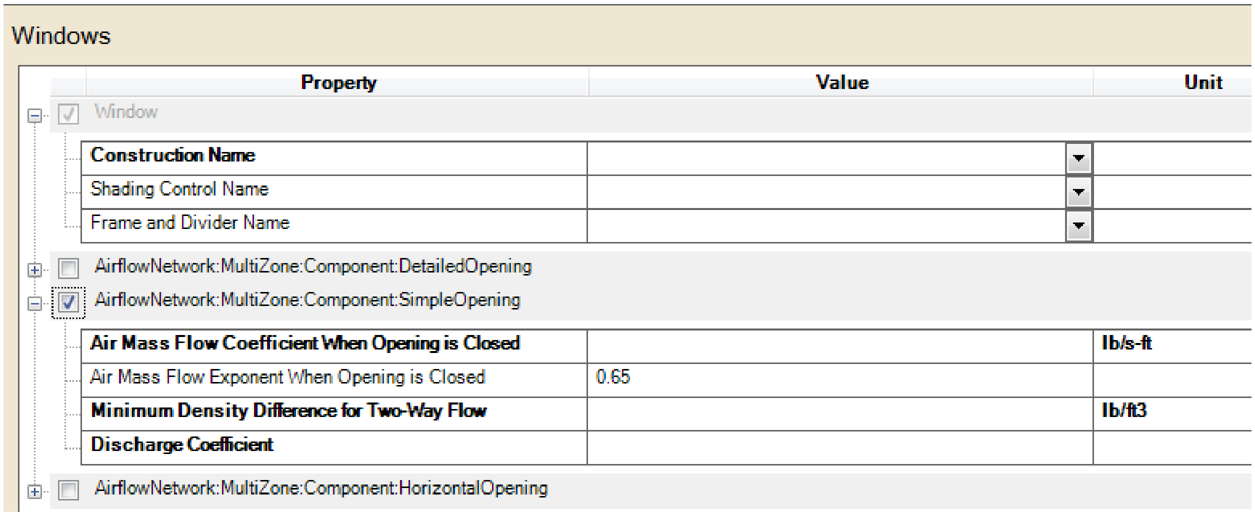
What to do if you want to create an Operable Window, Window Type using the Detailed Opening capabilities for the Air Flow Network within EnergyPlus:

- **Step 1:** Go to Libraries/Materials and Assemblies/Windows Workspace
- **Step 2:** Select New
- **Step 3:** Select Type = Typical Window and Sub Type = Exterior





- **Step 4:** Expand the property categories of Window and AirflowNetwork:MultiZone:Component:SimpleOpening by selecting the check boxes in the Property Values Table.



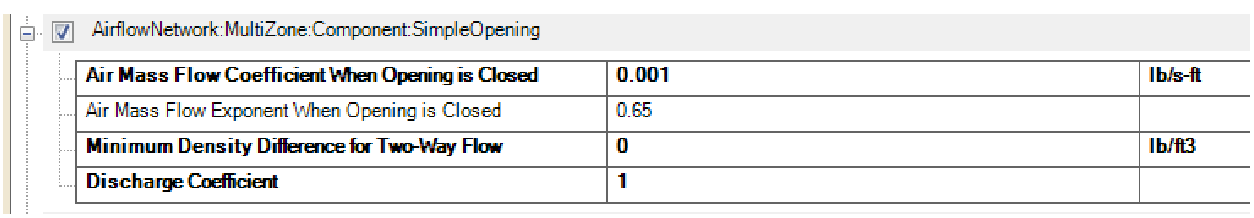
Note: For a Simple Operable Window library entry the AirflowNetwork:MultiZone:Component:DetailedOpening *should not have property values specified. It will lead to Validation errors and potential simulation problems.*

- **Step 5:** Make Construction, Shading Control and Frame and Divider selections from the drop down lists as applicable. See table below to identify sources for drop down lists.

Property Category	Property Name	Value Sources
Window	Construction Name	Libraries/Mat'l-Glaz Layer Sets/<all>
	Shading Control Name	Controllers/Shading Control/<all>
	Frame and Divider Name	Windows/Typical Window/FrameAndDivider Doors/Glazed Door/FrameAndDivider

Note: If there is not a desirable option in the drop down list and the user wants to create a new one or review in more detail the ones that are there, they will need to go to the source within libraries, which are the links included above.

- **Step 6:** Enter Values for the first four Detailed Opening Properties. See image below for typical values.



Air Mass Flow Coefficient When Opening is Closed

The value of the air mass flow coefficient, , in the simple opening air flow equation. It has units of kg/s-m at 1Pa. The temperature correction factor is not applied for mass flow calculation.

Air Mass Flow Exponent When Opening is Closed

Crack flow is assumed when the window or door is closed. In this case, the value of this field is the exponent, n, in the crack air flow equation. The valid range for this exponent is 0.5 to 1.0, with the default value being 0.65.

Minimum Density Difference for Two-Way Flow

This numeric field is used to input the minimum density difference above which two-way flow may occur due to stack effect. Density differences less than this value result in one-way flow. The minimum value for this field is greater than zero.

Field: Discharge Coefficient

This numeric field is used to input the discharge coefficient. This value must be greater than zero.

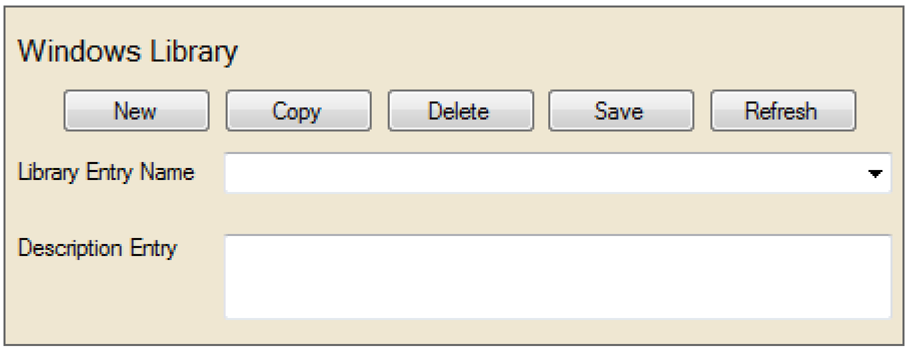
- **Step 7:** When all the desired input values have been entered, hit Save, and now the Library Entry has been stored in the Source Library that the user has active. The Operable Window type is ready to be specified in the user's Natural Ventilation BEM!

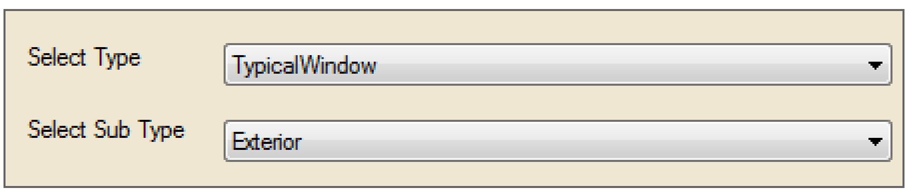
Example - Creating an Operable Window - "Detailed" Library Entry

Workspace: Libraries/Materials and Assemblies/Windows
Workspace Areas: Libraries Controls - Property Values Table
Related Examples - Creating an Operable Window - "Simple" Library Entry

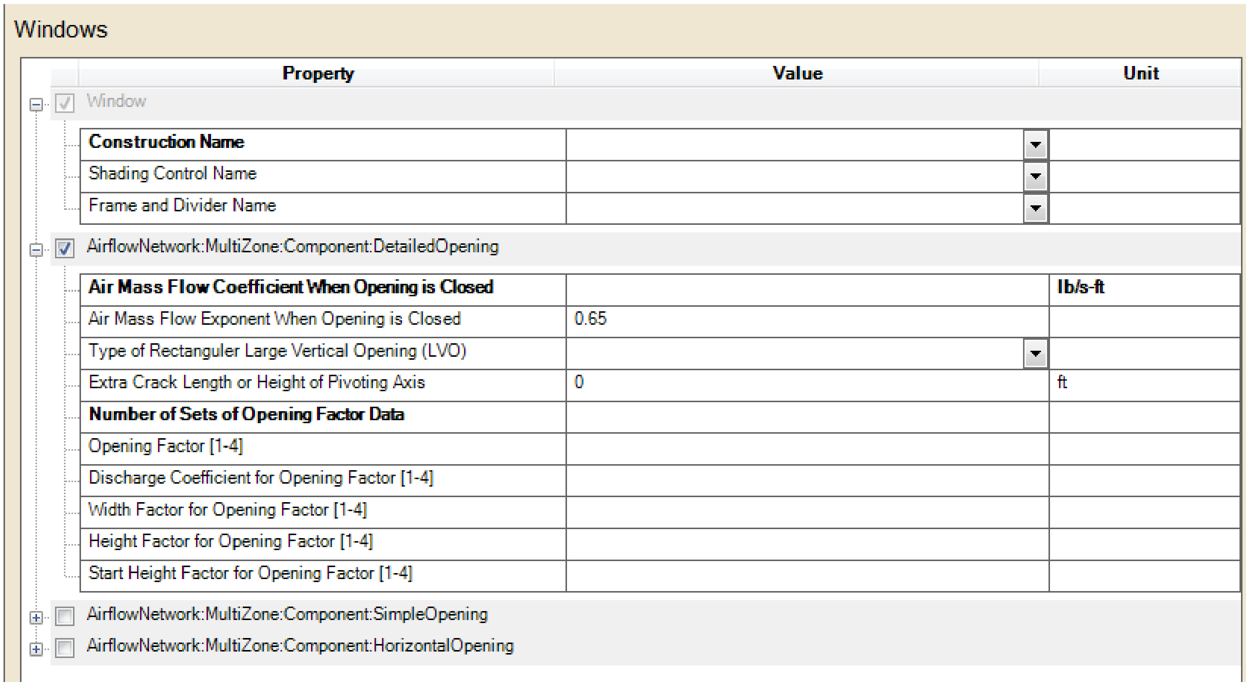
What to do if you want to create an Operable Window, Window Type using the Detailed Opening capabilities for the Air Flow Network within EnergyPlus:

- **Step 1:** Go to Libraries/Materials and Assemblies/Windows Workspace
- **Step 2:** Select New
- **Step 3:** Select Type = Typical Window and Sub Type = Exterior





- **Step 4:** Expand the property categories of Window and AirflowNetwork:MultiZone:Component:DetailedOpening by selecting the check boxes in the Property Values Table.



Windows

Property	Value	Unit
Window		
Construction Name		
Shading Control Name		
Frame and Divider Name		
AirflowNetwork:MultiZone:Component:DetailedOpening		
Air Mass Flow Coefficient When Opening is Closed		**lb/s-ft**
Air Mass Flow Exponent When Opening is Closed	0.65	
Type of Rectanguler Large Vertical Opening (LVO)		
Extra Crack Length or Height of Pivoting Axis	0	ft
Number of Sets of Opening Factor Data		
Opening Factor [1-4]		
Discharge Coefficient for Opening Factor [1-4]		
Width Factor for Opening Factor [1-4]		
Height Factor for Opening Factor [1-4]		
Start Height Factor for Opening Factor [1-4]		
AirflowNetwork:MultiZone:Component:SimpleOpening		
AirflowNetwork:MultiZone:Component:HorizontalOpening		

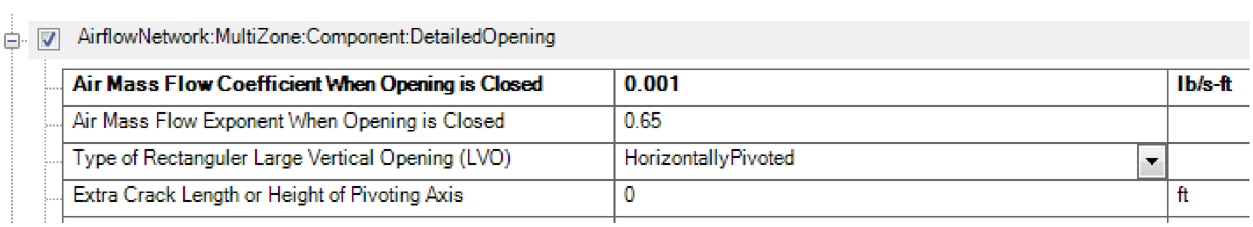
Note: For a Detailed Operable Window library entry the AirflowNetwork:MultiZone:Component:SimpleOpening *should not have property values specified. It will lead to Validation errors and potential simulation problems.*

- **Step 5:** Make Construction, Shading Control and Frame and Divider selections from the drop down lists as applicable. See table below to identify sources for drop down lists.

Property Category	Property Name	Value Sources
Window	Construction Name	Libraries/Mat'l-Glaz Layer Sets/<all>
	Shading Control Name	Controllers/Shading Control/<all>
	Frame and Divider Name	Windows/Typical Window/FrameAndDivider Doors/Glazed Door/FrameAndDivider

Note: If there is not a desirable option in the drop down list and the user wants to create a new one or review in more detail the ones that are there, they will need to go to the source within libraries, which are the links included above.

- **Step 6:** Enter Values for the first four Detailed Opening Properties. See image below for typical values.



AirflowNetwork:MultiZone:Component:DetailedOpening		
Air Mass Flow Coefficient When Opening is Closed	**0.001**	**lb/s-ft**
Air Mass Flow Exponent When Opening is Closed	0.65	
Type of Rectanguler Large Vertical Opening (LVO)	HorizontallyPivoted	
Extra Crack Length or Height of Pivoting Axis	0	ft

Air Mass Flow Coefficient When Opening is Closed

Crack flow is assumed when the window or door is closed. There is no default but the entered value must be greater than zero (recommend entering .001). EnergyPlus will automatically generate four cracks around the perimeter of the window or door--one along the bottom, one along the top, and one on each side.

Air Mass Flow Exponent When Opening is Closed

Crack flow is assumed when the window or door is closed. In this case, the value of this field is the exponent, n, in the crack air flow equation. The valid range for this exponent is 0.5 to 1.0, with the default value being 0.65.

Type of Rectangular Large Vertical Opening (LVO)

This alpha field specifies the type of rectangular window or door. (Open windows or doors are also called Large Vertical Openings (LVOs). The choices for the opening type are **NonPivoted** (LVO Type 1) and **HorizontallyPivoted** (LVO Type 2) with the default being **NonPivoted**. The NonPivoted type represents a regular window or door. The HorizontallyPivoted type represents a window with a horizontal axis ((i.e., a horizontally-pivoting window) and cannot be used for a door.

Extra Crack Length or Height of Pivoting Axis

Specifies window or door characteristics that depend on the LVO type.
For LVO Type 1 (rectangular non-pivoted windows and doors) this field is the extra crack length in meters due to multiple openable parts, if present. “Extra” here means in addition to the length, calculated by the program, of the cracks on the top, bottom and sides of the window/door.
For LVO Type 2 (rectangular horizontally-pivoted windows) this field gives the height of the pivoting axis measured from the bottom of the glazed part of the window.

- **Step 7: Enter Opening Factor value**

Number of Sets of Opening Factor Data

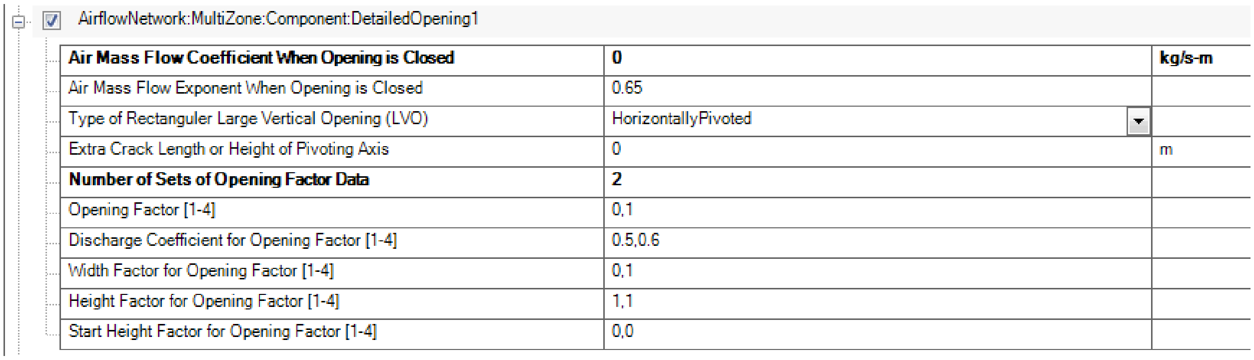
This is the number of the following sets of data for opening factor, discharge coefficient, width factor, height factor, and start height factor.

An “opening factor” refers to the amount that a window or door is opened. The program linearly interpolates each timestep between the values of discharge coefficient, width factor, etc., in these sets using the opening factor for the window or door for the timestep.
The allowable entries are 2 to 4, which determine the number of "opening states" that input values are being provided for.

- 2 = closed, fully open (or most open state)
- 3 = closed, intermediate, fully open (or most open state)
- 4 = closed, intermediate 1, intermediate 2, fully open (or most open state)

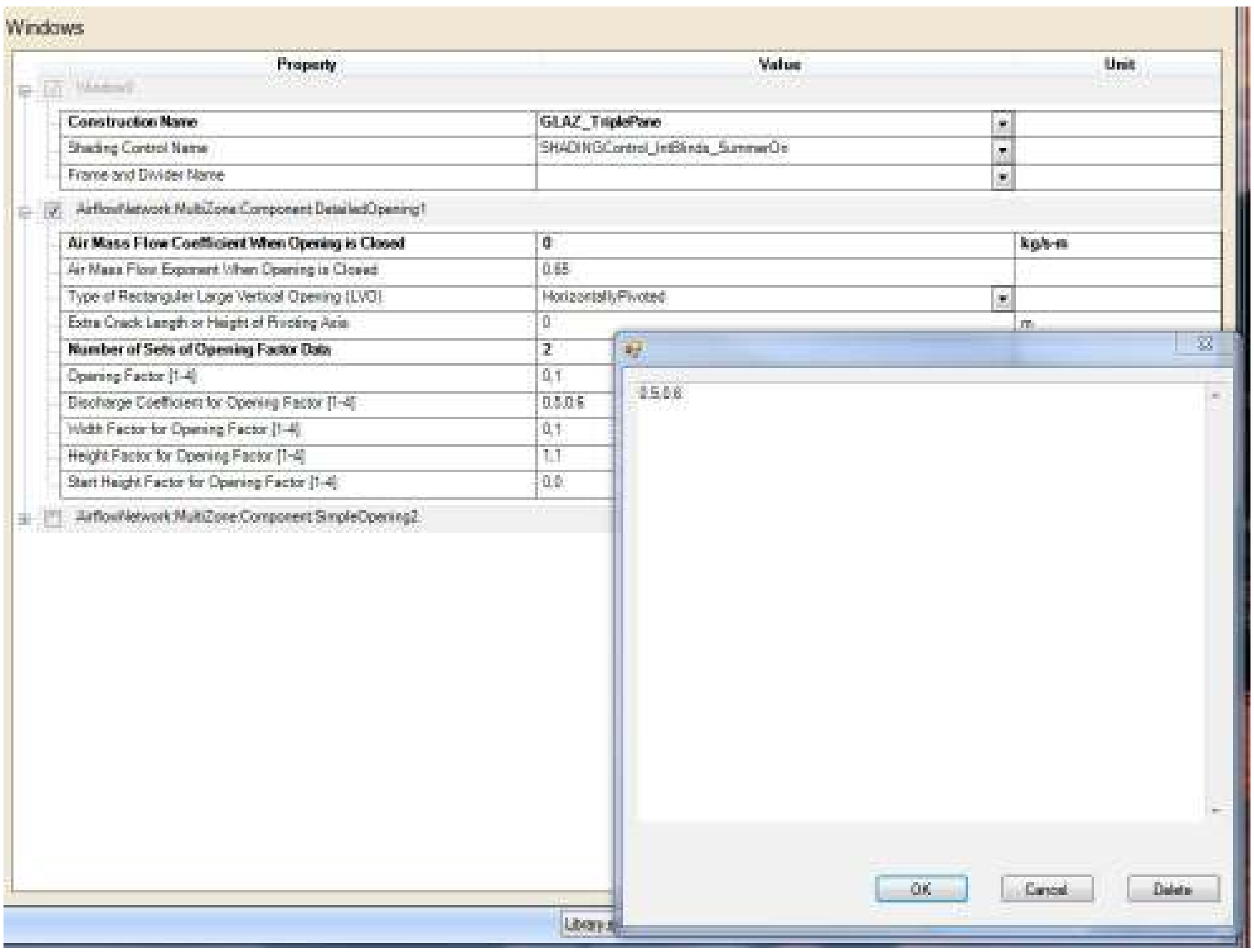
- **Step 8: Enter Dependent Opening Factors**

The next five property inputs are dependent on the number that was entered in the previous step. If "2" was entered, then two sets of input values are required for each value (image below). If "4" was entered, then four sets of input values are required.



AirflowNetwork:MultiZone:Component:DetailedOpening1		
Air Mass Flow Coefficient When Opening is Closed	**0**	**kg/s-m**
Air Mass Flow Exponent When Opening is Closed	0.65	
Type of Rectanguler Large Vertical Opening (LVO)	HorizontallyPivoted	
Extra Crack Length or Height of Pivoting Axis	0	m
Number of Sets of Opening Factor Data	**2**	
Opening Factor [1-4]	0,1	
Discharge Coefficient for Opening Factor [1-4]	0.5,0.6	
Width Factor for Opening Factor [1-4]	0,1	
Height Factor for Opening Factor [1-4]	1,1	
Start Height Factor for Opening Factor [1-4]	0,0	

When the user clicks on one of these five value cells a text writer dialog box will appear (shown below) where the values can be entered. The values require a comma in between. When finished, select OK. The dialog box will disappear and the values will appear in the cell in the "value column".



Opening Factor

The first opening factor of a window or door. This value must be 0.0. The default value is also 0.0. For LVO Type 1 (rectangular non-pivoted window or door), the Opening Factor corresponds to the fraction of window or door that is opened.

For LVO Type 2 (rectangular horizontally-pivoted windows), the Opening Factor is determined by the window opening angle. For example, an opening angle of 45° corresponds to an Opening Factor of 0.50 since the maximum opening angle is 90°.

Discharge Coefficient for Opening Factor

The discharge coefficient of the window or door for Opening Factor. The range is greater than 0.0 to less than or equal to 1.0. The default value is 0.001. The Discharge Coefficient indicates the fractional effectiveness for air flow through a window or door at that Opening Factor.

Note: "Width" and "Height" are glazing dimensions; they do not include the frame, if there is one present.

Width Factor for Opening Factor

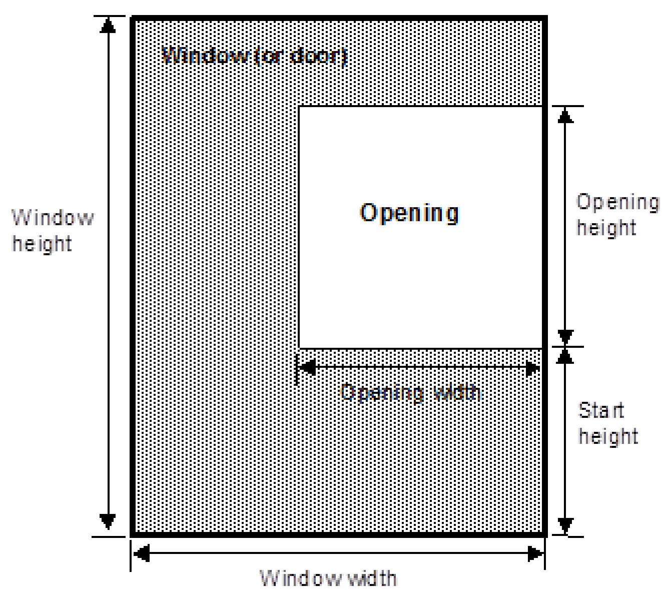
The Width Factor of the rectangular window or door for Opening Factor 1. The Width Factor is the opening width divided by the window or door width (see Figure 83). The range is 0.0 to 1.0. The default value is 0.0. Note that the width factor applies to rectangular windows or doors where the width is assumed constant along the entire height of the opening.

Height Factor for Opening Factor

The Height Factor of the rectangular window or door for Opening Factor 1. The Height Factor is the opening height divided by the window or door height (see Figure 83). The range is 0.0 to 1.0. The default value is 0.0. Note that the height factor applies to rectangular windows or doors where the height is assumed constant along the entire width of the opening.

Start Height Factor for Opening Factor

The Start Height Factor of the window or door for Opening Factor 1. The Start Height Factor is the Start Height divided by the window or door height (see Figure 83). The range is 0.0 to 1.0. The default is 0. Start Height is the distance between the bottom of the window or door and the bottom of the window or door opening. The sum of the Height Factor and the Start Height Factor must be less than 1.0 in order to have the opening within the window or door dimensions.



$$Width\ Factor = \frac{Opening\ Width}{Window\ Width}$$

$$Height\ Factor = \frac{Opening\ Height}{Window\ Height}$$

$$Start\ Height\ Factor = \frac{Start\ Height}{Window\ Height}$$

Figure 83 - Source EnergyPlus Input Output Reference

- **Step 9:** When all the desired input values have been entered, hit Save, and now the Library Entry has been stored in the Source Library that the user has active. The Operable Window type is ready to be specified in the user's Natural Ventilation BEM!

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