



INTEGRATED
ENVIRONMENTAL
SOLUTIONS

Breathing Buildings NVHR®

Virtual Environment User Guide



Contents

1. Overview	2
What is Breathing Buildings NVHR®?	2
Requirements for using NVHR in the Virtual Environment	2
2. NVHR Background.....	3
Product Information	4
Features	4
Options.....	4
Air Flow Strategies	4
Installation and Control	5
Find Out More.....	5
3. Using NVHR in the VE.....	6
Introduction	6
Importing the NVHR units.....	7
Using the NVHR Grouping Scheme	8
Duplicating Unit Groups.....	8
Deleting Unit Groups	8
Editing Unit Group Properties.....	9
Assigning NVHR to Rooms	11
What happens when a room is assigned?	13
What happens when a room is unassigned?	15
Simulating with NVHR.....	16
Results Analysis.....	18
4. NVHR and UK NCM analysis (Part L, Section 6, EPCs).....	19
The NCM framework	19
Analysing the real building and the Actual Building	19
Appendix A: Frequently Asked Questions	22
Appendix B: About Breathing Buildings Ltd.	23

1. Overview

What is Breathing Buildings NVHR®?

Natural Ventilation with Heat Recycling (NVHR®) is the latest natural ventilation product from Breathing Buildings Ltd. Natural ventilation is an important consideration for all new buildings. Good air circulation ensures that occupants are comfortable and it is required as part of the Building Regulations Part F. Additionally, with the environment, cost of energy and long term maintenance all being areas of concern, any system should provide energy-efficient long term ventilation.

NVHR is the latest product from Breathing Buildings that is changing the way the industry thinks about Natural Ventilation. The patented mixing ventilation system allows single-sided, natural ventilation in deep plan spaces whilst making the most of internal heat gains to deliver superb thermal comfort. This system allows buildings with limited façade and roof space to be naturally ventilated. Its low energy mixing fans mitigate cold draughts in winter and provide boost in summer. The system is fitted with external and internal temperature sensors that enable the system to create an ideal working environment.

The units are designed primarily for offices and school classrooms and can be deployed in almost any building due to their small size. They can work individually or as multiples (typically a pair for a standard school classroom), directing air to the back of the space to provide a quasi-cross-flow system. It is designed to meet the Department for Education *“Guidance on ventilation, thermal comfort and indoor air quality in schools”* and the Facilities Output Specification (FOS) for the Priority Schools Building Programme (PSBP). The units can be used with a grille or ducted arrangement to supply air.

Further details on the units, air flow strategies and technical data is provided in this user guide (see [NVHR Background](#)). For the latest details on the NVHR product or to discuss potential suitability for your project, please visit <http://www.breathingbuildings.com>.

Requirements for using NVHR in the Virtual Environment

The Virtual Environment (VE) software includes built-in support for simulating both ducted and ductless NVHR units from Breathing Buildings. However, in order to simulate you will need valid licenses for the following VE modules:

- ModelIT
- Apache
- MacroFlo
- SunCast
- ApacheSim

If you are missing one or more of these licenses, you will not be able to use the Breathing Buildings functionality within the VE. Please contact keys@iesve.com for queries or support with licensing issues.

2. NVHR Background

Breathing Buildings was asked by a number of designers and contractors to provide a system which delivered the benefits of controlled mixing ventilation but which enabled single-sided ventilation. The challenge was further compounded by the request that the height to depth ratio of the rooms being considered precluded them from being purely naturally ventilated throughout the year; either spatial air quality variations or temperature variations would be experienced. The development of the hybrid NVHR was therefore progressed to provide a controlled natural ventilation damper arrangement which can be used on its own or in conjunction with opening windows, but combined with fan-assisted flow and mixing when necessary. The designers were eager for a system to be developed which was sufficiently slimline in vertical extent that it could either be easily incorporated in a ceiling void or else if exposed would not negatively impact the natural daylighting provision from typical window systems. Hence a 300mm deep unit was specified. Finally, in order to make the unit small enough to be easy to install and to fit in a typical window system, a 900mm dimension was selected for the width.

These slimline, easy-to-install, units are incredibly popular and have changed the world of low energy ventilation. A critical feature for optimal use of the Breathing Buildings hybrid ventilation strategy is that the climate should ideally be relatively temperate (winters not too severe) and internal heat gains should not be low. When these criteria are satisfied, the Breathing Buildings solution is more energy efficient than a mechanical ventilation heat recovery device because the fan power usage in the NVHR is very low, and heat recovery is not helpful until external temperatures during the occupied day fall to around zero degrees centigrade – which isn't very often in temperate climates. Below this temperature MVHR is potentially more efficient but above this temperature NVHR is much more efficient, so that over the course of a whole winter the NVHR ends up being the most efficient system.

The mixing ventilation system allows single sided, natural ventilation in deep plan spaces whilst making the most of internal heat gains to deliver superb thermal comfort. It is designed to meet the Department for Education "Guidance on ventilation, thermal comfort and indoor air quality in schools" and the Facilities Output Specification (FOS) for the Priority Schools Building Programme (PSBP). The unit can be used with a grille or ducted arrangement to supply air.

- Can work individually or as multiples (typically a pair for a standard school classroom)
- System directs air to the back of the space to provide a quasi-cross-flow system
- Mounted horizontally
- Manual control with 4-position switch or fully automatic with override
- BMS interface option to report T/CO₂ or allow set-point changes and enable / disable
- Automatic units switch between winter mixing, natural and summer boost modes and include night cooling
- Integrates with manual windows when it is above 16°C outside or can control actuators on windows or dampers
- In winter the units use internal gains to temper incoming ventilation air, rather than a dedicated pre-heater, which has a significant impact in reducing heater sizing and energy consumption

- In a modern, well insulated building be it a classroom or well-occupied office environment, there is an abundance of heat when ventilation demand is at its highest, and these units capitalise on this
- Can be used on noisy sites – a standard unit provides 26dB D_{new} attenuation as independently verified by SRL
- Units can be exposed in a room or installed in a ceiling void
- Very low energy consumption - typical specific fan power 0.13W/l/s in winter mode for unit with grille

Product Information

Features

- Lightweight, plastic construction
- Low energy mixing fans to mitigate against cold draughts in winter
- Summer boost mode
- Night cooling mode
- Room temperature sensor with integrated CO2 sensor
- Internal mixed air temperature sensor
- External Temperature sensor
- Ready fitted mounting brackets
- Key switch for automatic operation; time override; long-term off; test

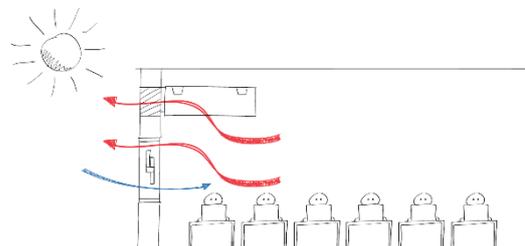
Options

- Manual or automatic control which responds to environmental conditions
- Weather louvre
- Additional sound attenuation for noisy sites through combination of acoustic louvres and internal baffles depending on site specific requirements
- Control signal for automated actuation of low level windows or dampers
- Traffic light indicator panel for window opening
- Modbus link for integration into wider Building Management Systems (BMS)
- Heater coil for space heating (1.5kW per unit)

Air Flow Strategies

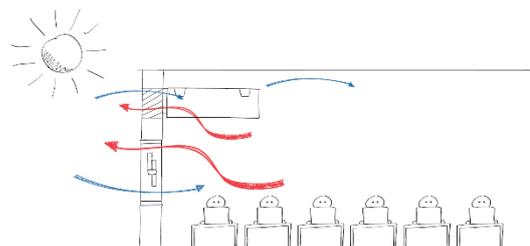
Natural Mode:

- Damper opens
- Single sided ventilation
- Works with other openings in the space



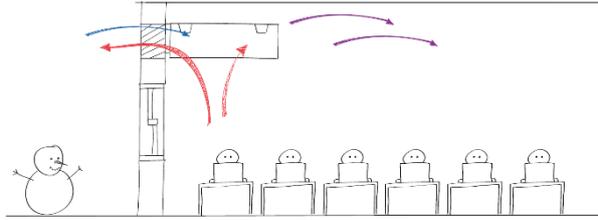
Summer Boost:

- Damper opens fully
- Air delivered to rear of the space
- Natural exhaust through the unit
- Night cooling



Winter Mixing:

- Draught mitigation strategy
- Mixes warm room air with fresh external air
- Natural exhaust through the unit



Installation and Control

The units are designed so that they can be exposed or enclosed in a bulkhead or ceiling void. The slimline nature of the units was part of the design which was undertaken in collaboration with Nicholas Hare Architects. When the units are exposed in the room or mounted in a bulkhead a grille is usually provided to direct air towards the ceiling and back of the room. The grille arrangement complies with the PSBP FOS. Exposed NVHR units can also be supplied with a fabric duct or solid duct.



Exposed NVHR unit with a grille



Exposed NVHR with a solid duct



Exposed NVHR with a fabric duct



Diffuser grille arrangement above a suspended ceiling

Find Out More

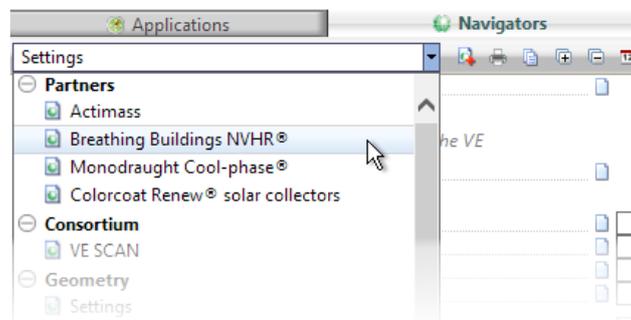
For full details on NVHR, please read the datasheet or contact Breathing Buildings for further information (see [Appendix B](#): for contact details).

3. Using NVHR in the VE

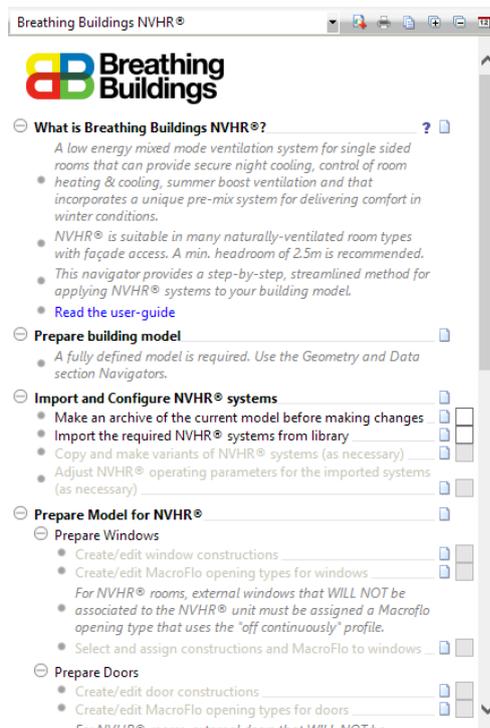
Introduction

The integration of NVHR support into the VE provides a fast, streamlined and easy-to-use method of simulating the effect of NVHR units within your VE building model. A dedicated Navigator is used to guide you step-by-step through the automated process, from importing the units into your model, configuring their operation, preparing and applying to rooms, thermal simulation and review of the results.

To get started, click on the dropdown list of available Navigators at the top of the *Navigators* pane (if the pane is not visible on the left side of the VE window, you can turn it on using the  button on the application toolbar, or by selecting Navigator from the view menu). You will find a **Breathing Buildings NVHR®** entry listed under the *Partners* section.



When selected, the *Breathing Buildings NVHR®* navigator will be displayed. This is what you will use to go through the process of applying NVHR to your building, simulating and analysing the results.

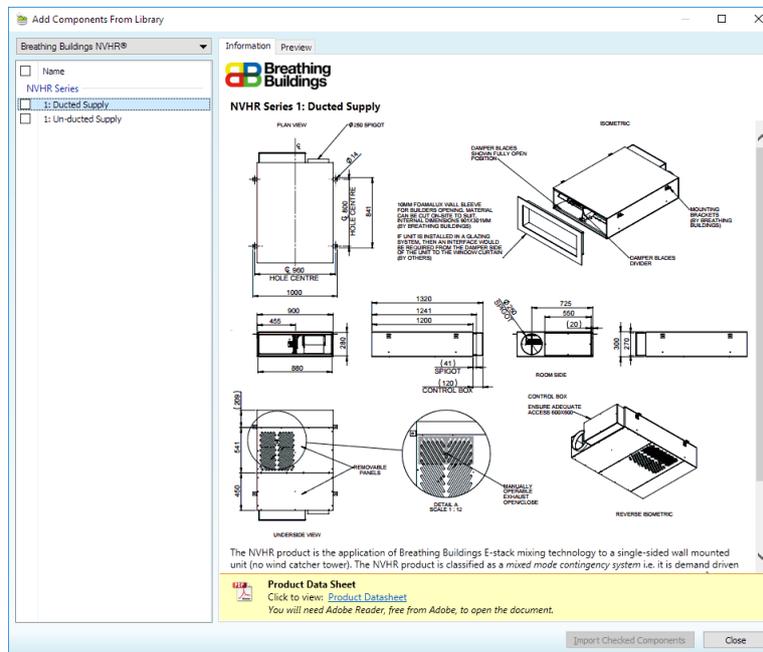


In order to start using the navigator, you will need to have a fully defined VE model already created and loaded. This model should contain valid geometry representing the building, and may also be set up with valid data (e.g. heating set-points, cooling set-points, Apache systems, internal gains, air exchanges, MacroFlo openings) already assigned to the rooms. As the assignment of NVHR to rooms will make direct modifications to the assigned data, it is always recommended that you **make a back-up of your model prior to commencing the NVHR integration** – this will allow you to have a baseline that you can easily revert back to in the event of any issues. You can do this by clicking the *Make an archive of the current model before making changes* item in the navigator, or by selecting the *Current Project* item from the *File->Archive* menu.

Once done, you will be ready to start with NVHR.

Importing the NVHR units

To get started with NVHR, you will need to import the units into your building model. The units are represented in the VE by components – when placed into a room, the room will automatically be updated to make use of the NVHR unit. You can import the units by clicking on the *Import the required NVHR® systems from library* item in the navigator – this will open the *Add Components From Library* window with the *Breathing Buildings NVHR®* library pre-selected:



There are currently two types of unit that you can import into the VE – ducted or un-ducted. Details on selecting which type of unit would be best suited for your usage are given in [NVHR Background](#) or should be discussed with Breathing Buildings (see [Appendix B](#): for contact details). You can review the overview of each unit by clicking on it – this will also allow you to download the product datasheet.

To import the units, click on the checkbox next to the type(s) you want, then click on the *Import Checked Components* button. This will then copy the relevant component(s) into your model's component library, making them ready to be assigned to rooms. In addition to the unit(s) themselves, the first import of an NVHR unit to the model will also import some typical ancillary data that can be used when setting up your default room openings (louvres and windows) prior to assignment:

- Typical MacroFlo opening types for louvres and windows
- Typical CDB constructions for louvres

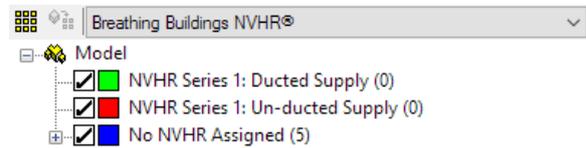
Note: If you do not require these items, they can be manually removed from your model after import using standard CDB and MacroFlo functionality if you have not already assigned them to openings in the model.

Once the units have been imported, you can close the *Add Components From Library* window by clicking on the *Close* button.

Using the NVHR Grouping Scheme

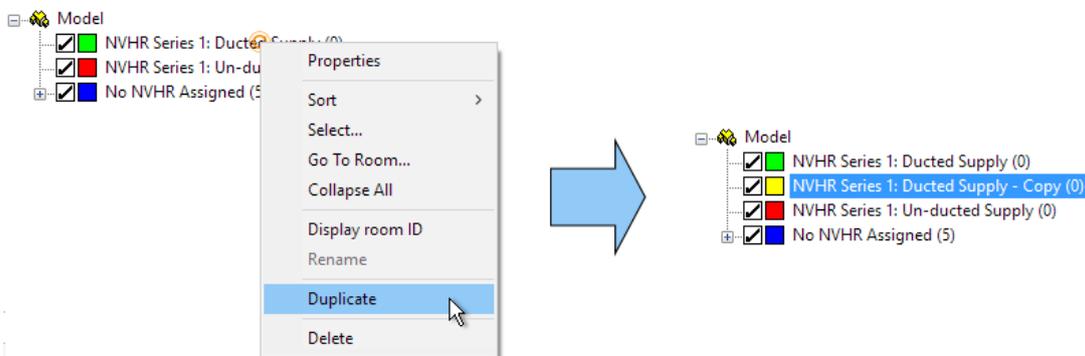
Once you have imported one or both of the unit components from the library, a new *Breathing Buildings NVHR®* room grouping scheme will be created in your model and automatically selected in the room browser pane (if the pane is not visible at the bottom left of the VE window, you can display it using the  button on the application toolbar, or by selecting *Browser* from the *File->View* menu).

The NVHR grouping scheme is the mechanism used to assign an NVHR unit to a room in the model. The scheme contains one or more *unit groups* representing each unit type you have in your model – this will initially be the unit(s) you imported using the previous navigator action. There is also a final unit group called *No NVHR Assigned* – if a room is not being served by an NVHR unit, it is contained in this group (initially, all rooms in the model will be in this group).



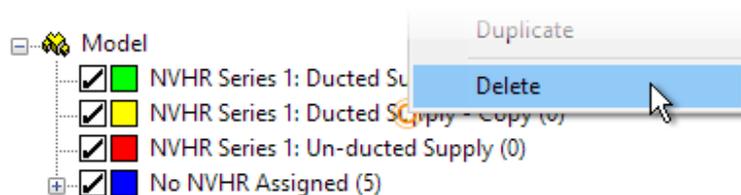
Duplicating Unit Groups

Since all rooms assigned to a particular unit group will share the same NVHR properties (i.e. number of units in room, operation schedule, set-points and so on), you may want to create one or more duplicates to allow the same basic type of unit (ducted or un-ducted) to be used with different properties on each (e.g. a different number of units per room, or different setpoints). To duplicate a group, right-click on it in the grouping scheme and select the *Duplicate* item – this will then create a new unit group below the right-clicked group that can be edited and assigned to independently.

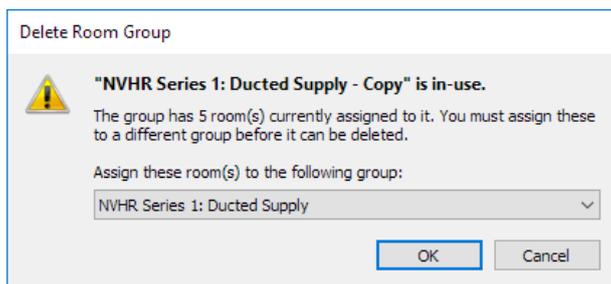


Deleting Unit Groups

If you have unit groups that are no longer required, you can remove them to avoid clutter. To remove a unit group, right-click on it in the grouping scheme and select the *Delete* item.



If there are one or more rooms currently assigned to the unit group, they will need to be re-assigned before the group can be deleted. The software will prompt you to do this before you can proceed:



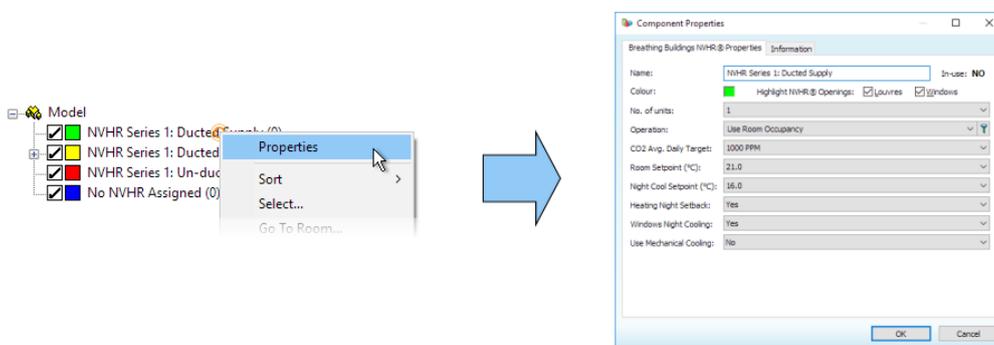
Clicking *Cancel* at this point will mean that the unit group is not deleted and the room(s) remain assigned to it. Clicking *OK* will re-assign the room(s) to the alternative unit group and then then remove the unit group.

All unit groups can be deleted (excluding the *No NVHR Assigned* group). Note that if the last "real" unit group is removed, the grouping scheme itself will be automatically removed and the following alert will be displayed:



The grouping scheme can be reinstated by importing one or both of the original components again.

Editing Unit Group Properties



You can view and edit the NVHR properties for each unit group (excluding the *No NVHR Assigned* group) by right-clicking on the group item and selecting *Properties*. This will display the *Component Properties* window, consisting of two tabs: *Breathing Buildings NVHR® Properties* and *Information*.

The *Breathing Buildings NVHR® Properties* tab allows you to control the settings that will be used to simulate NVHR in each room that is assigned to the unit group, as well as edit the basics of the unit group such as naming, number of units per room, whether it will highlight its assigned louvres and windows, and its colour (displayed next to it in the grouping scheme and used by opening highlighting and if the *By Room Group* option is selected in the *View->Colour* menu).

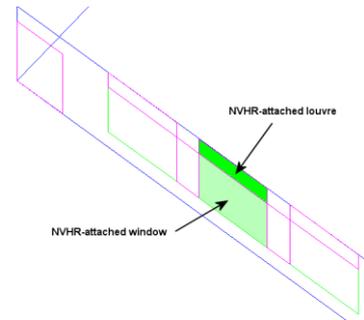
Name:	<input type="text" value="NVHR Series 1: Ducted Supply"/>	In-use: NO
Colour:	<input type="color" value="#00FF00"/> Highlight NVHR® Openings: <input checked="" type="checkbox"/> Louvres <input checked="" type="checkbox"/> Windows	
No. of units:	<input type="text" value="1"/>	
Operation:	<input type="text" value="Use Room Occupancy"/>	<input type="button" value="Filter"/>
CO2 Avg. Daily Target:	<input type="text" value="1000 PPM"/>	
Room Setpoint (°C):	<input type="text" value="21.0"/>	
Night Cool Setpoint (°C):	<input type="text" value="16.0"/>	
Heating Night Setback:	<input type="text" value="Yes"/>	
Windows Night Cooling:	<input type="text" value="Yes"/>	
Use Mechanical Cooling:	<input type="text" value="No"/>	

Name: Allows you to change the name of the unit group. Editing this name will also update the name of the associated component in the model’s component library.

In-use: Indicates whether the unit group is in-use (has one or more rooms assigned to it) or not in use (has no rooms assigned to it).

Colour: Displays the colour currently used by the unit group for highlighting. Clicking on the colour will display the standard colour picker window, allowing this colour to be changed.

Highlight NVHR® Openings: These options control whether rooms assigned to this unit group will highlight their attached louvre(s) and/or window(s). Louvres will be highlighted in full colour, while windows will be highlighted in a lightened version of the colour.



Note that the opening highlighting is only displayed if the *Breathing Buildings NVHR®* grouping scheme is active in the room browser.

No. of units: Sets the number of NVHR units that will be simulated in each room assigned to this unit group. This can be between 1 and 6 units (2 would be typical for a standard-sized classroom).

Operation: Lists modulating profiles (weekly or yearly only) that can be used to control the operation of the NVHR unit(s) in the room(s) assigned to this unit group. By default, the filtering on this list will only show profiles that include the *Occupancy* category or have no categories set. You can change the filtering options by clicking the button.

There is also an additional option *Use Room Occupancy*. When selected, this means that the operation of the NVHR unit(s) will be determined by the occupancy profile for each assigned room. Note that if an assigned room does not have a defined occupancy (i.e. an internal gain of type *People*), it will be considered to be using *off continuously* (unoccupied).

CO2 Avg. Daily Target: Sets the average daily CO₂ target in parts per million (PPM) for each room assigned to the unit group.

Room Setpoint: Sets the temperature set-point for the occupied hours in room(s) assigned to the unit group.

Night Cool Setpoint: Sets the temperature set-point for the unoccupied hours in room(s) assigned to the unit group.

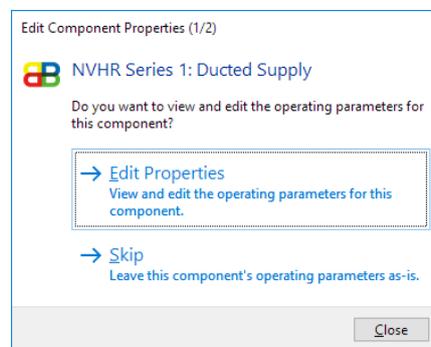
Heating Night Setback: Sets whether a heating night setback strategy is used for room(s) assigned to the unit group.

Windows Night Cooling: Sets whether windows night cooling is used for room(s) assigned to the unit group.

Use Mechanical Cooling: Sets whether mechanical cooling is used for room(s) assigned to the unit group.

Note that if there are already room(s) assigned to the unit group when you apply changes to one or more of these values, the updates will be applied to all currently assigned rooms.

The navigator action *Adjust NVHR® operating parameters for the imported systems (as necessary)* will simply cycle through all available unit groups, asking you whether you want to edit the properties or skip:



This is equivalent to right-clicking on each unit group in turn and clicking on *Properties*.

Assigning NVHR to Rooms

With the appropriate unit group(s) set up and valid properties set (see previous section for details), the unit groups are ready to be assigned to room(s) in your model. Note that in order to be valid for NVHR assignment, any room must meet the following pre-requisites:

- The room **must** have a wall with **at least one external window** that is assigned a MacroFlo opening type that uses a *Degree of Opening* profile **other than off continuously**. Note that ALL wall-based external windows that meet these criteria will be considered attached to the NVHR unit(s) in the room.
- The room **must** have a wall with **at least one external door** that is assigned a MacroFlo opening type that uses a *Degree of Opening* profile **other than off continuously**. These doors will then be treated as the louvres for the NVHR unit(s). Note that ALL wall-based external doors that meet these criteria will be considered attached to the NVHR unit(s) in the room.

As modelling all non-NVHR attached windows and doors with *off continuously* (i.e. never opening) is unlikely to be practical, the intended workflow is as follows:

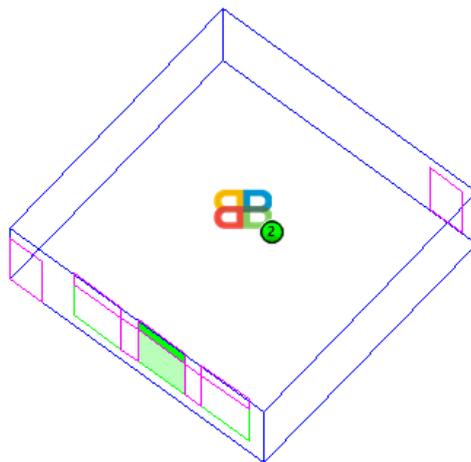
- 1) Prior to beginning NVHR assignment, ensure that all external windows and doors in the desired room(s) are assigned a MacroFlo opening type that uses *off continuously* as the *Degree of Opening* profile.

- 2) Select the window(s) and door(s) in each room that WILL be used by NVHR, and assign them a MacroFlo opening type that uses *on continuously* as the *Degree of Opening* profile.
- 3) Assign the relevant rooms to NVHR (the active openings will then be highlighted).
- 4) Update the assigned MacroFlo opening types for the inactive doors and windows as appropriate for your model.

The *Breathing Buildings NVHR*[®] navigator will attempt to guide you through this process. Use the *Prepare Model for NVHR*[®] section actions to assist with this – they will allow you to create suitable MacroFlo opening types for your needs (alternatively, you can use the standard types imported with the original components – e.g. *Louvres (on continuously)*, *Louvres (off continuously)* etc.), create suitable CDB constructions (if desired), select openings and assign the relevant types using the *Opening Selection and Assignment* utility in ModelIT. This will allow you to select doors or windows (the tool operates on one or the other at any one time) either by click/drag in the viewport, or based on criteria (e.g. area, orientation, slope). It then offers a quick route to assigning MacroFlo and/or constructions onto the selected opening(s).

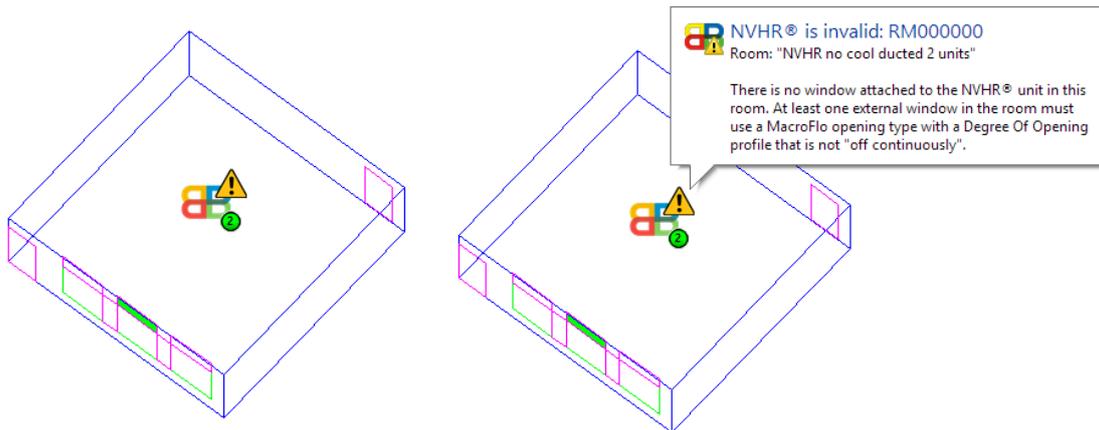
You designate a room to be served by NVHR by assigning it to the appropriate unit group in the *Breathing Buildings NVHR*[®] navigator – this can be done by any of the standard methods (e.g. using the  button above the room browser, or by using the *Room Groups* tab within Tabular Room Data in ModelIT).

Once a room is assigned to an active unit group (i.e. a group other than *No NVHR Assigned*), the room will display a Breathing Buildings logo in the viewport (as well as indicating which of the openings are attached to the NVHR within that room) whenever the *Breathing Buildings NVHR*[®] grouping scheme is active in the room browser. The logo will also display a small circle overlay at the bottom-right, indicating the number of NVHR units being represented in that room:



If a problem is detected with the room set-up (e.g. there was no valid window or louvre to attach to the NVHR), then an exclamation mark overlay will be displayed at the top-right of the Breathing Buildings logo – if you hover over the exclamation mark with the select tool () active, a balloon tip will be displayed to indicate the problem with the room.

For example, if the room did not have any external window set with a Degree of Opening other than *off continuously*:



To correct this scenario, you must apply a valid (not off continuously) MacroFlo opening type to at least one external window in the room (or to one external door, if the problem indicated that there was no attached louvre). You can then either:

- Assign the room to the same unit group again using the  button above the room browser. This will re-attempt the assignment and should then correctly detect and attach the opening.
- Use the *Ensure that all rooms assigned to NVHR® systems are valid* navigator action. This will go through all assigned rooms that are currently marked with an exclamation mark and attempt to correct them.

Note that the presence of the exclamation mark does *not* indicate that the model cannot be simulated – it simply indicates a problem with the NVHR set-up in that room, which may result in inaccurate NVHR simulation results.

What happens when a room is assigned?

The act of assigning a room to an NVHR unit group makes a number of modifications to that room's assigned data, internal gains, air exchanges, MacroFlo opening types and Apache System, each with the intent of setting up the room for an accurate simulation of NVHR. This will involve creating a number of profiles based upon the specified operation profile. The exact modifications are controlled by the properties of the unit group you have assigned the room to – modifications to these properties after assignment will then cause the relevant values in the room to be updated again.

The following modifications are made to the Room Data for the room:

- The **Heating Profile** will be set to *on continuously*.
- The **Heating Setpoint** will be set to *Timed* and a suitable set-point profile created and applied to the room, based upon the unit group's operation profile and set-point values.
- The **Cooling Profile** will be set to *on continuously* if the unit group has *Use Mech. Cooling* active, otherwise it will be set to *off continuously*.
- The **Cooling Setpoint** will be set to *Timed* and a suitable set-point profile created and applied to the room, based upon the unit group's operation profile and set-point values.
- A modified copy of the room's **main Apache System** will be created and assigned (see below).

- The **System Outside Air Supply Variation Profile** will be set to *off continuously*.
- The **Variation Profile** for any existing Natural and Auxiliary Ventilation air exchanges in the room will be set to *off continuously*.
- One Machinery internal gain added to represent the electrical usage of the NVHR Supply Fan.
- One Auxiliary Ventilation air exchange added to represent the NVHR Supply Fan.
- One Machinery internal gain added to represent the electrical usage of the NVHR Mixing Fan.

The modifications for the room's main Apache System are performed on a copy, as the system may be assigned to room(s) that are not part of the NVHR unit group. However, if a suitable copy of the system already exists, this one will be used instead (this is done to avoid bloating the Apache Systems list for the model). The name of the copy will be prefixed with either *NVHR® (Nat. Vent)*: or *NVHR® (Air Con.)*: depending on the *Use Mech. Cooling* setting in the unit group. The following modifications are performed for the copied Apache System:

- The **Cooling/Ventilation Mechanism** will be set to *Natural Ventilation* if the unit group has *Use Mech. Cooling* active, otherwise it will be set to *Air Conditioning*.
- If the unit group has *Use Mech. Cooling* active, the **Changeover Mixed Mode Free Cooling** value will be set to *Mechanical Ventilation*.
- The **Auxiliary Energy Method** will be set to *Use SFPs*.
- If the unit group has *Use Mech. Cooling* active, the **Air Supply Mechanism** for fans will be set to *Other Local Ventilation Units*, and the **System Specific Fan Power (SFP)** for fans will be set to *0.0 w/l.s.*

Similar to the Apache System, the modifications to the MacroFlo opening types applied to the attached window and louvre openings in the room are performed on copies, as these opening types may be applied to other openings in the model that are not attached to NVHR. Again, if a suitable copy of the MacroFlo opening type already exists in the model, this one will be used instead to avoid bloating. The name of the copy will be prefixed with either *NVHR® (Louvre)*: or *NVHR® (Window)*: depending on the type of opening (door or window) it is being created for. The following modifications are performed for the copied MacroFlo opening type:

- If the opening type is being created for an external door, the **Opening Category** will be set to *Louvre*.
- A suitable profile will be created and set as the **Degree of Opening Profile**, based upon the unit group's operation profile, set-point values and CO₂ daily target values.

When creating the Auxiliary Ventilation air exchange for the Supply Fan, the following values will be used:

- The **Reference** will be called *NVHR® Supply Fan*, optionally suffixed by a number if necessary.
- The **Max Flow** value will be set to *180.0 l/s*, scaled by the number of units specified in the unit group (e.g. for 2 units, the value will be set to *360.0 l/s*)
- A suitable profile will be created and set as the **Variation Profile**, based upon the unit group's operation profile, set-point values and CO₂ daily target values. The formula data

within the profile will differ based on whether the unit group represents a ducted or un-ducted NVHR unit.

When creating the Machinery internal gain for the Supply Fan, the following values will be used:

- The **Reference** will be called *NVHR[®] Supply Fan*, optionally suffixed by a number if necessary.
- The **Input Mode** will be set to *Watts (W)*.
- The **Maximum Sensible Gain** and **Maximum Power Consumptions** value will be set to *180.0 l/s*, scaled by the number of units specified in the unit group, then scaled by a design setting SFP of *0.3 w/l·s at 20 Pa*.
- A suitable profile will be created and set as the **Variation Profile**, based upon the unit group's operation profile, set-point values and CO₂ daily target values. The formula data within the profile will differ based on whether the unit group represents a ducted or un-ducted NVHR unit.

When creating the Machinery internal gain for the Mixing Fan, the following values will be used:

- The **Reference** will be called *NVHR[®] Mixing Fan*, optionally suffixed by a number if necessary.
- The **Input Mode** will be set to *Watts (W)*.
- The **Maximum Sensible Gain** and **Maximum Power Consumptions** value will be set to *80.0 l/s*, scaled by the number of units specified in the unit group, then scaled by a design setting SFP of *0.3 w/l·s at 20 Pa*.
- A suitable profile will be created and set as the **Variation Profile**, based upon the unit group's operation profile, set-point values and CO₂ daily target values. The formula data within the profile will differ based on whether the unit group represents a ducted or un-ducted NVHR unit.

Where profiles are automatically created, these will be marked as having a Data Source of *Breathing Buildings*. These are not assignable through profile dropdowns, as they are automatically managed by the VE and are only intended to be used by the automatic assignment process for NVHR. Whilst you can make modifications to the profile values using [ApPro](#), this is **NOT** recommended as it may produce results that do not reflect the properties defined by the NVHR unit groups in the model. The profiles may be automatically updated or deleted by making modifications to the properties of unit groups in the room browser.

What happens when a room is unassigned?

The act of assigning a previously-assigned room to the *No NVHR Assigned* unit group will result in the following modifications being made:

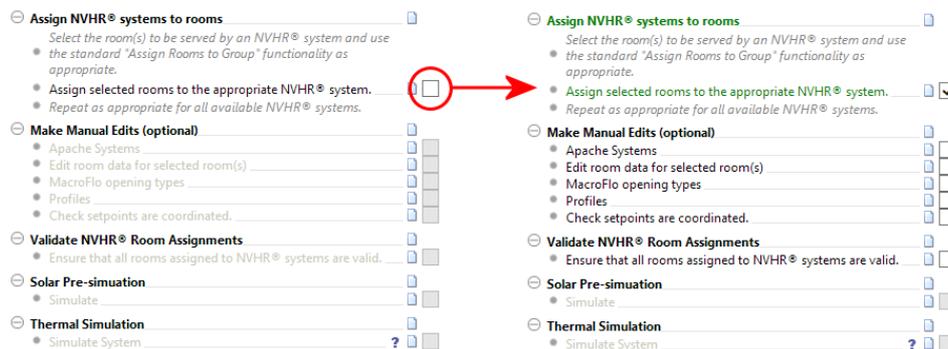
- NVHR Supply Fan internal gain and air exchange will be removed from the room.
- NVHR Mixing Fan internal gain will be removed from the room.
- **All** template-derived values for the room will be set back to *From Template*.
- The MacroFlo opening types assigned to the window(s) and door(s) attached to the unit will be reset back to the source opening type (i.e. the opening type that the automatic copy was created from).

- Any automatically created profiles, MacroFlo opening types, internal gains, air exchanges and Apache Systems that are not in use will be removed from the model.

At this point, the room will no longer display the Breathing Buildings logo and the openings will not appear highlighted.

Simulating with NVHR

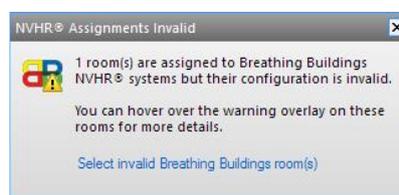
Once you have assigned the rooms in your model to NVHR unit groups as appropriate (and then performed any subsequent manual edits to room data, profiles, templates and so on), the model should be ready to simulate. The relevant Navigator actions will be enabled when you click the checkbox to the right of the *Assign selected rooms to the appropriate NVHR® system* action (acknowledging that you have completed the action).



Note that the *Make Manual Edits* actions are optional – you will be able to continue without them. However, it is recommended that you review these items prior to simulation to ensure that the assigned options are valid for your model intent (particularly review the assignment of MacroFlo opening types on windows and doors that are **not** assigned to the NVHR units, as these will have been set as *off continuously* prior to NVHR unit group assignment).

In order to enable the *Solar Pre-simulation* and *Thermal Simulation* steps, you should perform the *Ensure that all rooms assigned to NVHR® systems are valid* action – this will attempt to correct any problems with the NVHR data on any room that is marked with an exclamation mark.

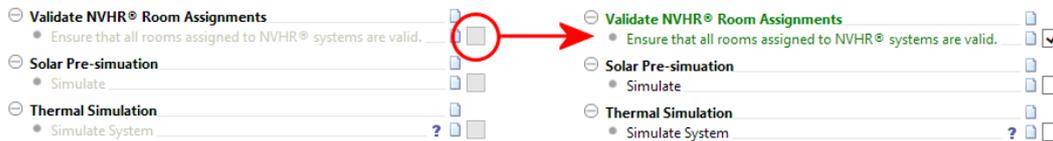
If one or more rooms could not be corrected automatically, an alert should display at the bottom-right of the VE window indicating the number of rooms that need manual attention.



In this situation, you should review the problems for each invalid room by hovering the mouse over each room’s exclamation mark – you can then take appropriate action to resolve the issue and then retry this step. Once all assigned rooms are valid, the following alert should display at the bottom-right of the VE window:



You should then click the checkbox to the right of the *Ensure that all rooms assigned to NVHR® systems are valid* action to enable the actions for Solar Pre-Simulation and Thermal Simulation.

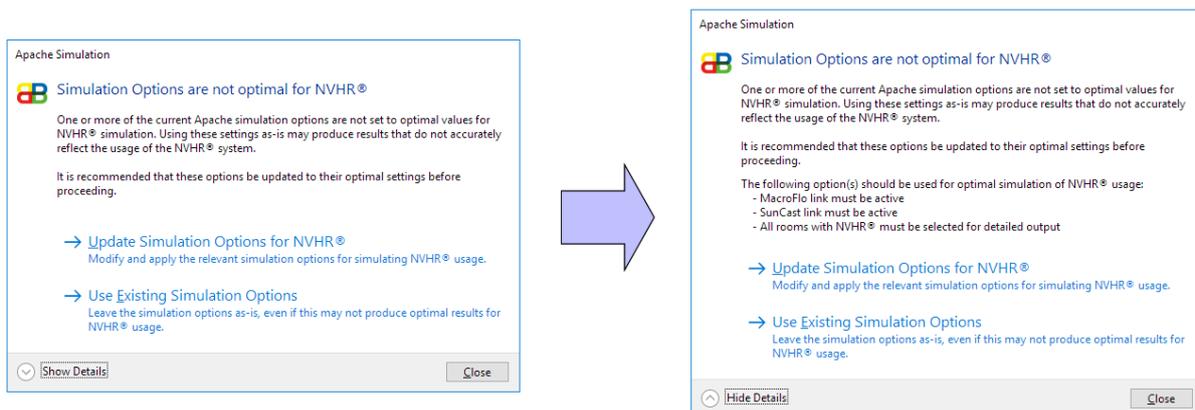


You can then click the *Simulate* option under Solar Pre-simulation – this will switch the VE into SunCast view and run the solar shading calculations.

Once completed, clicking the *Simulate System* action under Thermal Simulation will switch to Apache view and prepare to run an Apache Simulation. In order to effectively simulate and view results for the NVHR, the following simulation options are required:

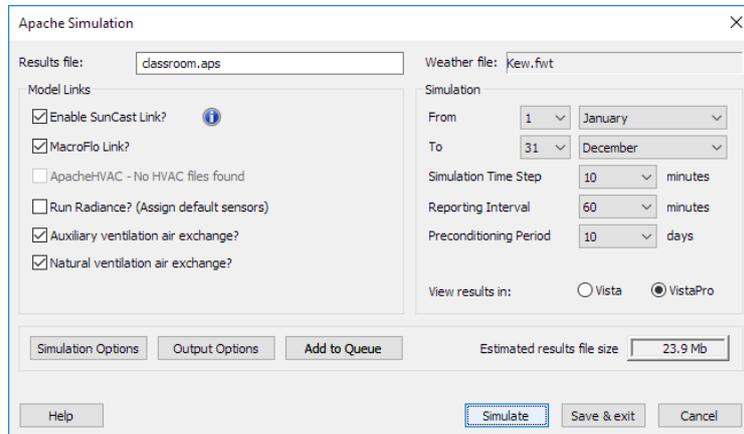
- **Enable SunCast Link?** should be active
- **MacroFlo Link?** should be active
- **Auxiliary ventilation air exchange?** should be active
- **Natural ventilation air exchange?** should be active
- All NVHR-assigned rooms should be selected for detailed output
- **Sensible internal gains breakdown** should be active for detailed output

The *Simulate System* action will first check your current simulation options to see if they match these desired values – if not, a message will be displayed to indicate this:



You can use the *Show Details* button at the bottom-left to display information on which setting(s) are not at the expected value. If you would like the settings to be automatically updated to be optimal for simulating NVHR, you can click the *Update Simulation Options for NVHR®* button – otherwise, click the *Use Existing Simulation Options* button to continue with your current simulation options.

The standard *Apache Simulation* window should then appear, allowing you to configure which period you want the simulation to cover. Once ready, you can start the simulation by clicking the *Simulate* button.



Note that due to the requirement of detailed output for the assigned rooms, the simulation may take some time to run. Once completed, you should switch to VistaPro to view and analyse the results.

Results Analysis

Refer to the [VistaPro](#) manual for details on the use of this module; however, the following is typical:

Carry out common sense simulation checks:

- Occupancy & gains operate at the desired times (line chart & table);
- Set-points are correct at the desired times (line chart & table);
- Auxiliary ventilation (NVHR supply fan) operates at the desired times (line chart & table);
- Openings operate at the desired times (line chart & table);
- Room temperature conditions do not lie outside of sensible limits (line chart & table);
- Room CO₂ conditions do not lie outside of sensible limits (line chart & table).

It is important that an appropriate number of NVHR rooms are assigned to a space; an insufficient number of units can often be detected by poor CO₂ performance.

Carry out design performance checks:

- Winter temperature test (range test < X°C (e.g. 20°C), occupied hours, heat map);
- Summer low-level overheating test (range test > X°C (e.g. 23°C), occupied hours, heat map);
- Summer comfort overheating test (range test > X°C (e.g. 25, 28°C), occupied hours, heat map);
- CO₂ test (range test > X PPM (e.g. 1000 PPM), occupied hours, heat map);
- Room temperature both when occupied and during night cool (line chart);
- Operation of mechanical cooling if provided versus room temperature (line chart);
- Active opening operation versus internal & external temperatures (line chart & table);
- Energy use (line chart & summary table).

It is important that you review simulated operation and consider adjusting NVHR set-point values to fine tune the design performance.

Carry out compliance performance checks:

- CIBSE TM52 automated tests (see the [VistaPro CIBSE TM52 Adaptive Comfort](#) user guide)

4. NVHR and UK NCM analysis (Part L, Section 6, EPCs)

The NCM framework

Then National Calculation Methodology (NCM) is the framework defined by the UK Government for the analysis of buildings and their systems for the purpose of analysis relating to Part L (for England, Wales and Northern Ireland), Section 6 (for Scotland), and Energy Performance Certificates (for all UK regions).

NCM analyses are governed by rules setting out the simulation methods to be used and the conditions applying in those simulations. Setpoints, occupancy, DHW consumption, internal gains and minimum ventilation rates are specified for a standardised set of building types and activities. Systems are organised into categories, infiltration rates are calculated by approved methods, and rules are laid down for the calculation of energy used by fans and pumps ('auxiliary energy'). These rules mean that conditions and methods used within the NCM framework to simulate the *Actual Building* (a specialised NCM term) may differ from those applicable to the *real building* (the building as designed, occupied and operated).

Analysing the real building and the Actual Building

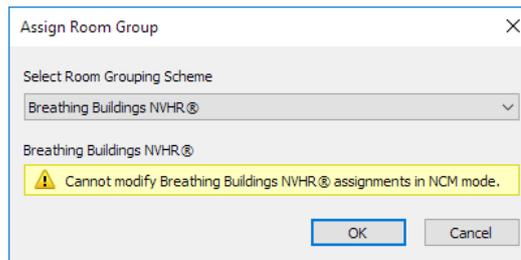
The main sections of this document have described the approach to analysing the real building, using simulation methods tailored to the detailed representation of NVHR systems.

In order to comply with the special requirements of NCM a modified approach is required. This involves analysis of the *Actual Building* and the buildings which the software derives automatically from it – the *Notional Building* and (for EPC purposes) the *Reference Building*. These analyses are performed in the *VE Compliance* view of the VE, where tools are provided to facilitate the input and editing of the additional data items.

Because some of the data required for NCM is shared with the analysis of the real building, NCM analysis should be conducted on a copy of the real building model which is modified to accommodate the NCM requirements.

In the VE Compliance view the NVHR units and logos are not displayed, and their place is taken by provisions compatible with the NCM rules.

In this view, it is not possible to modify the assignment of rooms to unit groups. The standard *Assign Room Group* window will notify you when this is the case:



Fan heat gains from NVHR systems will be ignored in NCM analyses, which use standard prescriptions for room heat gains. The electricity consumption of the ventilation fans, must, however, be accounted for.

To represent NVHR systems working in combination with the systems providing heating (and where appropriate cooling) to the building, one or more Apache Systems must be created (or adapted from their counterparts used for the real building). The characteristics of these systems should be entered via the *UK NCM system data wizard*, starting with the selection of a suitable system type from the *UK NCM system type* menu. Adjustments should then be applied to cater for the unique features of the NVHR systems.

For heated-only rooms served by NVHR systems, *Cooling/vent.* on the *Ventilation* tab should be set to Mechanical ventilation. In cases where the NVHR system provides all the ventilation, the *Air supply* setting on the *Ventilation* tab of the *UK NCM system data wizard* should be set to *Local ventilation-only units, such as window/wall/roof units serving a single area*. The natural ventilation component of the system will be taken into account via SFP adjustments described below. It should be noted that the aspects of the system which provide benefit in the form of reduced summertime temperatures do not explicitly receive credit for this benefit under the current NCM *Criterion 3* rules, which in contrast to earlier editions of the Regulations are expressed exclusively in terms of reduced solar gain. However, this aspect of performance will form an important part of the design as assessed by the performance of the *real building*.

Any rooms for which an NVHR system supplements an air conditioning system should be modelled with an appropriate air conditioning system type, and in this case *Changeover mixed mode free cooling* on the Apache System *Cooling* tab should be set to *Mechanical ventilation*.

Set up this way, the system will be assessed for regulatory purposes against a comparable system in the *Notional Building*.

Close attention should be paid to the settings on the *System adjustment*, *Metering Provision* and *System controls* tabs of the *UK NCM system data wizard*, since these have a critical effect on performance as assessed by the Regulations.

On the *System* tab of the Room Data dialog for each room served by an NVHR system:

- *System* and *Auxiliary vent. system* should be set to the appropriate Apache System.
- DHW system should be set to the Apache System created for this purpose.
- *Free cooling flow capacity* should be set to the maximum volume flow rate that the NVHR system is able to deliver to the room.

- *Is there mechanical supply in this room?* (when present) should be ticked, and immediately below it the checkbox *Specific fan power* should be set according to the principles described below.
- *Demand controlled ventilation Type* should be set to *Demand control based on occupancy density (Cd = 0.85)*.

Fan power used by an NVHR system is represented within the NCM framework as a component of *auxiliary energy*. This is the sum of contributions from pumps and fans. Pump power is a function of system category and subject to limited user control. Fans fall into two categories – central and local – for each of which a specific fan power (SFP) must be specified.

In the case of heating-only systems for which ventilation is provided locally the SFP parameter on the Apache System dialog (System specific fan power (SFP)) should be set to zero and a suitable SFP value entered on the *System* tab of the Room Data dialog for each room. This value should represent the average SFP applicable to the room ventilation during operating hours, accounting for the fact that for many hours the fan will be off. A suitable value (which will typically be very small) should be derived from detailed simulations performed (under equivalent assumptions) for the real building.

Where heating and cooling is supplied by a separate system providing mechanical air distribution there will be SFPs associated with the central system and/or the local air delivery. Where appropriate these SFPs should be modified to take account of the small additional fan power incurred by an NVHR system.

A separate Apache System, with suitable operation parameters, should be created to provide domestic hot water (DHW), and assigned to the rooms for this purpose.

For the model used for NCM analysis, infiltration is set using parameters on the *Building & System Data* dialog. MacroFlo analysis should be disabled by ensuring that the *MacroFlo link?* checkbox is unticked on the *Simulation Settings* tab of the *Building & System Data* dialog.

With regard to the numerous other data inputs relating to NCM presented in the VE Compliance view, reference should be made to the general guidance provided on this aspect of the software.

Appendix A: Frequently Asked Questions

Q: Why are some actions on the Breathing Buildings NVHR® navigator greyed out?

A: If the action is greyed out but also has a small padlock icon shown on its checkbox (), this indicates that you do not have a suitable view licence to carry out that action. See [Requirements for using NVHR in the Virtual Environment](#) for more details on the licences required to use the NVHR integration within the VE.

If the padlock is not displayed but the action remains greyed out, this means the action requires you to tick one or more previous actions (therefore acknowledging that you have performed them) before you can carry out the action.

Q: I have a number of rooms contained in one NVHR unit group. I want one of these rooms to use slightly different NVHR properties (e.g. heating set-point) to the others – how can I do this?

A: All rooms assigned to an NVHR unit group will share the same NVHR properties. If you want one or more of the rooms to use tweaked values, you must create a duplicate of the unit group, tweak the relevant values in that duplicate group, then re-assign the appropriate rooms to that duplicate group instead. See [Duplicating Unit Groups](#) for guidance on how to achieve this.

Q: Can I have different NVHR units within the one room (e.g. a ducted unit and a ductless unit)?

A: This is not currently possible – for modelling within the VE, a room can only be assigned to a single NVHR unit group (and therefore a single unit type).

Q: Do I need to use the Breathing Buildings NVHR® navigator workflow to apply NVHR to my model, or can I do it myself?

A: The navigator acts as a guide to best-practice and offers the most straightforward workflow for applying NVHR to your model. However, you can import NVHR components from the source library, assign rooms to the unit groups and so on without using the navigator. It is recommended that you follow the navigator for convenience and practicality, unless you have a specific situation where you need to do otherwise.

Appendix B: About Breathing Buildings Ltd.

Breathing Buildings Ltd. was formed as a spin out company from the University of Cambridge in 2006, following the discovery and development of the proprietary low energy e-stack mixing ventilation system as part of a major research programme at the BP Institute, through the Cambridge-MIT Institute, with funding from BP plc. The technology was filed for patent by the University of Cambridge, and Breathing Buildings has exclusive rights to the technology.

Breathing Buildings was set up to develop and commercialize this low energy ventilation system. During 2006-07 prototypes of the system were developed and tested in the Breathing Buildings laboratories, with a team of highly qualified ventilation experts. The value and potential of the innovation has been recognised by several awards for innovation. Furthermore, since the e-stack system was commercially introduced in 2007, the success of the product and associated consultancy has been recognised by industry via an increasing number of awards.

E-stack systems are operating in hundreds of buildings across the UK, ranging from retail projects to local primary schools, and there is a substantial pipeline of new projects for which Breathing Buildings is actively engaged in supplying e-stack systems.

The Breathing Buildings team contributes significantly to research into natural ventilation. Our links with the University of Cambridge are very strong. [Click here](#) for a reference list of background papers and to watch Dr. Shaun Fitzgerald giving an introductory lecture on Natural Ventilation please [click here](#).

Contact Us:

Address: Breathing Buildings,
Unit 3a, The Shade
Soham
CB7 5HF
United Kingdom

Telephone: +44 (0)1223 450 060

Fax: +44 (0)1223 450 061

E-mail: info@breathingbuildings.com