Modelling R and S series e-stacks in IES

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Introduction

This document is to allow IES users to model the e-stack ventilation system.

The main advantage of the e-stack system over other natural ventilation systems is that in the winter, we do not bring in air via opening windows, as this requires a large amount of preheating energy. Instead we operate in 'mixing mode' where we bring in air at high level and mix it with warm room air to create a tempered air stream which is comfortable for occupants.

To accurately model conventional natural ventilation systems, preheating at the low level openings would have to be incorporated. However as IES and building regulations do not take account of thermal comfort in relation to draughts; therefore any energy input to mitigate cold draughts does not need to be included. So the e-stack system will look the same as any other natural ventilation system in terms of heating energy consumption, because the need for preheating is disregarded by IES which just takes into account the bulk air temperature.

Summary of the Strategy

External Temperature	Internal Temperature	Strategy
< 16 degC	-	Winter Mixing Mode Minimum ventilation on CO_2
> 16 degC	<24 degC	Upwards Displacement Mode No Fans
> 16 degC	>24 degC	Upwards Displacement Mode Fan Assistance
>25degC	-	Nightcooling operates that night

Modelling the Winter Mixing Mode

The e-stack system is not a heat exchanger, and therefore cannot be modelled as a mechanical system with heat recovery. The system saves energy by bringing air into the space and mixing it with room air to reduce cold draughts, by using low powered fans. The casual gains produced inside the space by the occupants lighting and equipment, keep it warm on all but the coldest days (<5-10degC).

As the system is controlled on CO_2 in winter the supply should be set to provide minimum fresh air. This means that if the space is unoccupied (eg. during lunchtime) the ventilation should stop. This is in contrast to uncontrolled systems that provide fresh air at a constant rate.

The simplest way to define the flow rate is to specify an 'Natural Air Exchange' to provide an equivalent of 5l/s/person, with the adjacent condition set to 'External Air' and create a variation profile which operates in the same way for each occupied day of the year, inputting the formula "**to<16**" during all occupied hours. The specific fan power should be set at 0.6 W/l/s for the R-Series and S-1200 unit and 0.41 W/l/s for the S-1500 unit.

Modelling the Upwards Displacement Mode

This mode relies on natural buoyancy and wind to drive air through the space and the fans are not required. In this mode, the unit consumes minimal power. In IES the unit can be simply modelled as a protrusion from the roof of approximately 0.5 metres, with a *door* on the top. The size of the door for each unit is as follows, however in order to account for the free area of the whole system including the e-stack unit and roof termination, the aerodynamic free area should be achieved as specified below:

Unit	Door Dimension *(mm)*	Aerodynamic Free Area *(m²)*	Equivalent Orifice Area in IES assuming C_d of 0.62 *(m²)*
R-Series with penthouse louvre	1600 x 950	0.476	0.754
R-Series with mushroom	1600 x 950	0.401	0.647
S-1500 with penthouse louvre	1500 x 1500	0.803	1.295
S-1500 with mushroom	1500 x 1500	0.691	1.115
S-1200 with penthouse	1200 x 1200	0.551	0.889

It is also important that all the windows and other openings are positioned correctly in the space as this will affect the natural ventilation flow. Both the door on the top of the protrusion and all of the low level openings should open based on a modulating profile that varies linearly between the following values:

Int T	Opening (%)
19degC	0
24degC	100

Two profiles should be created separately for the low level openings and the e-stack 'door'. The low level openings should operate in the same way all year round for each occupied day, inputting the formula "**gt(ta,21.5,5)&(to>16)&(ta>to)**" during all occupied hours.
The daily profile for the e-stack will be more complicated but should begin with the same formula as above put in for all occupied hours.

Modelling the Upwards Displacement Mode with Fan Assistance

The system is still driven predominantly by buoyancy and wind, but assistance is given to the flow by the fans that are also used in winter. To model this, an additional mechanical extract should be specified from the room to the exterior. The maximum extract rate for each unit is as follows:

Unit	Daytime Fan Assistance (l/s)	Nightcool Fan Assured (l/s)
R-Series	100	240
S-1200	100	100
S-1500	150	150

In this mode only one fan is used so specific fan power should be set to 0.3 W/l/s for the R-Series and S-1200 unit and 0.2 W/l/s for the S-1500 unit.

The simplest way to define the flow rate is to specify an 'Air Exchange' with the correct flow rate, with the adjacent condition set to 'External Air' and create a 'Variation Profile' which operates in the same way for each occupied day of the year, inputting the formula "**(ta>24) & (ta>to)**" during all occupied hours.

Modelling the Nightcool Mode

If the day before has been particularly hot, a night cooling strategy is used that night. This is operated between the hours of 21.00 and 06.00. During this time the unit is fully open.

In IES it is difficult to control the nightcool based on temperatures the previous day, so a simplified formula such as **"(ta>18) & (ta>to)"** can be applied from 21.00 to 03.00 during the summer months (1st May-30th August), to the e-stack door opening profile which was partially created earlier. For the other months of the year the simple low level opening profile can be applied. *Where necessary hours of nightcool operation can be extended to be exclusive of occupied hours.*

If the room temperature has not dropped below 18degC by 03.00, the fans are switched on and provide assisted ventilation at the rate described in the last table until 6am. This rate is a fan assured flow rate and therefore is applied <u>instead</u> of the louvre opening in MacroFlo.

The simplest way to define the flow rate is to specify an 'Air Exchange' with the correct flow rate, with the adjacent condition set to 'External Air' and create a 'Variation Profile' which operates from 03.00 to 06.00, inputting the formula "**(ta>18) & (ta>to)**" and applying it only during the summer months.