SCEME 15th Dec 2009

Ventilation in schools

Integrating ventilation, thermal comfort and daylighting

Malcolm Orme AECOM

John Palmer AECOM - Chairman CIBSE Schools Design Group

Introduction

- Design criteria
- Computer tools for assessing the school design strategies
- Detailed design ventilation options
- Recommendations
- Conclusions

Design criteria

The appropriate design conditions for **ventilation, thermal comfort, daylighting and noise** in schools are given in:

- Building Bulletin 101 – Ventilation in School Buildings,
- Building Bulletin 87 – Guidelines for Environmental Design in Schools,
- Building Bulletin 90 – Lighting Design for Schools,
- Building Bulletin 93 – Acoustic Performance in Schools,
- BREAAM for Schools.

Ventilation

DfES Building Bulletin 101 states that:

- "*When measured at seated head height, during the continuous period between the start and finish of teaching on any day, the average concentration of carbon dioxide should not exceed 1500 parts per million (ppm)*",
- "*Purpose-provided ventilation (i.e. controllable devices to supply air to and extract air from a building) should provide external air supply to all teaching and learning spaces of:*
  - a minimum of 3 l/s per person (litres per second per person), and
  - a minimum daily average of 5 l/s per person, and
  - the capability of achieving a minimum of 8 l/s per person at any occupied time".

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Thermal comfort in summer

DfES Building Bulletin 101 states that:

– "The performance standards for summertime overheating in compliance with Approved Document L2 for teaching and learning areas are:

a) There should be no more than 120 hours when the air temperature in the classroom rises above 28°C,

b) The average internal to external temperature difference should not exceed 5°C (i.e. the internal air temperature should be no more than 5°C above the external air temperature on average)

c) The internal air temperature when the space is occupied should not exceed 32°C".

Thermal comfort in winter

DfES Building Bulletin 87 “Guidelines for Environmental Design in Schools” requires that teaching spaces are heated to an air temperature of 18^{o}C under winter conditions of external temperature.

Daylighting

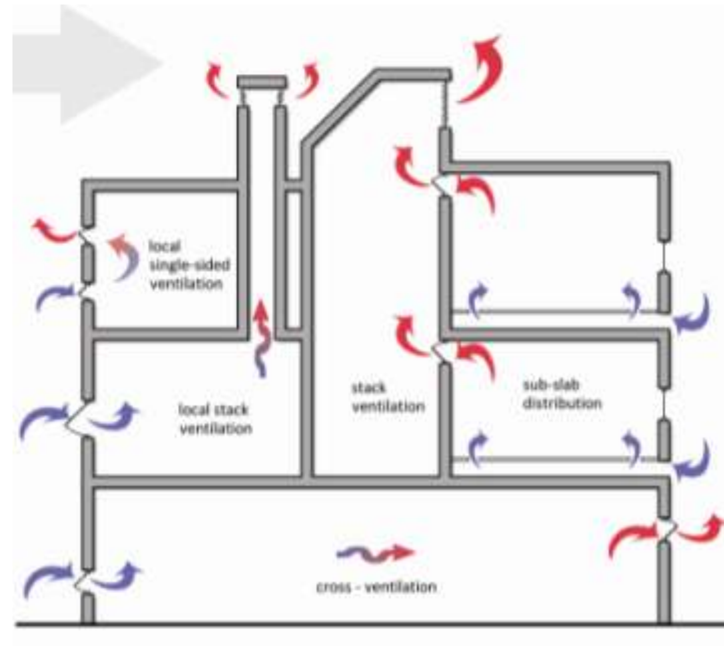
- DfES Building Bulletin 87 “Guidelines for Environmental Design in Schools” states that “*natural light should be the prime means of lighting during daylight hours*” and advises that “*A space is likely to be considered well lit if there is an average daylight factor of 4% - 5%*”.
- DfES Building Bulletin 90 suggests that daylight factors below 2% will require frequent use of electric light.

Noise

– DfES Building Bulletin 93 states that:
  - "if the design uses a *minimum fresh air supply rate* that is equal or greater than 3 l/s per person, the indoor ambient noise levels with this ventilation rate should not exceed the upper limit for the indoor ambient noise of 35 dB LAeq,30min in classrooms, tutorial rooms, seminar rooms, and language laboratories.
  - when the *design capability supply rate* of 8 l/s per person is provided by natural ventilation, the design should achieve the BB93 performance standards for the indoor ambient noise levels when they have been increased by 5 dB LAeq,30min".

Ventilation design strategies in schools

- Natural ventilation:
  - Single-sided ventilation (windows, vents),
  - Cross ventilation (windows, vents, windcatchers),
  - Passive stack
- Hybrid ventilation
- Mechanical ventilation



Section - Different types of ventilation

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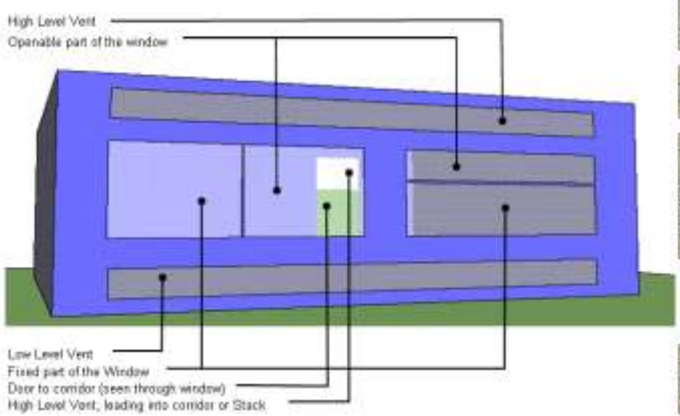
Computer tools for assessing the school design strategies

– *ClassVent design spreadsheet*

Classvent - This tool produces the "equivalent" area of ventilation openings required for the supply of a specific volume flow per person

Legend of typical ventilation elements



ClassRoom Geometry	
Width - m	7.70
Depth - m	7.00
Ceiling height (or highest level for opening) - m	3.00
Slab height - m	3.33
Number of Floors	1

ClassRoom Occupancy	
Number of Pupils	30
Teacher (1 or 2?)	2

Design and Environmental Variables		
Temperature Profile - default season or user input		Winter
Default temperatures	Outside	Inside
Winter	5	20
MidSeason	11	20
Summer	24	27
Other - User defined temperatures	16	24

Required Volume flow	8 l/sec/per
Equivalent to (m³/sec)	0.26
Equivalent to (ach)	5.7

Go to any strategy by clicking			
Single Vent	Here	Stack (room + stack)	Here
Vent & Window	Here	Stack (rooms+corridor+stack)	Here
CrossFlow	Here	Roof Terminal	Here

This spreadsheet is a simple tool to predict the area of the openings needed to provide external air under specified conditions
The recommended ventilation values are: 3, 5 or 8 litres/second/person
The User should enter the geometry and occupancy for the room and then progress throught the various design scenarios as indicated on the tabs below
Six possible combinations are given that include variations of Single Sided, Crossflow, Stack ventilation and roof mounted split-duct terminal
The "Single Vent" is either a single opening like a window or a vent; the "Vent Window" has two identical vents at different heights, but also allows the user to change the area of the top vent/window (which will then produce a different area for the bottom vent/window)
The "CrossFlow" case looks at diplacement ventilation with the windows/vents on two opposite walls; the "Stack(single)" and "Stack(multiple)" cases look a stack ventilation with either a room flowing directly into a stack, or a number of rooms flowing into a corridor which is connected to the stack.
The "Roof Terminal" case looks at split-duct devices like the "Windcatcher" (Monodraught), "Airscoop" (Passivent) or "Windvent" (Midtherm).
Most cases allow a multi-storeys layout and the presence of wind.
The temperatures recommended as the default conditions for each period of the year are as shown in the table above.
The tool provides the area required to provide the ventilation rates requested by the user and it also provides the pressure at the inlets/outlet for the windless condition.
Note: the areas predicted are equivalent areas - i.e. they will pass the same volume of air as a square edged orifice of the same area.
The "hole in the wall" to install an actual ventilator that provides this equivalent area will be greater than these calculations imply.
See the "Equivalent Area" page for more informations.

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Based on CIBSE AM10

Sizing openings for naturally ventilated buildings

Stack ventilation Based on outside - stack temperature difference(s

Input item	Units	Input value(s)		
Building definition				
Number of floors	-	1		
Building height (roof level)	metres	3		
For each floor	Floor no.	1		
Floor area naturally ventilated	sq m.	53.90	53.90	53.90
Floor-ceiling height	metres	3.000	3.000	3.000
Slab to slab height	metres		3.333	3.333
Height of inlet above slab	metres	**1.700**	1.700	1.700
Room temperature	deg C	20	20	20
Required air change rate	achr-1	not neede	not neede	not needec
Wind pressure coeff for inlet	-	0.50	0.50	0.50
Height of outlet above ground	metres	**2.300**		
Wind presure coefficient for outlet	-	0.50	**For Opening on the**	
Stack definition				
Number of stack slices	-	1		
For each slice (starting from bottom)		1		
Vertical length of slice	metres	3.333	3.333	3.333
Temperature of slice	deg C	20.0	20.0	20.0
Height of NPL above ground	metres	2.000	*Recommended betwe*	
Weather conditions				
Outside temperature	deg C	5		
Windspeed	m/s	1.5		
Local or meteorological?	L or M	L		
Terrain (Open,Rural,Urban, City)		City		

Single sided – single opening

Single Sided Ventilation - One Opening (Vent or Window)

Inputs		
Number of Floors	1	
Vertical depth of opening (vent/window) - m	1.85	

Temperatures	Outside	Inside
Winter	5	20
MidSeason	11	20
Summer	24	27
User defined - select your temperature	16	24
Temperature Profile - default season or user input		Wint

Windspeed	1.5
Source of data (Local, Meteorological) ? (see Notes)	Loca
Location (Open, Rural, Urban, City) ? (see Notes)	City

Required Volume flow	3 l/second/pers	
Equivalent to	m³/sec	0.096
Equivalent to	ach	2.1

Note that the results of the CIBSE Equation will reflect either buoyancy effects or wind driven effect, and not buoyancy effects corrected if wind is present. This explains why even moderate wind speeds may produce unrealistic results.

Results

Results

The CIBSE equation evaluates the areas for the buoyancy condition **or** the wind condition, they are totally indipendent from each other.

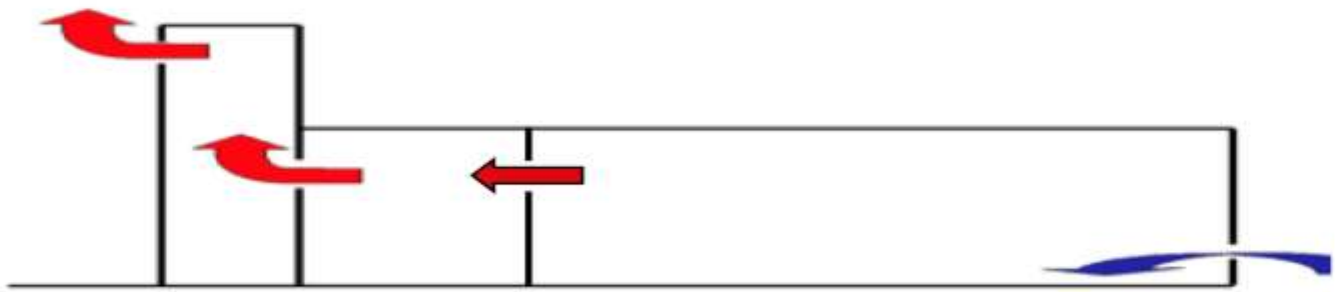
The deGids & Phaff equation treats temperature and wind together, but its results need careful interpretation.

Results		
CIBSE equation, temperature and wind effects are indipendent.		
Area (temperature only)	**m²**	**0.48**
Area (wind only)	**m²**	**2.56**
Pressure at vent (temperature only)	***Pa***	***0.1***
deGids & Phaff equation, combined temperature and wind effects		
Area (temperature & wind)	**m²**	**0.58**

Go to the next case clicking >>>>>>>	Here

Other Design Options

Stack (multiple): Ventilation with a multi-classroom supply



Inputs	
Number of Floors	1
Number of Classroom on this corridor	4
Stack Outlet height from ground - m	11.50
Front Vent height from floor - m	1.85
optional - Area of stack outlet - m²	8.00
Area of "classroom to corridor" transfer vent (each) - m²	1.00
Area of "corridor to stack" vent - m²	100.00
Area of any additional vent) - m²	100.00

Caution! Outlet too high?

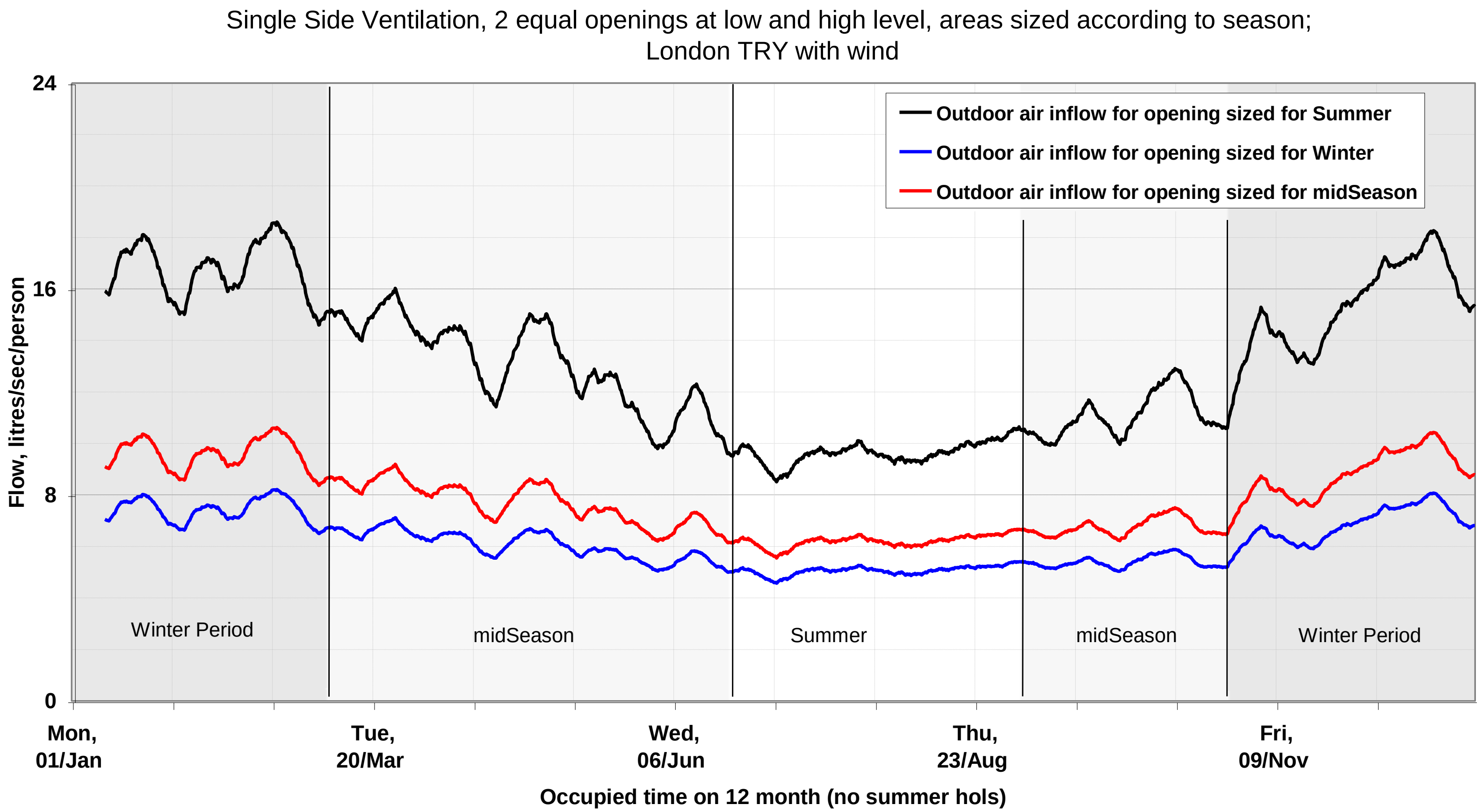
Temperatures	Outside	Inside
Winter	5	20
MidSeason	11	20
Summer	24	27
User defined - select your temperatures	16	24
Temperature Profile - default season or user input		Wint

Windspeed	1.5 r
Source of wind data (Local, Meteorological) ? (see Notes)	Loca
Location (Open, Rural, Urban, City) ? (see Notes)	City

Required Volume flow	3 l/second/pers	
Equivalent to	m³/sec	0.096
Equivalent to	ach	2.1

Assumptions :-
Size of rear wall vent is the same across the floors.
NPL is placed at least 0.25m above roof level.

Predicted Annual Performance



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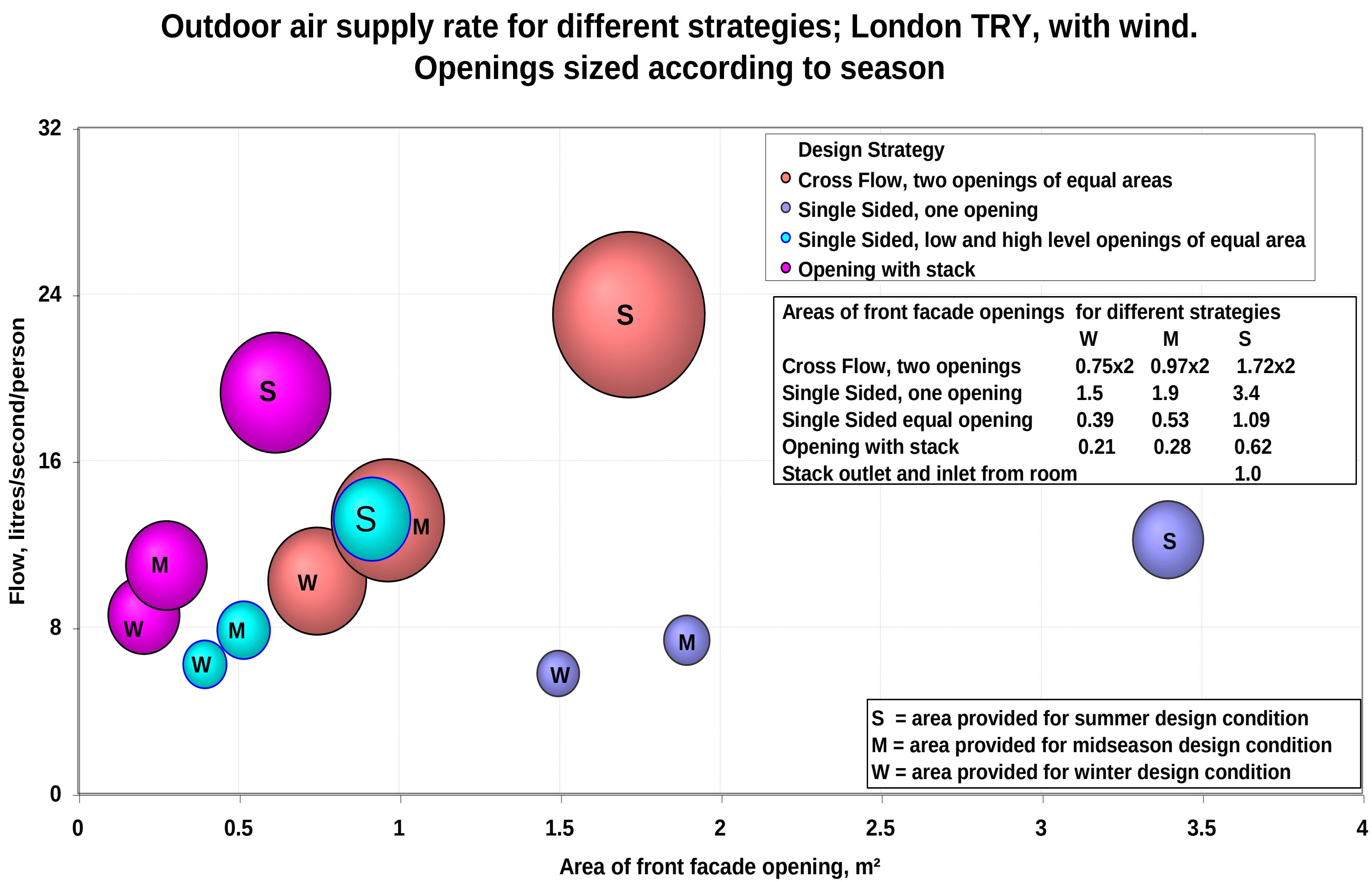
Predicted Annual Performance



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ClassCool – Avoiding Overheating Part L Compliance Tool for Classrooms

Window Area

g-value

Louvres

Classroom Selection by orientation and floor

Overhang

MidPane Blinds

Casual Gains

Thermal Mass

Day Ventilation

Night Ventilation

Classroom Definition

The basic classroom is assumed to have a floor area of ~54m² and a volume of ~162m³. This tool does not allow a change in these variables, as it cannot replace proper thermal modelling.

Note to the user:- do **not** cut 'n' paste cells **unless using /edit/value** which will preserve the formatting of the cells.

		Gf		1F	
Window Area	Percentage of Façade Area (between 20% and 60%)	60		60	
g-value	Choose between No, Partial, Full solar control (between 0.675 and 0.38)	No Solar Control	Partial Solar Control		
	if choosing "Other", provide input from Glazing datasheets here ===>>		and here>		0.668
Louvres	Numbers of louvre blades, 0 to 6	0	0		

…ientation and floor

		Gf	Max	1F	Orientation	Gf	1F
Overhang	Width in cm, **North East** (120cm for 100% shading of a 185cm window)	0	120	0	North East	☑	☑
	Width in cm, **East** (169cm for 100% shading of a 185cm window)	0	169	169	East	☑	☑
	Width in cm, **South East** (120cm for 100% shading of a 185cm window)	120	120	60	South East	☑	☑
	Width in cm, **South** (98cm for 100% shading of a 185cm window)	98	98	98	South	☑	☑
	Width in cm, **South West** (120cm for 100% shading of a 185cm window)	120	120	60	South West	☑	☑
	Width in cm, **West** (169cm for 100% shading of a 185cm window)	169	169	84.5	West	☑	☑
	Width in cm, **North West** (120cm for 100% shading of a 185cm window)	120	120	60	North West	☑	☑
	Width in cm, **North** (98cm for 100% shading of a 185cm window)	98	98	49	North	☑	☑

		Gf	1F	
MidPane Blinds	Shading Coefficient : - Choose "Full", "Half", "None", or "Other"	Half	Half	
	If choosing "Other", provide input in here ===================>>		and here>	0.878
Casual Gains	Between 15 W/m² and 115 W/m²	115	115	
Thermal Mass	Low (1.18 W/K/m²), Medium (3.0 W/K/m²), High (4.9 W/K/m²), (GF).	Middle Weight	Middle Weight	
	If choosing "Other", provide input in here ===================>>			
Day Ventilation	Day Ventilation, l/sec/person - between 5 l/sec			
Night Ventilation	Night Ventilation 0 to 512 l/sec (~12 ach)			
	Inpu			

Results
Hours of Overheating above 28°C (figures
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	Hours >28°C		Avg Delta T		Max Tint	
Orientation	Gf	1f	Gf	1f	Gf	1f
North East	255	265	6.9	6.3	>35°C	>35°C
East	230	250	7.3	5.9	>35°C	34.5
South East	230	260	6.7	6.3	34.7	35.0
South	215	250	6.3	5.7	34.4	34.5
South West	230	255	6.4	6.3	34.6	34.6
West	245	255	6.5	6.6	34.4	34.3
North West	250	280	6.5	6.2	34.9	34.4
North	240	275	6.4	6.1	34.8	>35°C

Developing ClassCool

- Dynamic simulation - hourly data, overheating is a short term effect
  - IES Apache V5.01
- Experimental design
  - response surface methodology
  - second order face centred hyper-cubic design

Analysis Steps – Parameter Selection

Step One - Solar Gains

- glazed areas
- g-value
- overhangs
- louvres
- blinds

Step Two – Overheating Prediction

- solar gains
- admittance
- ventilation
- day
- night
- casual gains

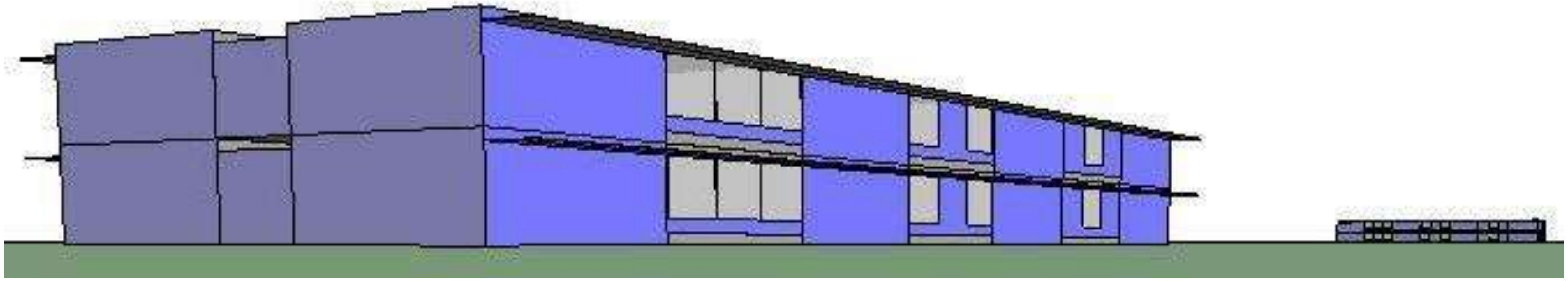
Parameter ranges -- low : mid-point : high

Step One – Solar Gains

• glazed area (%)	20 : 40 : 60
• normal g-value	0.68 : 0.52 : 0.38
• overhangs (% shading)	0 : 50 : 100 (shading on June 21st)
• louvres	0 : 3 : 6 (shading by SUNCAST)
• blinds	1 : 0.64 : 0.28 (shading coefficient)

Step Two – overheating prediction

• solar gains	from step one
• admittance ($W/K/m^2$)	1.1 : 3.0 : 4.9
• Ventilation	
○ Day (l/s per person)	5 : 8 : 13
○ Night (air changes/h)	0 : 4 : 12
• casual gains (W/m^2)	15 : 65 : 115 (also scheduled by occupancy)



The simulated model (seen above) is made of 4 classroom blocks, 2 storeys high, angled at 45° to each other.

Each floor has 3 classrooms with a different amount of glazed area, a corridor and three other classrooms on the opposite side

The four different blocks allowed the 8 basic orientations to be modelled simultaneously

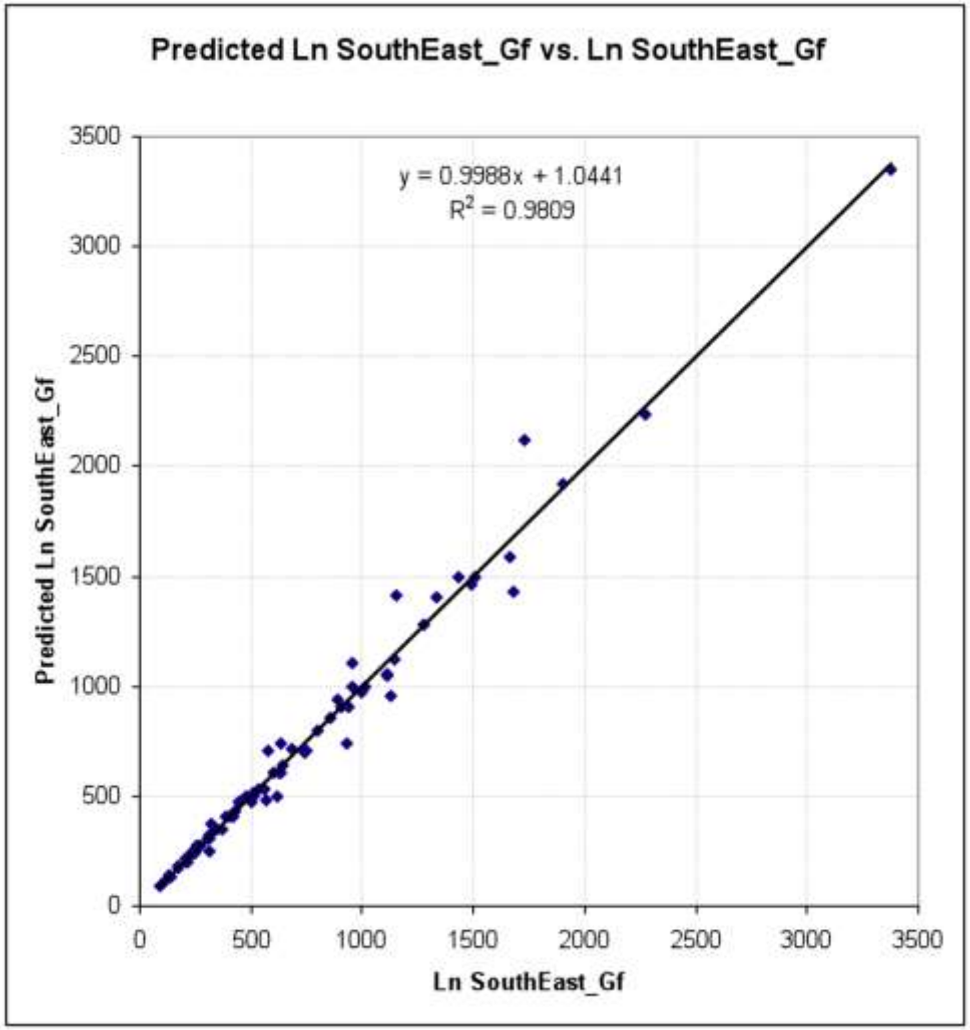
The simulation used the London TRY (Test Reference Year) weather file and the model is located in Heathrow for solar shading calculations.

Predicted Performance

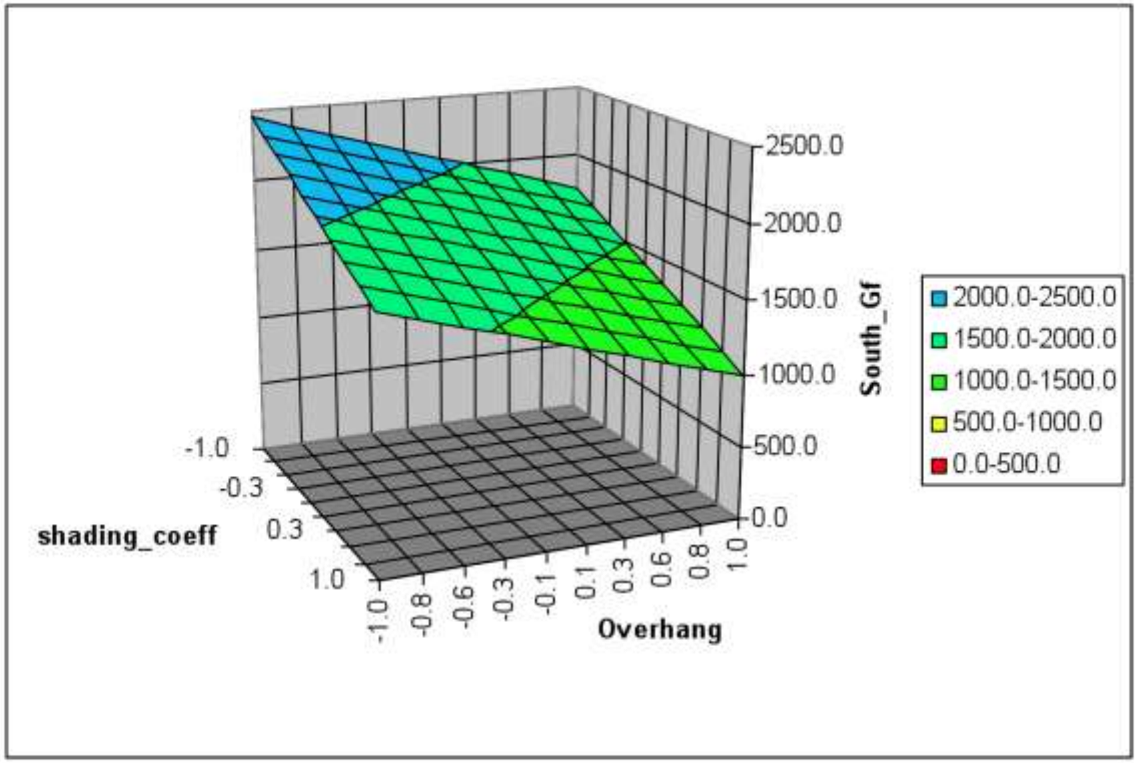
- Internal air temperature
- Maximum air temperature
- Internal to external temperature difference

- CIBSE London Test Reference Year
- Monday to Friday from 1st May to 30th September
- Occupied hours from 9.00am to 3.30pm.

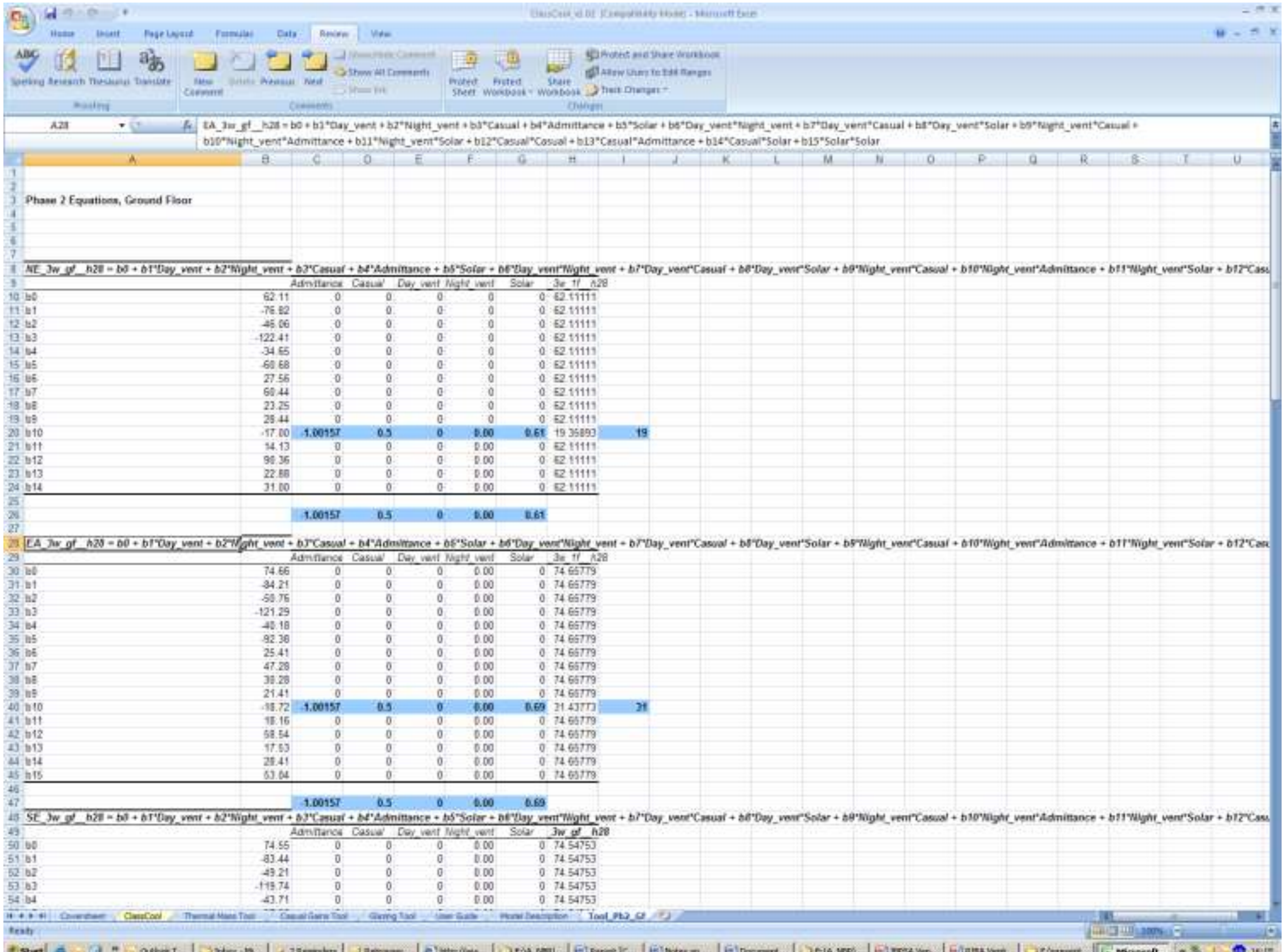
Example of prediction of solar gains from modeled data



Solar Gains with Overhang and Shading Coefficient



Equations behind ClassCool – hours above 28^{o}C



EA_3w_gf__h28 = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Solar + b9*Night_vent*Casual + b10*Night_vent*Admittance + b11*Night_vent*Solar + b12*Casual*Casual + b13*Casual*Admittance + b14*Casual*Solar + b15*Solar*Solar

Phase 2 Equations, Ground Floor

NE_3w_gf__h28 = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Solar + b9*Night_vent*Casual + b10*Night_vent*Admittance + b11*Night_vent*Solar + b12*Casu

		Admittance	Casual	Day_vent	Night_vent	Solar	3w_1f_h28	
b0	62.11	0	0	0	0	0	62.11111	
b1	-76.82	0	0	0	0	0	62.11111	
b2	-46.06	0	0	0	0	0	62.11111	
b3	-122.41	0	0	0	0	0	62.11111	
b4	-34.65	0	0	0	0	0	62.11111	
b5	-60.68	0	0	0	0	0	62.11111	
b6	27.56	0	0	0	0	0	62.11111	
b7	60.44	0	0	0	0	0	62.11111	
b8	23.25	0	0	0	0	0	62.11111	
b9	28.44	0	0	0	0	0	62.11111	
b10	-17.00	1.00157	0.5	0	0.00	0.61	19.35893	19
b11	14.13	0	0	0	0.00	0	62.11111	
b12	90.36	0	0	0	0.00	0	62.11111	
b13	22.88	0	0	0	0.00	0	62.11111	
b14	31.00	0	0	0	0.00	0	62.11111	
		1.00157	0.5	0	0.00	0.61		

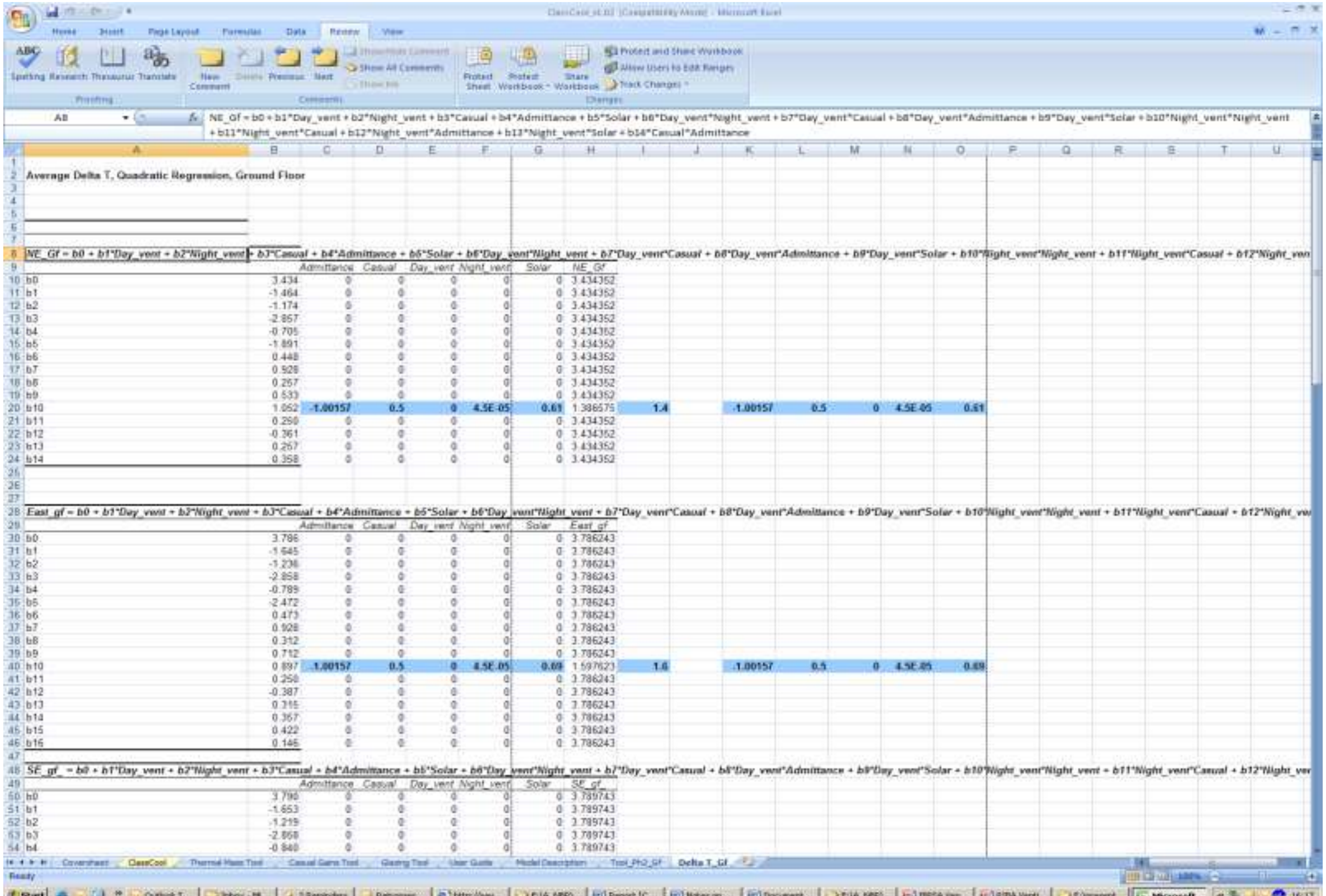
EA_3w_gf__h28 = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b6*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Solar + b9*Night_vent*Casual + b10*Night_vent*Admittance + b11*Night_vent*Solar + b12*Casu

		Admittance	Casual	Day_vent	Night_vent	Solar	3w_1f_h28	
b0	74.66	0	0	0	0.00	0	74.65779	
b1	-84.21	0	0	0	0.00	0	74.65779	
b2	-50.76	0	0	0	0.00	0	74.65779	
b3	-121.29	0	0	0	0.00	0	74.65779	
b4	-40.18	0	0	0	0.00	0	74.65779	
b5	-92.38	0	0	0	0.00	0	74.65779	
b6	25.41	0	0	0	0.00	0	74.65779	
b7	47.28	0	0	0	0.00	0	74.65779	
b8	38.28	0	0	0	0.00	0	74.65779	
b9	21.41	0	0	0	0.00	0	74.65779	
b10	-18.72	1.00157	0.5	0	0.00	0.69	21.43773	21
b11	18.16	0	0	0	0.00	0	74.65779	
b12	58.54	0	0	0	0.00	0	74.65779	
b13	17.53	0	0	0	0.00	0	74.65779	
b14	28.41	0	0	0	0.00	0	74.65779	
b15	53.04	0	0	0	0.00	0	74.65779	
		1.00157	0.5	0	0.00	0.69		

SE_3w_gf__h28 = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Solar + b9*Night_vent*Casual + b10*Night_vent*Admittance + b11*Night_vent*Solar + b12*Casu

		Admittance	Casual	Day_vent	Night_vent	Solar	3w_gf_h28
b0	74.55	0	0	0	0.00	0	74.54753
b1	-83.44	0	0	0	0.00	0	74.54753
b2	-49.21	0	0	0	0.00	0	74.54753
b3	-119.74	0	0	0	0.00	0	74.54753
b4	-43.71	0	0	0	0.00	0	74.54753

Equations behind ClassCool – temperature difference



NE_Gf = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Admittance + b9*Day_vent*Solar + b10*Night_vent*Night_vent + b11*Night_vent*Casual + b12*Night_vent*Ven

		Admittance	Casual	Day_vent	Night_vent	Solar	NE_Gf						
b0	3.434	0	0	0	0	0	3.434352						
b1	-1.464	0	0	0	0	0	3.434352						
b2	-1.174	0	0	0	0	0	3.434352						
b3	-2.857	0	0	0	0	0	3.434352						
b4	-0.705	0	0	0	0	0	3.434352						
b5	-1.891	0	0	0	0	0	3.434352						
b6	0.448	0	0	0	0	0	3.434352						
b7	0.928	0	0	0	0	0	3.434352						
b8	0.257	0	0	0	0	0	3.434352						
b9	0.533	0	0	0	0	0	3.434352						
b10	1.052	-1.00157	0.5	0	4.5E-05	0.61	1.386575	1.4	-1.00157	0.5	0	4.5E-05	0.61
b11	0.250	0	0	0	0	0	3.434352						
b12	-0.361	0	0	0	0	0	3.434352						
b13	0.257	0	0	0	0	0	3.434352						
b14	0.358	0	0	0	0	0	3.434352						

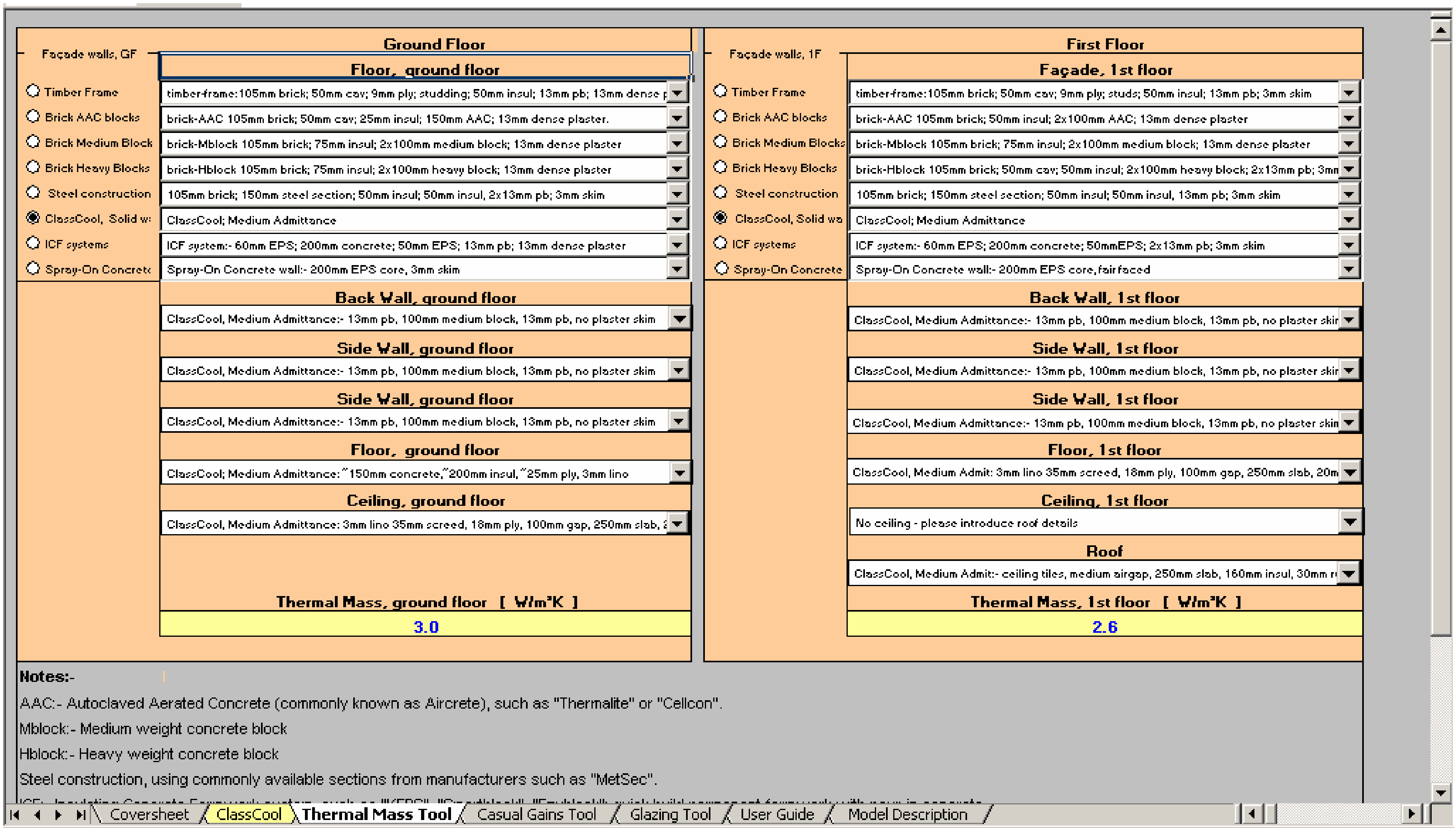
East_gf = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Admittance + b9*Day_vent*Solar + b10*Night_vent*Night_vent + b11*Night_vent*Casual + b12*Night_ve

		Admittance	Casual	Day_vent	Night_vent	Solar	East_gf						
b0	3.786	0	0	0	0	0	3.786243						
b1	-1.645	0	0	0	0	0	3.786243						
b2	-1.236	0	0	0	0	0	3.786243						
b3	-2.858	0	0	0	0	0	3.786243						
b4	-0.789	0	0	0	0	0	3.786243						
b5	-2.472	0	0	0	0	0	3.786243						
b6	0.473	0	0	0	0	0	3.786243						
b7	0.928	0	0	0	0	0	3.786243						
b8	0.312	0	0	0	0	0	3.786243						
b9	0.712	0	0	0	0	0	3.786243						
b10	0.897	-1.00157	0.5	0	4.5E-05	0.69	1.597623	1.6	-1.00157	0.5	0	4.5E-05	0.69
b11	0.258	0	0	0	0	0	3.786243						
b12	-0.387	0	0	0	0	0	3.786243						
b13	0.315	0	0	0	0	0	3.786243						
b14	0.367	0	0	0	0	0	3.786243						
b15	0.422	0	0	0	0	0	3.786243						
b16	0.146	0	0	0	0	0	3.786243						

SE_gf_ = b0 + b1*Day_vent + b2*Night_vent + b3*Casual + b4*Admittance + b5*Solar + b6*Day_vent*Night_vent + b7*Day_vent*Casual + b8*Day_vent*Admittance + b9*Day_vent*Solar + b10*Night_vent*Night_vent + b11*Night_vent*Casual + b12*Night_ve

		Admittance	Casual	Day_vent	Night_vent	Solar	SE_gf_
b0	3.790	0	0	0	0	0	3.789743
b1	-1.653	0	0	0	0	0	3.789743
b2	-1.219	0	0	0	0	0	3.789743
b3	-2.868	0	0	0	0	0	3.789743
b4	-0.840	0	0	0	0	0	3.789743

ClassCool – Thermal Mass Tool



ClassCool – Casual Gains Tool

The user should click a radio button to select the appropriate lighting load and fill in the fields with a **white background**

Lighting	GF	1F	Equipment List	GF	1F	Occupants, GF	Occupants, 1F
				Number	Number	Number	Number
None - natural light	○	○	PCs with VDU (number)	1	1	32	32
Localised lighting - 100W	○	○	Laser printer	1	1		
Localised lighting - 200W	○	○	Interactive whiteboard (& digital projector)				
Localised lighting - 300W	○	○	Digital projector				
8 W/m²	○	○	Overhead projector				
9 W/m²	○	○	Slide projector				
10 W/m²	◉	◉	Plotter A4-A0 B/W electrostatic				
11 W/m²	○	○	Plotter A4-A0 Colour electrostatic				
12 W/m²	○	○	Plotter colour A4 thermal				
15 W/m²	○	○	Plotter colour A0 thermal				
20 W/m²	○	○	Pen plotter				
25 W/m²	○	○					
			Totals [W]	**337**	**337**	**2880**	**2880**
Totals [W/m²]	**10.0**	**10.0**	**Totals [W/m²] (on 54m² floor area)**	**6.3**	**6.3**	**53.4**	**53.4**
	GF	**1F**					
Overall Totals [W/m²]	**70**	**70**					

Coversheet / ClassCool / Thermal Mass Tool / **Casual Gains Tool** / Glazing Tool / User Guide / Model Description

ClassCool – Glazing ‘g-value’ Tool

Some glazing layouts are "greyed" and cannot be selected. This is because the U-value or g-value are too high or too low. In this case, see the "User Guide" sheet.

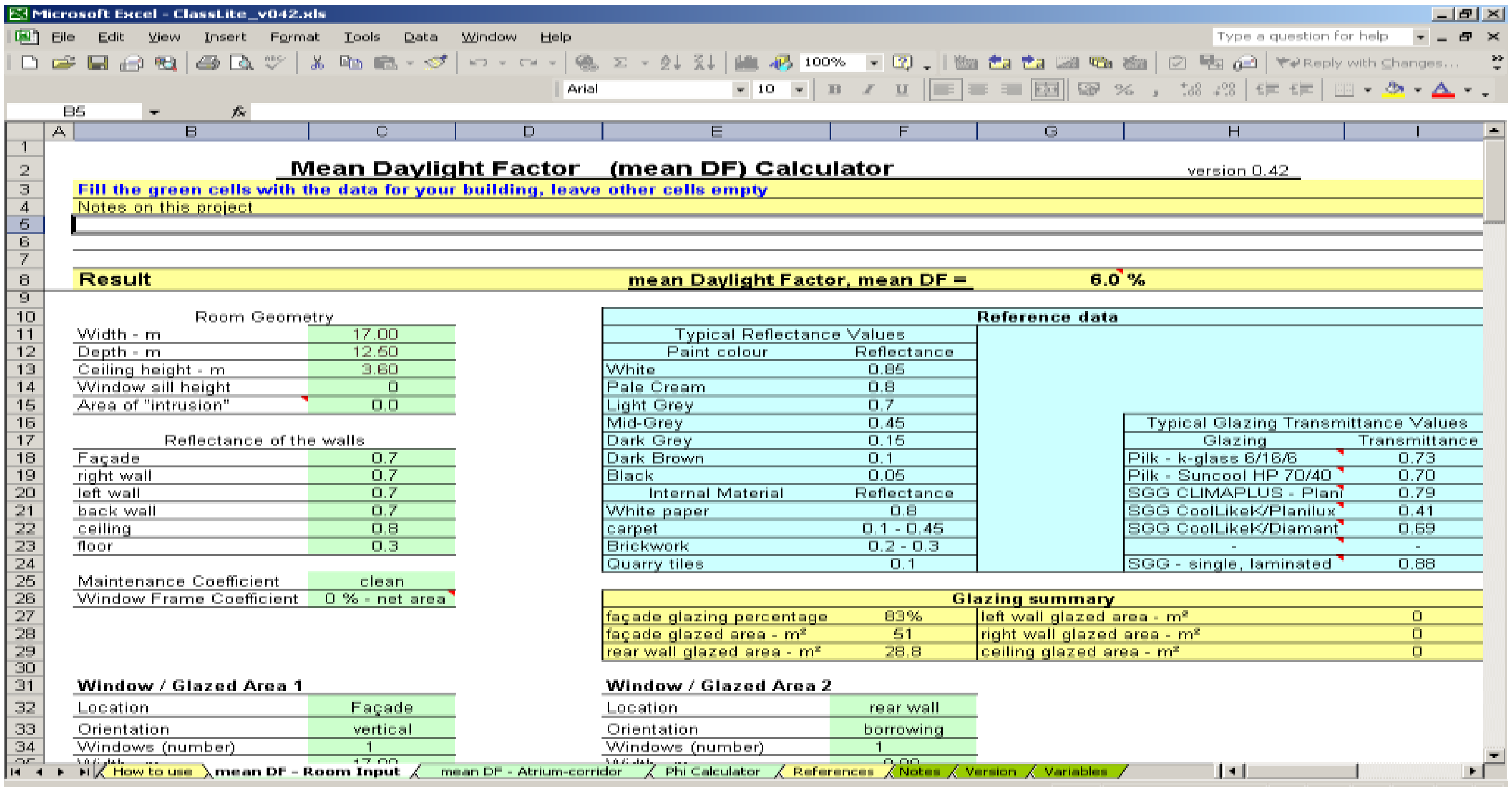
g- value selected by the tool: 0.68 0.68

Pilkington	layout	U-value	GF g-value	1F g-value
Optifloat_Kglass	6_16_6	1.7	◉ 0.68	◉ 0.68
Optifloat_Optitherm	6_16_6	1.4	○ 0.61	○ 0.61
Artic_EclipseAdvantage	6_16_6	1.8	0.31	0.31
Suncool30_EclipseAdvantage	6_16_6	1.3	0.16	0.16
Suncool50_EclipseAdvantage	6_16_6	1.3	0.23	0.23
Suncool66_EclipseAdvantage	6_16_6	1.3	0.28	0.28
SuncoolHP_EclipseAdvantage	6_16_6	1.3	0.36	0.36
SuncoolBrilliant30_Optifloat	6_16_6	1.3	0.19	0.19
SuncoolBrilliant50_Optifloat	6_16_6	1.3	0.27	0.27
SuncoolBrilliant66_Optifloat	6_16_6	1.3	0.36	0.36
SuncoolHPNeutral_Optifloat	6_16_6	1.5	○ 0.39	○ 0.39
SuncoolHPClear_Optifloat	6_16_6	1.4	○ 0.43	○ 0.43
Activ_EclipseAdvantage	6_16_6	1.8	○ 0.57	○ 0.57
Activ_Kglass	6_16_6	1.7	○ 0.64	○ 0.64
Activ_Optitherm	6_16_6	1.4	○ 0.57	○ 0.57
Saint Gobain				
Planilux				
Planilux_Planilux	6_16_6	2.7	0.72	0.72
Planilux_EKOPlus	6_16_6	1.7	○ 0.66	○ 0.66
Planilux_Planitherm	6_16_6	1.5	○ 0.61	○ 0.61
Planilux_PlanithermFuturN	6_16_6	1.4	○ 0.60	○ 0.60
Planistar_Planilux	6_16_6	1.4	○ 0.41	○ 0.41
Antelio				

Coversheet / ClassCool / Thermal Mass Tool / Casual Gains Tool / **Glazing Tool** / User Guide / Model Description

Computer tools for assessing the school design strategy

– ***ClassLight design spreadsheet*** was developed to calculate the average/mean daylight factor in a room with a number of windows on all four orientations and the ceiling.



Detailed design ventilation options

Monitored Schools

Room	Location	VS	Vol. [m^3]	Type	Windows	Openable area [m^2]	Heating	Comments
A1	rural	NV	151	single sided	top hung x 3	0.65	LTHW	In both rooms some thought had been given to providing cross ventilation by providing a small grill into the suspended ceiling and a duct that led to the atrium space from which the classrooms were entered. No fan was found. A smoke test carried out suggested that the ducted extract contributed insignificantly to the ventilation strategy in the room.
A2	rural	NV	151	single sided	top hung x 3	0.65	LTHW	
B1	suburban	MV	177	two ceiling based supplies and one extract	low level top hung x 2	0.36	underfloor	The fresh air is tempered and conveyed to the room via a simple duct system mounted in a void above the suspended ceiling. The extract, which leads to the large void space above the suspended ceiling, is not separately ducted but a small transfer hole connects this plenum void to the corridor. The corridors have additional extract fans located on the roof.
B2	suburban	MV	138		low level top hung x 2	0.36	underfloor	
C1	suburban	MM	181	variable speed fan and automatic windows	high level electrically-actuated top hung x 2	0.40	underfloor	100% fresh air is fed into the packaged air handling unit where it is conditioned (tempered) - the system being controlled by a BMS. The tempered air from the AHU is conveyed to each classroom through externally buried concrete pipes (any mould growth in the pipes was not an issue that was investigated). Suspended ceilings were not generally fitted so that the exposed thermal mass could provide some passive cooling.
C2	suburban	MV	302	variable speed fan	top hung x 4	0.60	underfloor and trench heating	
D1	suburban	NV	116	single sided	low level horizontal pivot x 5	7.90	vertical heating panels	In addition the ventilation strategy in both rooms is underpinned by trickle ventilators. Note that most of the trickle ventilators were either broken or not in working order.
D2	suburban	NV	144	cross-ventilated	low level top hung x 4 and high level top-hung x 2	0.70	vertical heating panels	

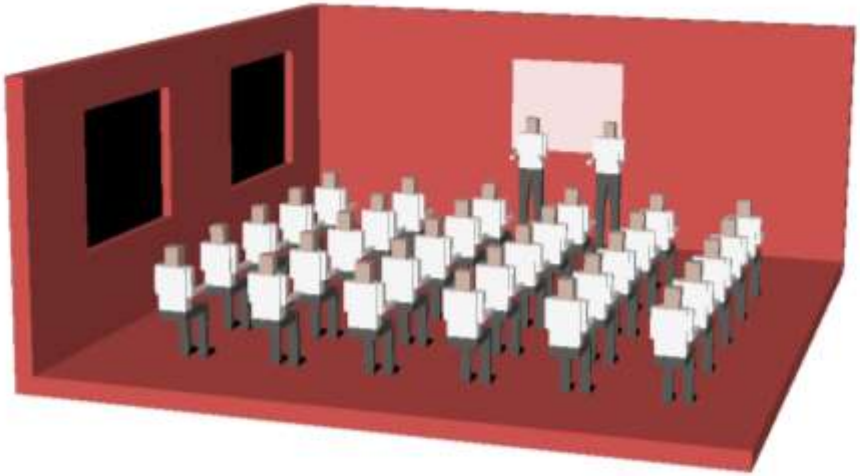
Monitored Results

Room	CO_2 max [ppm]	CO_2 av [ppm]	CO_2 STD [-]	'PURGE' [l/s/p]	'MIN' [l/s/p]	'USUAL' [l/s/p]	Tmin [°C]	Tmax [°C]	RHmin [%]	RHmax [%]	PPD [%]	DDR [%]
A1	1857	960	331	3.9 (30)	0.9 (30)*	3.6 (10)	21.0	29.0	36	56	<17	<15
A2	1725	1054	397	3.9 (30)	n/a	n/a	21.0	29.1	34	55	<15	<15
B1	1047	789	171	8.4 (30)	0.5 (30)	8.4 (30)	19.0	24.8	35	46	<20	<20
B2	880	733	142	8.0 (30)	0.5 (30)	9.4 (30)	20.0	25.0	38	45	<15	<20
C1	1472	853	268	5.3 (25)	0.6 (25)	6.3 (12)	19.0	22.0	52	58	<10	<10
C2	1615	1100	320	10.5 (25)	1.7 (25)**	4.5 (25)	18.2	21.5	53	66	<30	<28
D1	4016	1801	740	7.9 (30)	0.8 (30)*	1.3 (28)	19.4	24.4	34	62	<15	<15
D2	2676	1255	588	8.4 (30)	1.3 (30)*	3.0 (20)	19.2	23.4	33	62	<15	<15

D. Mumovic[*a], J. Palmer[a], M. Davies[a], M. Orme[b], I. Ridley[a], T. Oreszczyn[a], C. Judd[c],
R. Critchlow[d], H.A. Medina[a], G. Pilmoor[c], C. Pearson[c], P. Way[d]

Model assumptions

- For the modelling study **34** various natural and mechanical ventilation design options were investigated.
- The classroom dimension: 7.0m deep and 7.7m wide with floor-to-ceiling height of 3.0m.
- The class compromised of 30 pupils and 2 teachers, each generating sensible heat of 100W. Additionally there was an interactive whiteboard (IWB) installed generating 355W.



Perimeter heating with louvre windows

– **Wintertime ventilation performance – ideal**. The window design is able to provide the ventilation rate of 8 litres of fresh air per second per person.

– **Thermal comfort in winter - satisfactory**

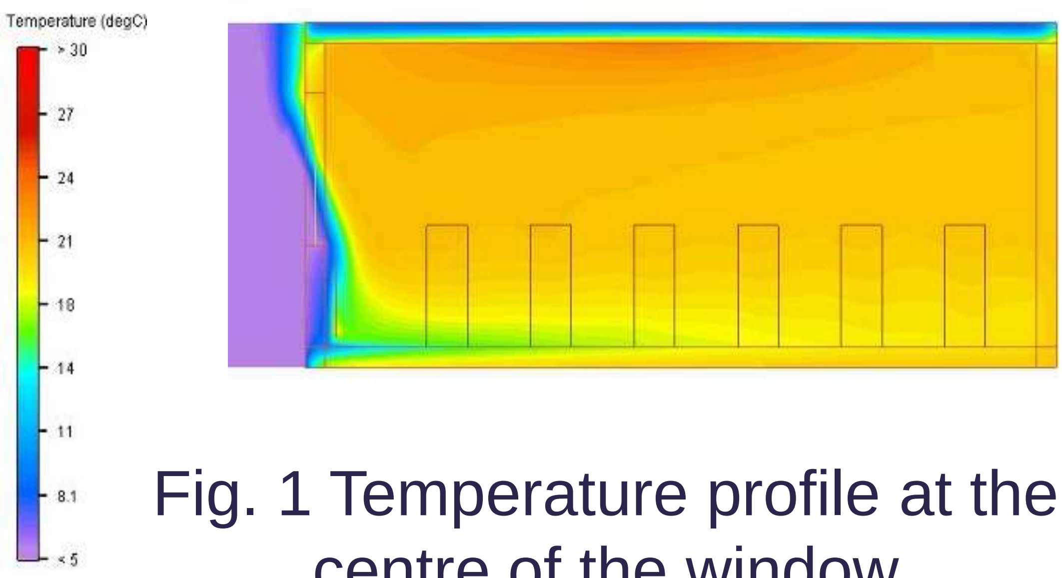


Fig. 1 Temperature profile at the centre of the window

– **Summertime Overheating- satisfactory**

Perimeter heating with louvre windows

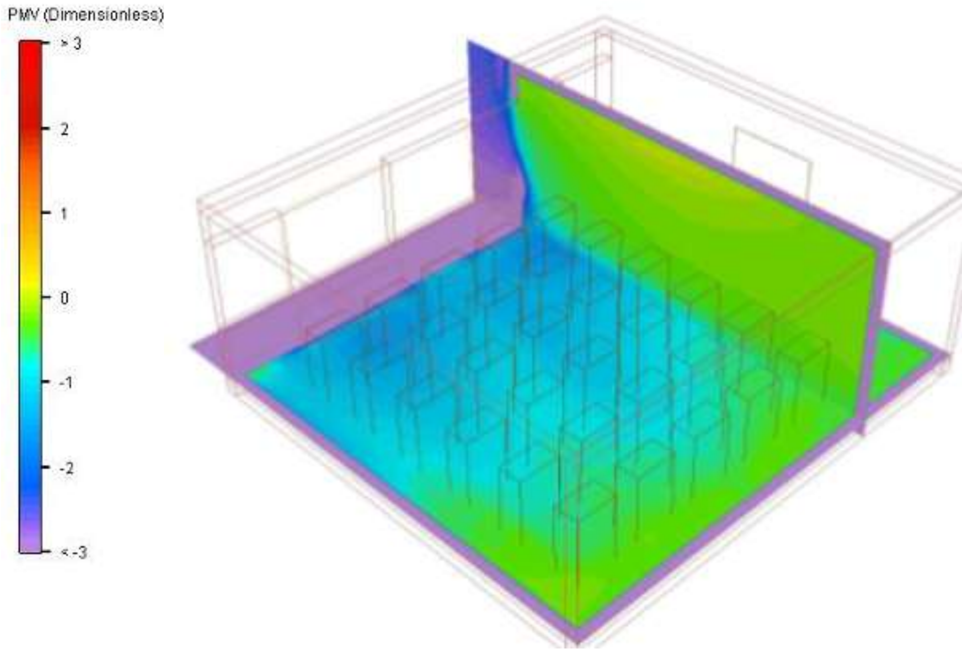


Fig. 2 PMV profile at the centre of the window and at the distance 0.1m above the floor

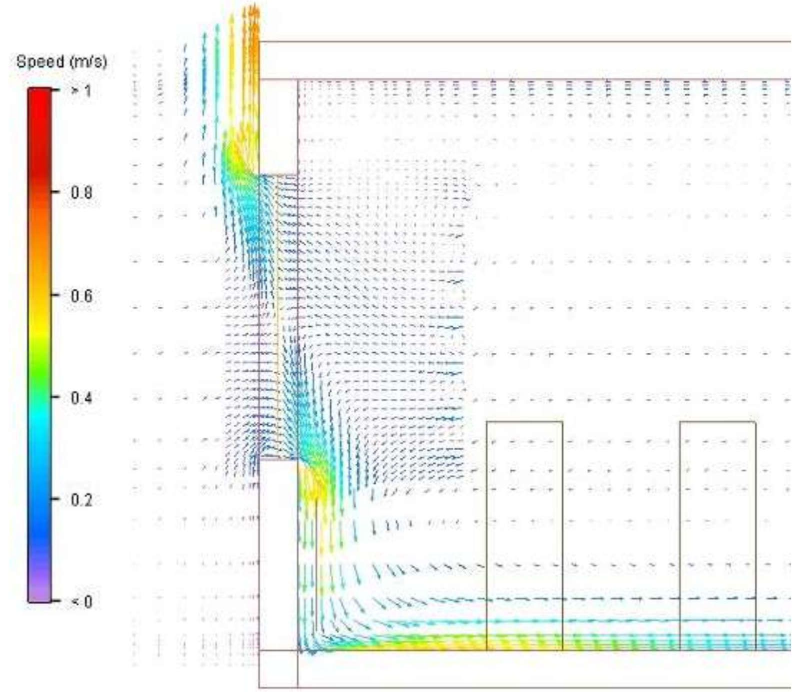


Fig. 3 Velocity vector profile at the centre of the window

AECOM

Perimeter heating with mid-façade centre pivot windows

– **Wintertime ventilation performance – satisfactory**. Two windows each of 2m by 1.5m with an opening width restricted to 100mm are capable of providing the ventilation rate of 8 litres of fresh air per second per person.

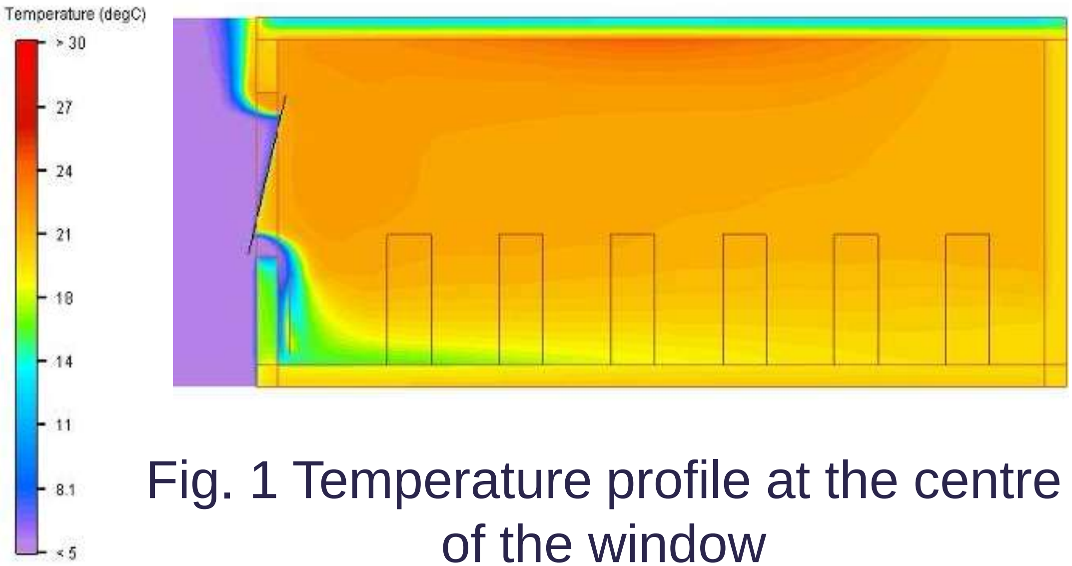


Fig. 1 Temperature profile at the centre of the window

– **Thermal comfort in winter – satisfactory**

– **Summertime Overheating – satisfactory in certain conditions**

Perimeter heating with mid-façade centre pivot windows

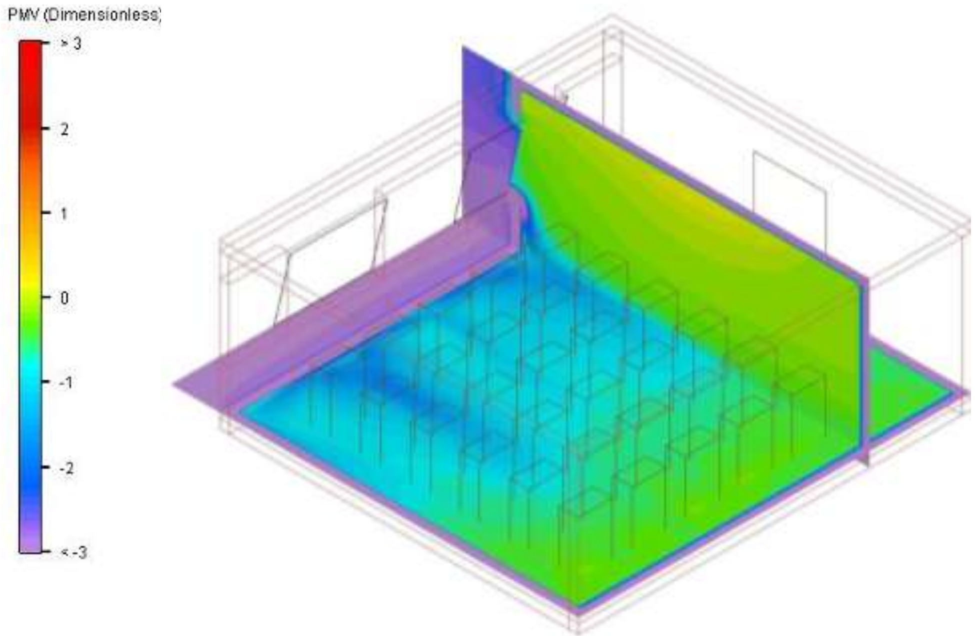


Fig. 2 PMV profile at the centre of the window and at the distance 0.1m above the floor

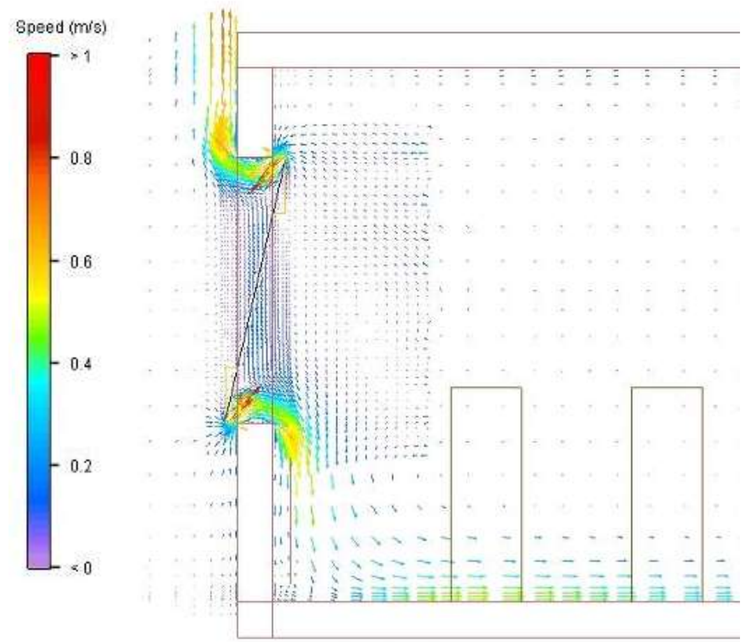


Fig. 3 Velocity vector profile at the centre of the window

Perimeter heating with bottom hung inward lights

– **Wintertime ventilation performance – satisfactory**. Two windows each of 2m by 1.5m are capable of providing the ventilation rate of 8 l/s per person. However, in case where the widow opening is limited to 100mm, the practical design may not be acceptable.

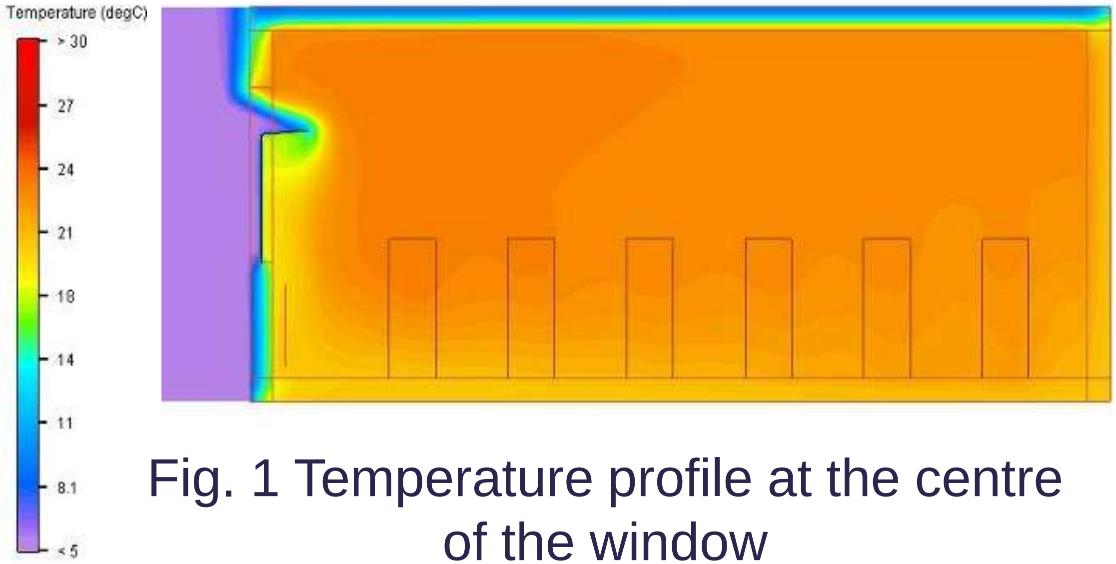


Fig. 1 Temperature profile at the centre of the window

– **Thermal comfort in winter – ideal**

– **Summertime Overheating – unsatisfactory**

Perimeter heating with bottom hung inward lights

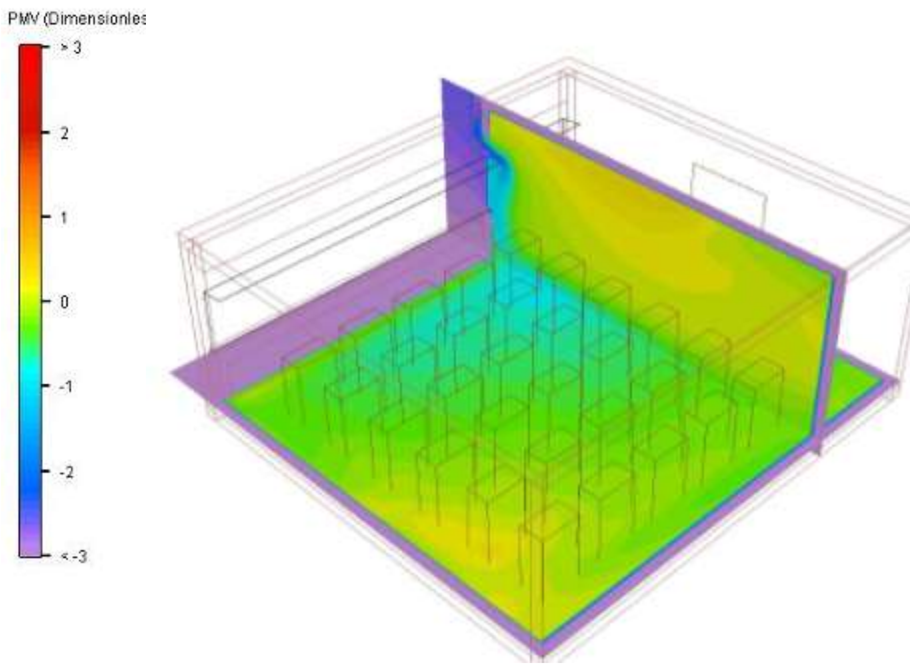


Fig. 2 PMV profile at the centre of the window and at the distance 0.1m above the floor

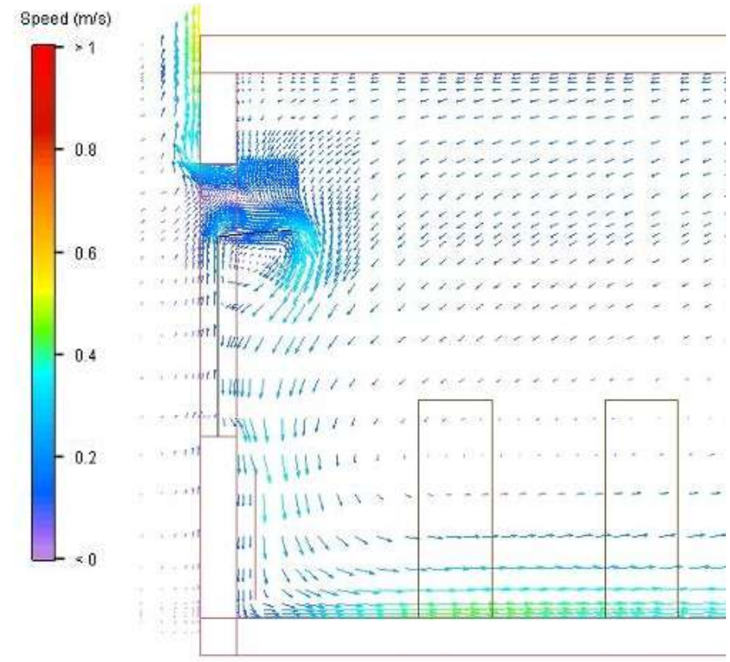


Fig. 3 Velocity vector profile at the centre of the window

Underfloor heating with top hung windows

- **Wintertime ventilation performance – satisfactory in certain conditions**. Two windows each of 2m by 1.5m are capable of providing the ventilation rate of 8 l/s per person if an opening width is **not** restricted to 100mm.

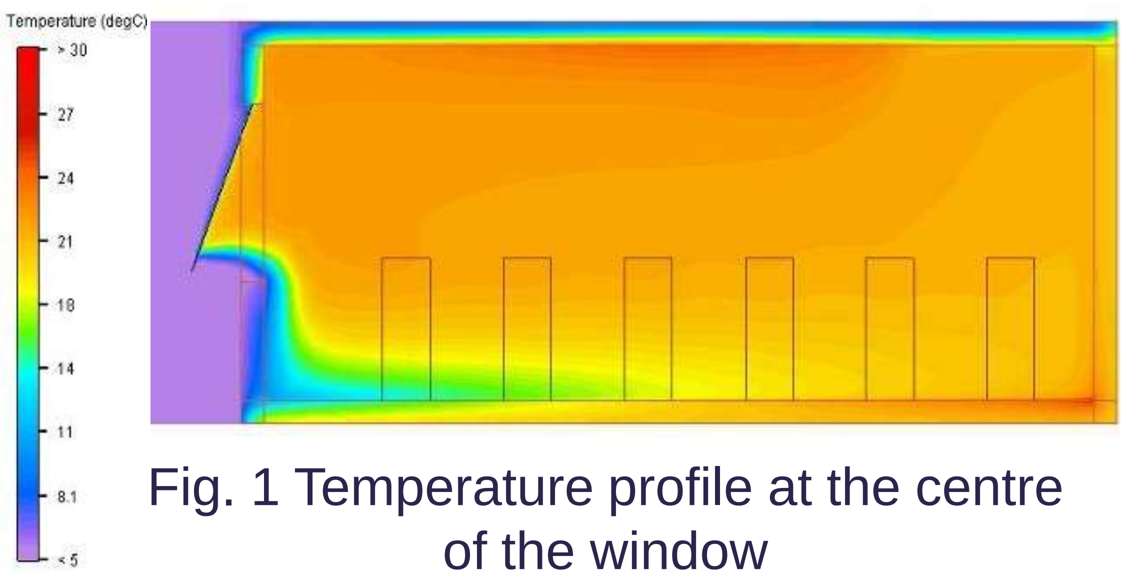
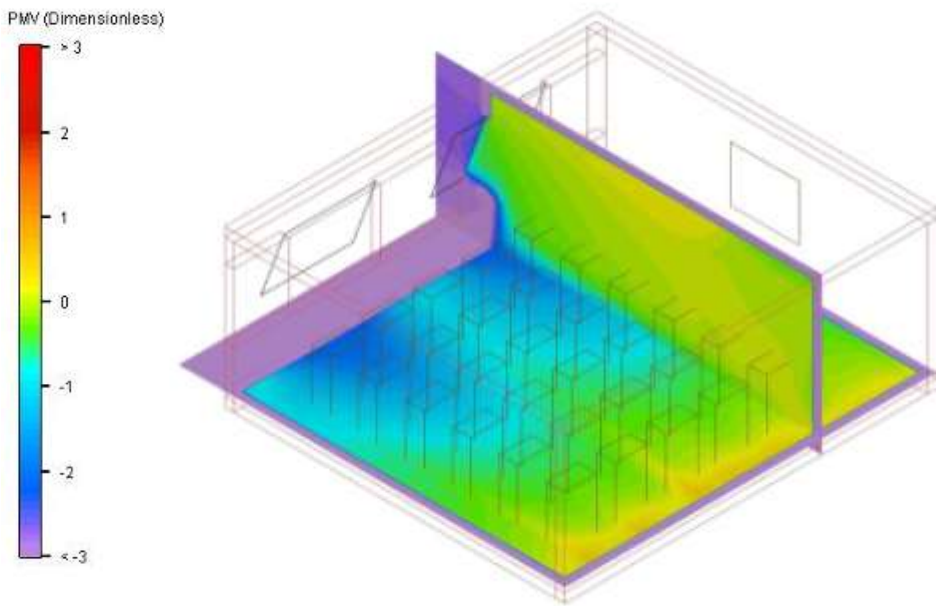


Fig. 1 Temperature profile at the centre of the window

- **Thermal comfort in winter – satisfactory in certain conditions**
- **Summertime Overheating – unsatisfactory**

Underfloor heating with top hung windows



2 PMV profile at the centre of the window and at the distance 0.1m above the floor

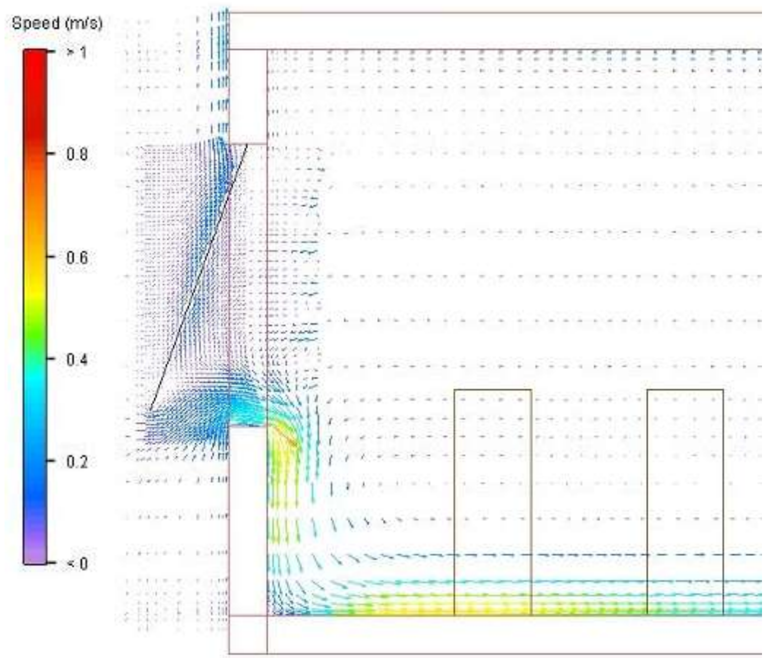
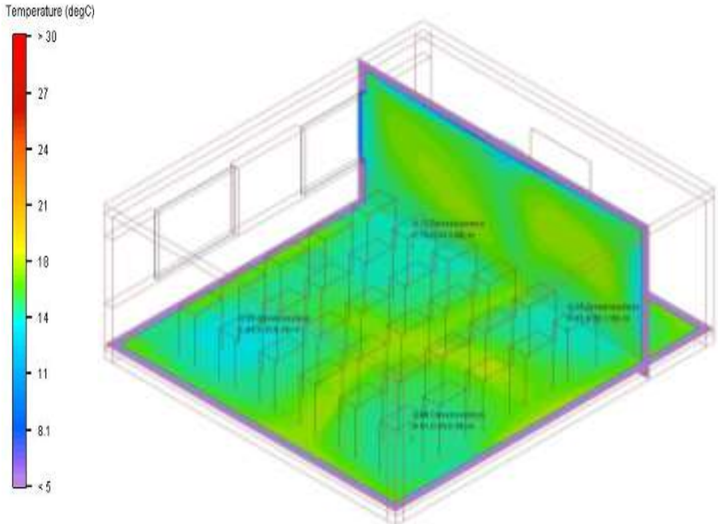
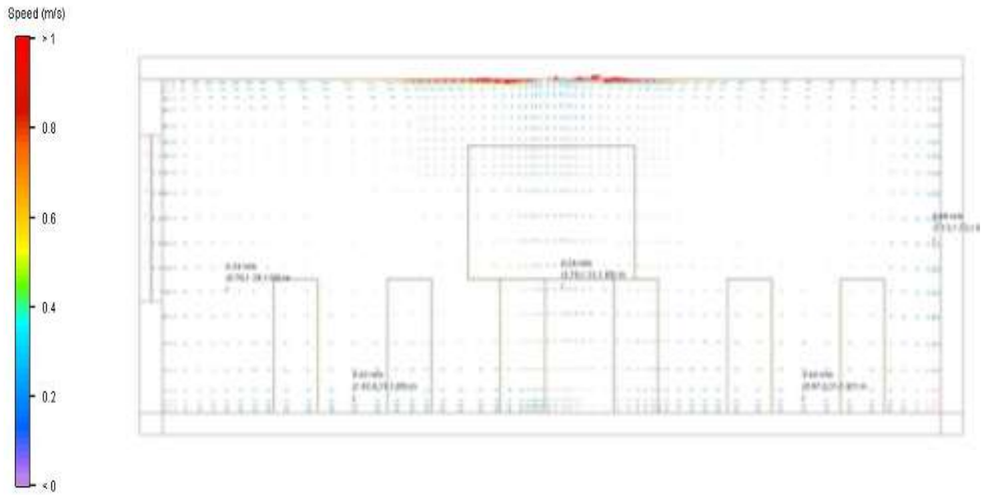


Fig. 3 Velocity vector profile at the centre of the window

Ceiling mounted supply swirl diffusers and ceiling mounted extract grille





PMV profile at the centre of the window and at the distance 0.1m above the floor

Velocity vector profile at the centre of the window

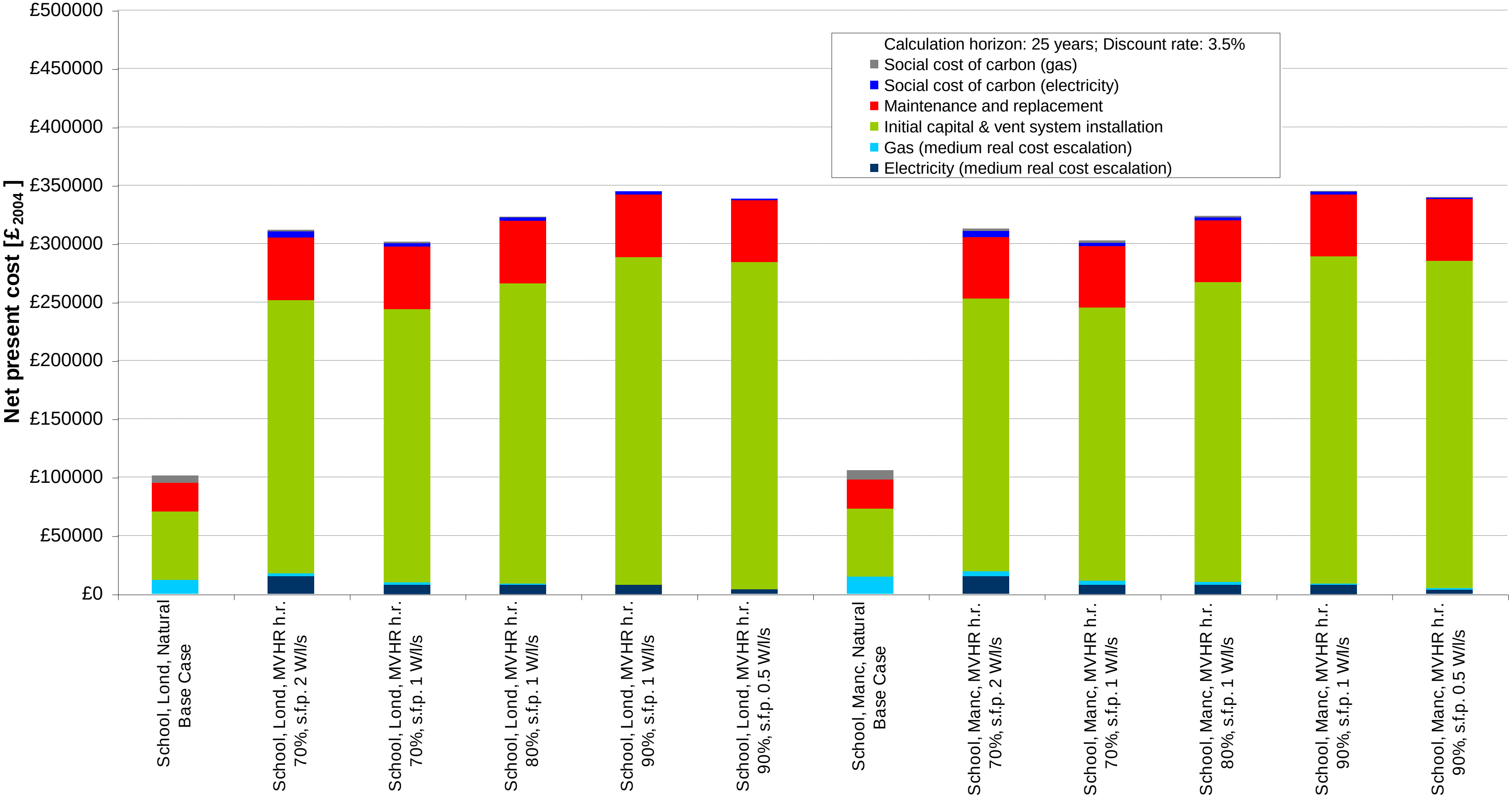
Modelling design strategies and indoor environmental conditions rating

– The best and worst design strategies

	DESIGN OPTION	Heating strategy	Wintertime Ventilation Performance (IAQ)	Thermal Comfort in Winter	Summertime Ventilation Performance (IAQ)	Summertime Overheating	Daylighting	Environmental impact
15	Louvres windows	PH						
16	Louvres windows	UH						
17	Front low level and rear high level openings	PH						
...	...							
10	Top hung windows	PH						
32	Floor mounted supply swirl diffusers and ceiling mounted extract grilles	AH						
11	Top hung windows	UH						

IDEAL
SATISFACTORY
SATISFACTORY IN CERTAIN CONDITIONS
UNSATISFACTORY

Life cycle costs



Victorian Classroom

Louvre windows

Typical Modern Classroom

Top hung casements limited to 100mm

Recommendation

Natural ventilation should be always considered as the first design option for school buildings

The recommended ventilation strategies are:

- Louvre windows with perimeter heating which works well in single sided configuration
- Cross ventilation via high level windows on both sides
- Mid-façade centre pivot windows with perimeter heating not limited to 100mm.

Methods to avoid would include:

- top hung casement windows in single sided designs
- low level inlets with underfloor heating systems.

Recommendation

Mechanical Ventilation Design Strategies

- Mechanical ventilation systems should only be specified when all other natural means have been ruled out.
- In this case the following strategies are favoured:
  - Ceiling mounted supply square diffusers suppling preheated air and ceiling mounted extract grilles.
- Methods to avoid would include:
  - Any low level supply of air, including trench heaters.