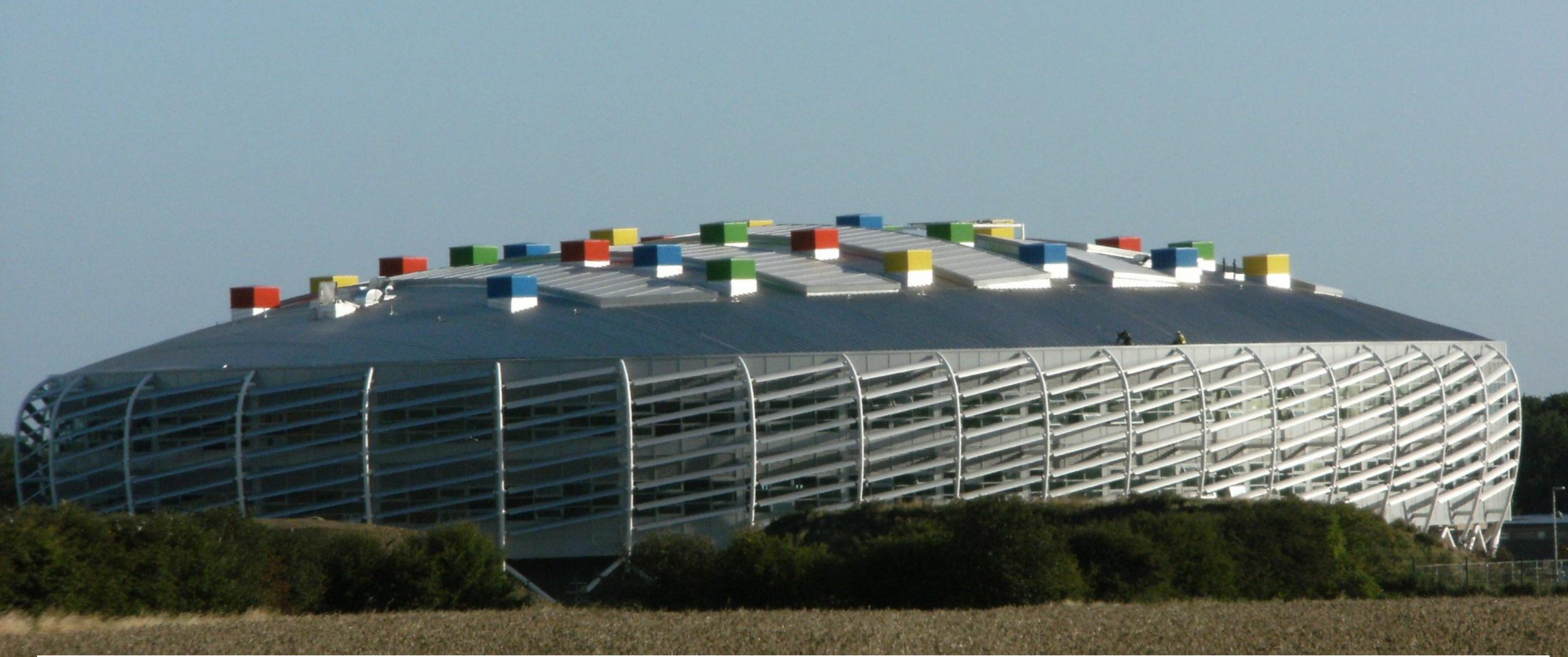
Natural ventilation and low energy building design



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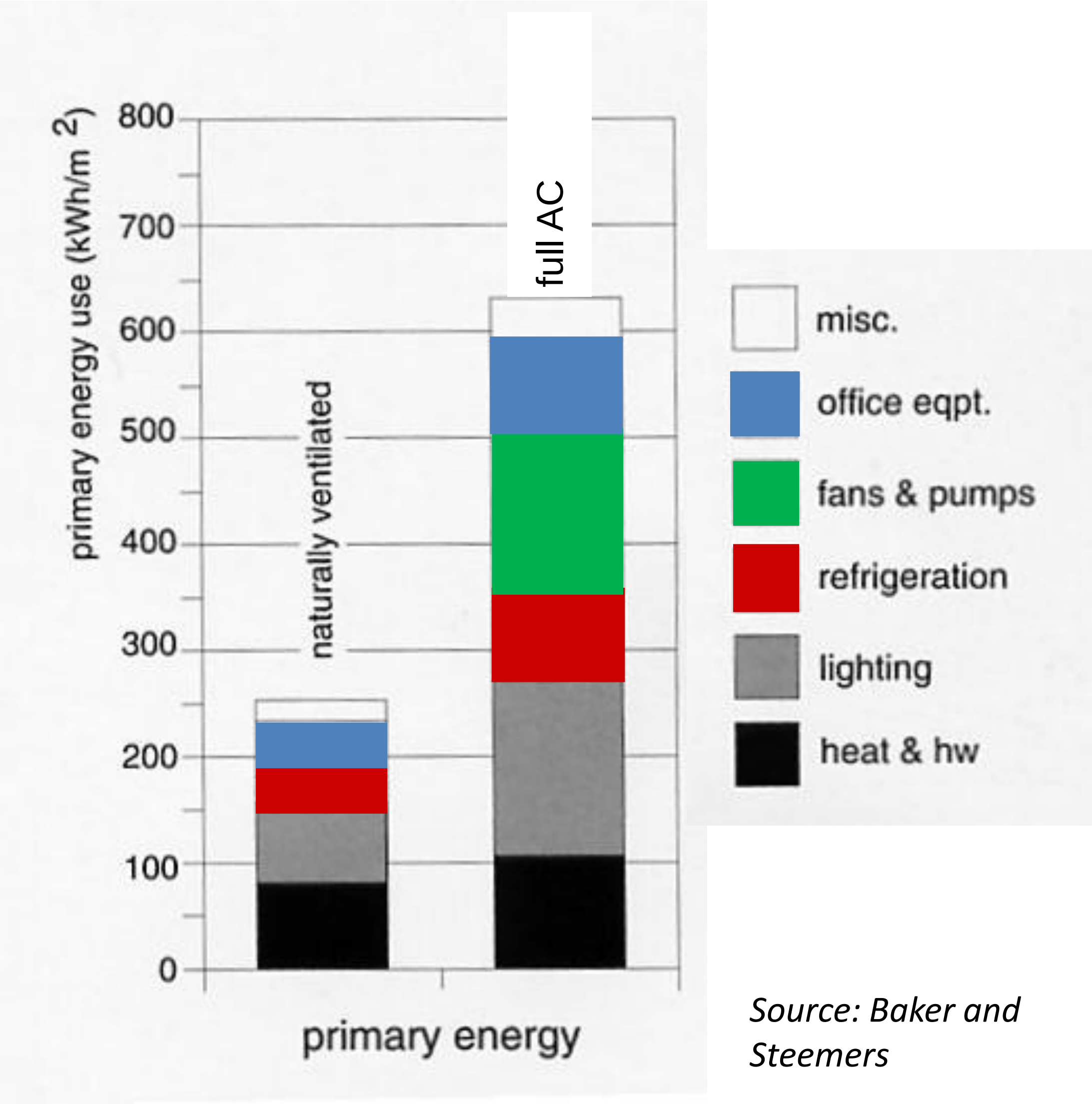
Breathing Buildings

Energy Use In Buildings

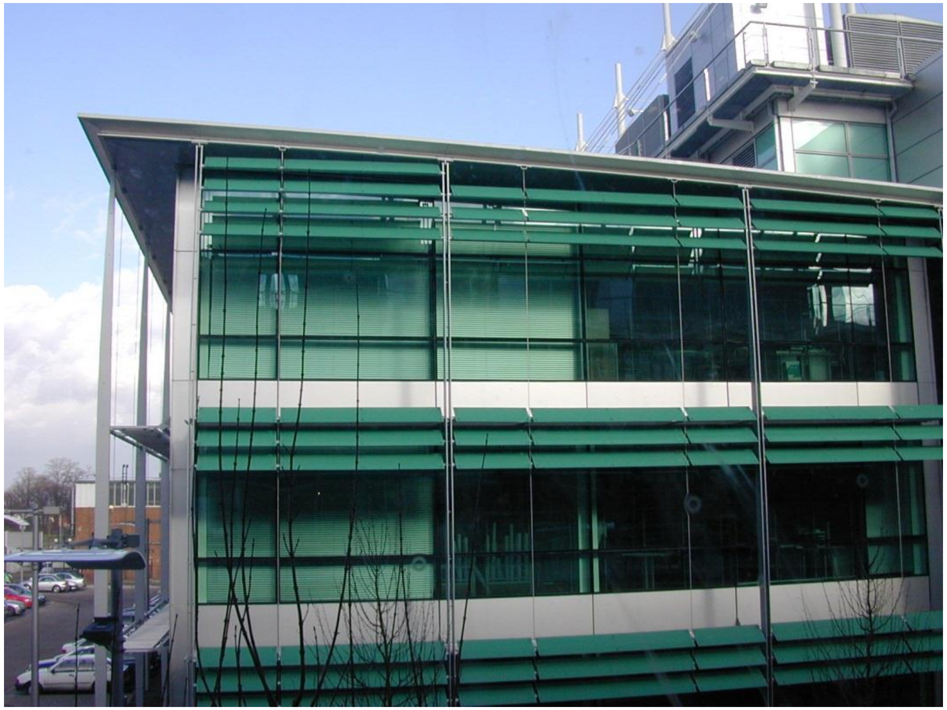


Source: Baker and Steemers

Mechanical Ventilation Scheme

Significant HVAC equipment

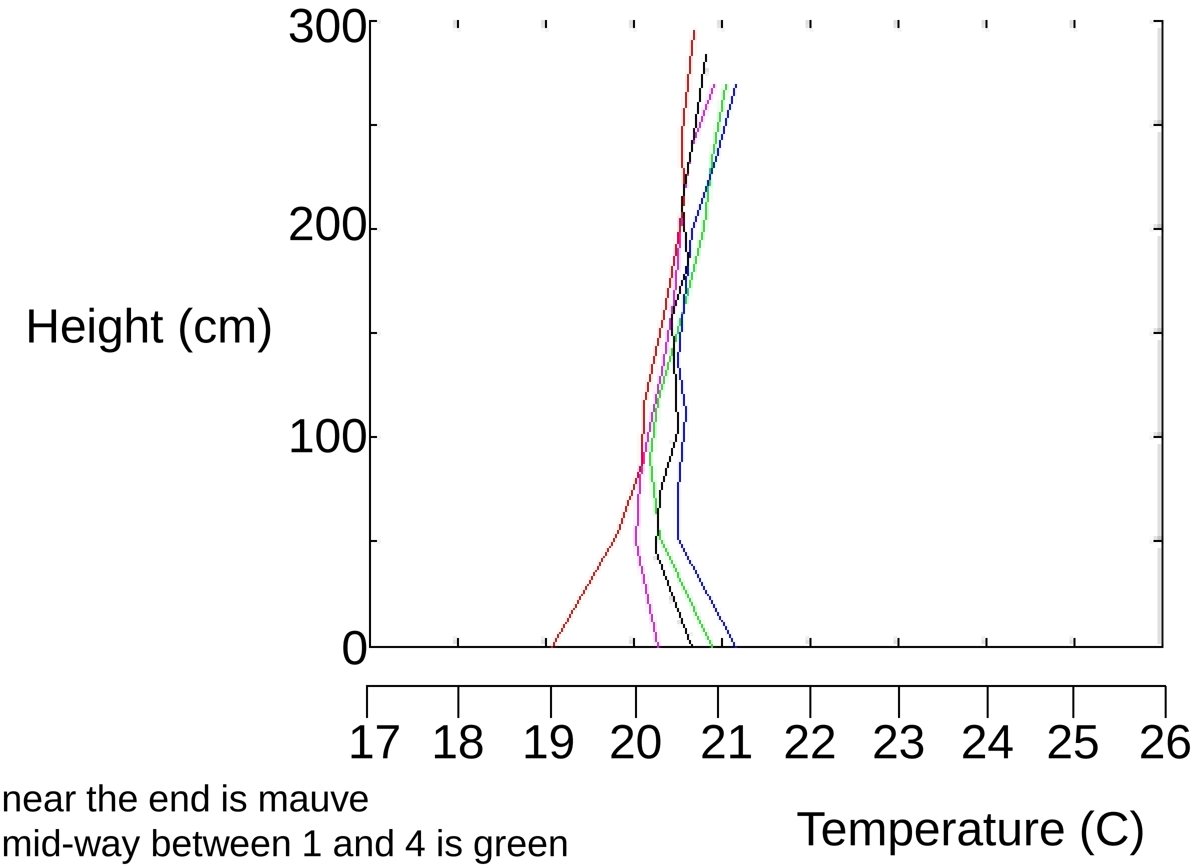
Energy consumption - heating and cooling run simultaneously



Mechanical Ventilation Scheme

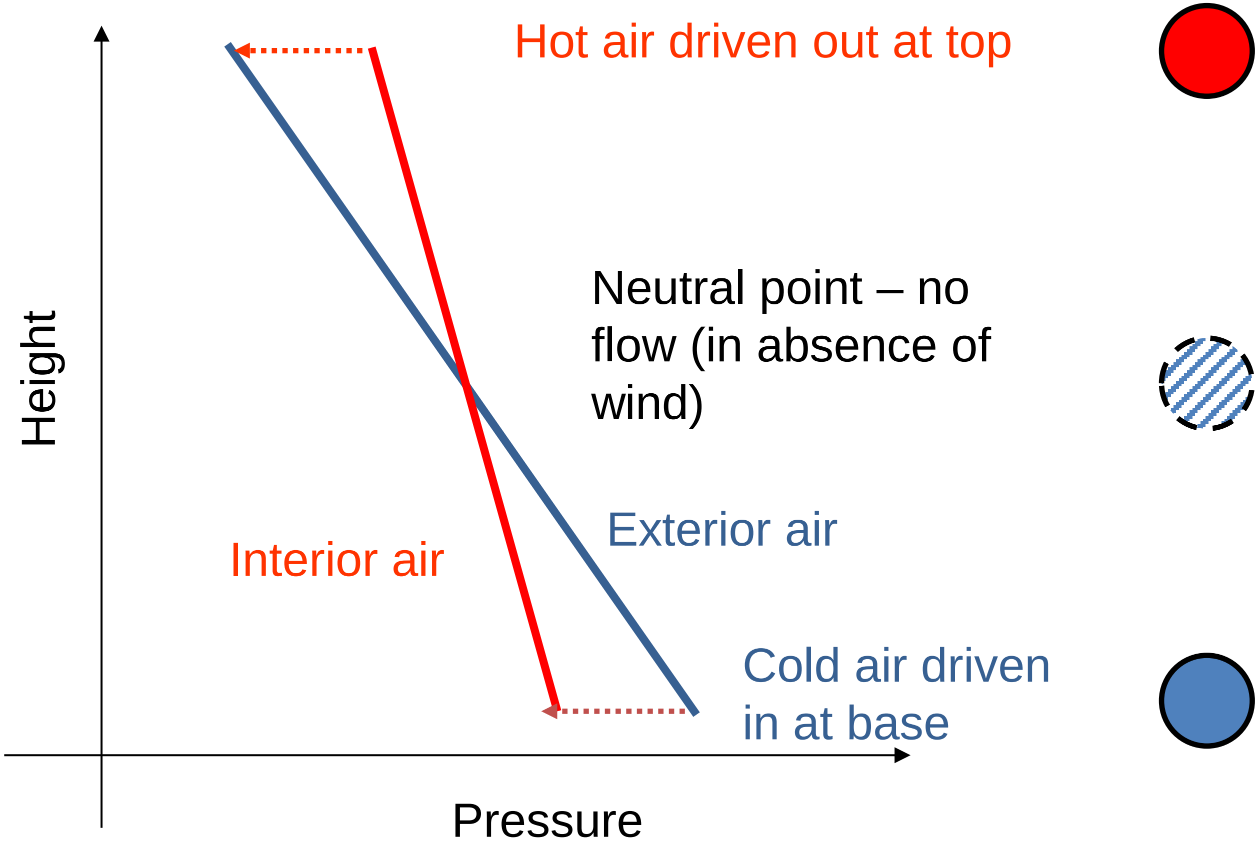
1st Floor Sunbury A, Week 16/11 through 21/11

Starts at 0600 Sat 16/11, finish 1050 on Thur 21/11

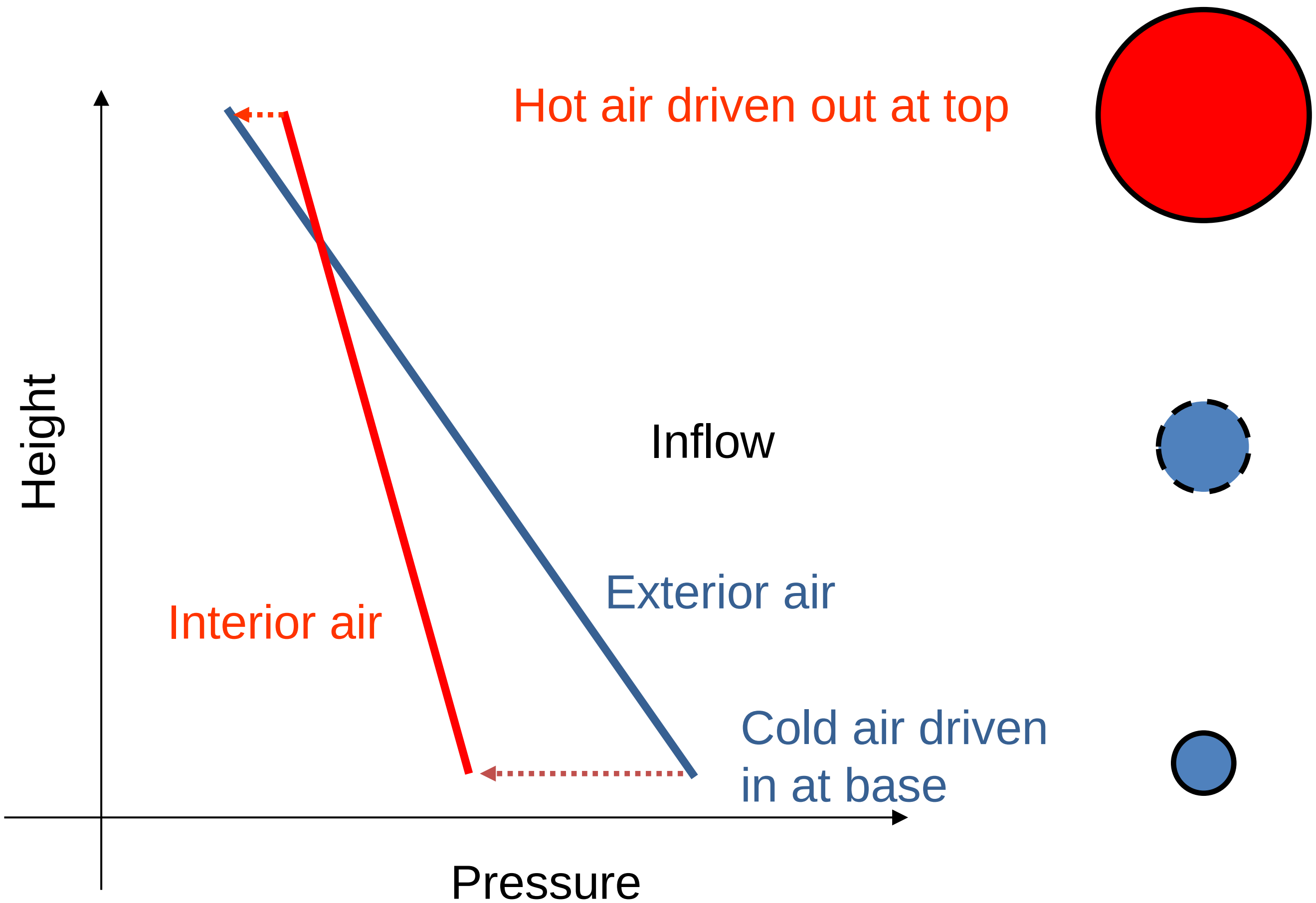


#1 near the end is mauve
#2 mid-way between 1 and 4 is green
#3 Stand near window, ¼ way along the building is red
4 stand near the middle and away from the window is blue
#5 near the middle, but at the window is black

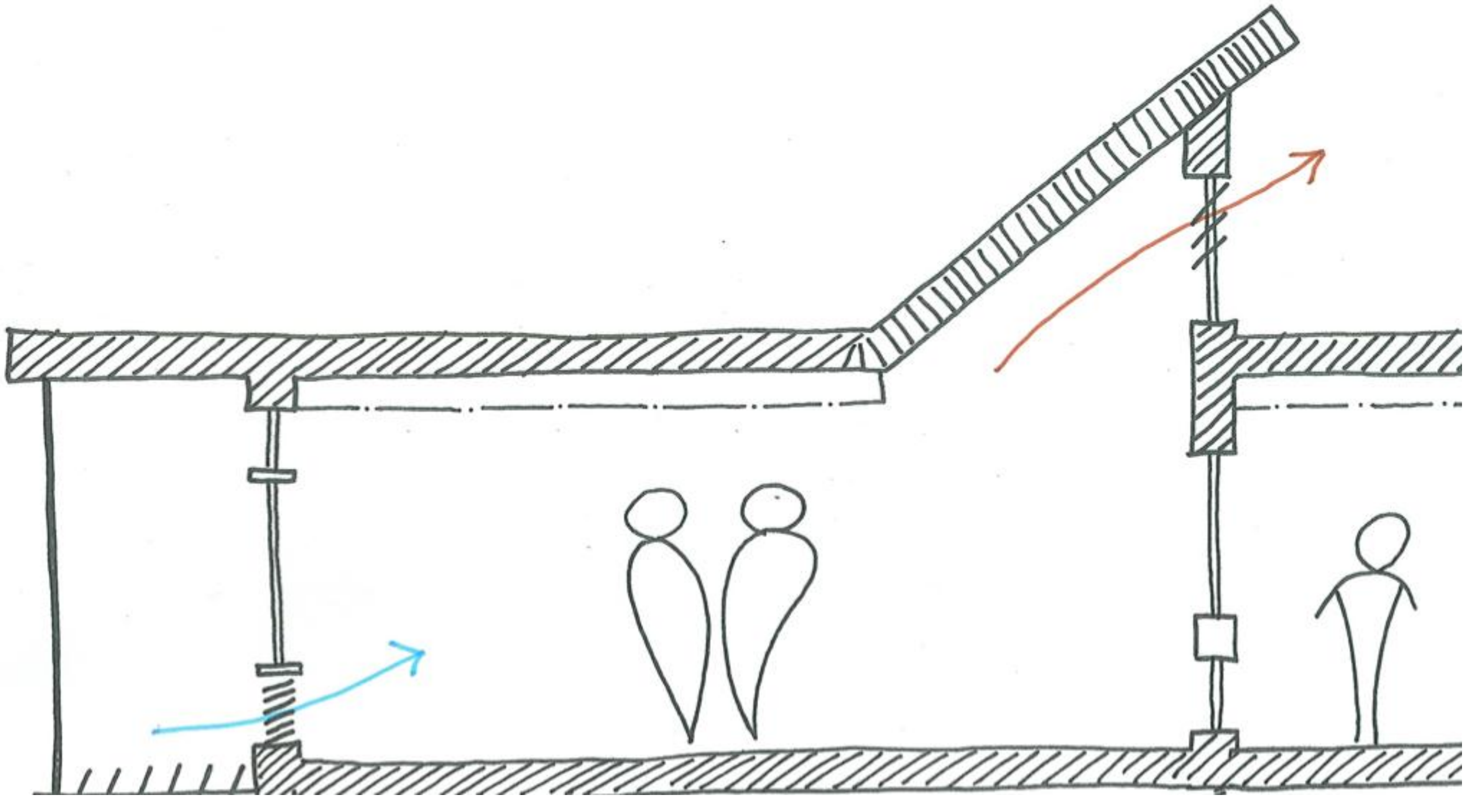
Displacement



Displacement



Simple Spaces

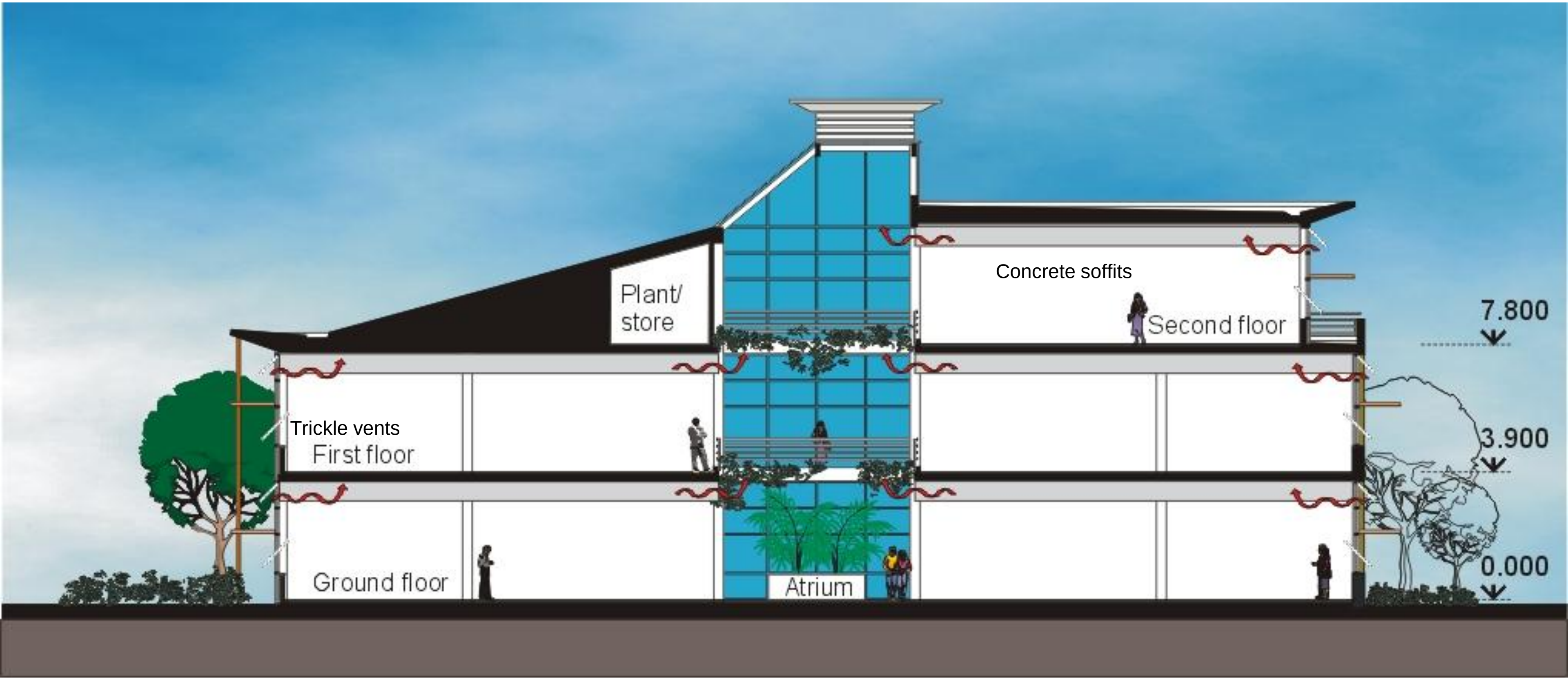


HOUGHTON HALL

HOUGHTON HALL

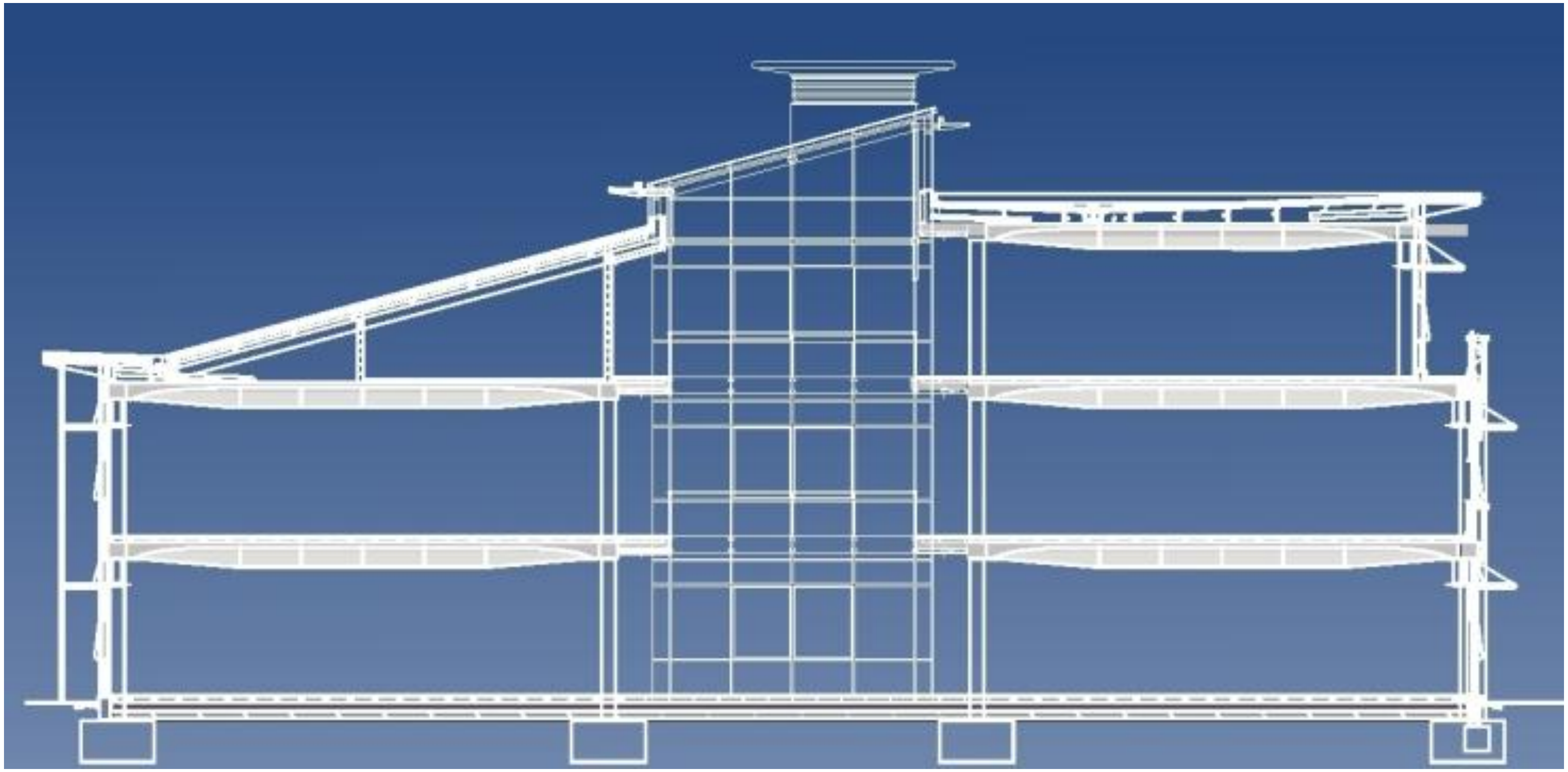
HOUGHTON HALL

HOUGHTON HALL

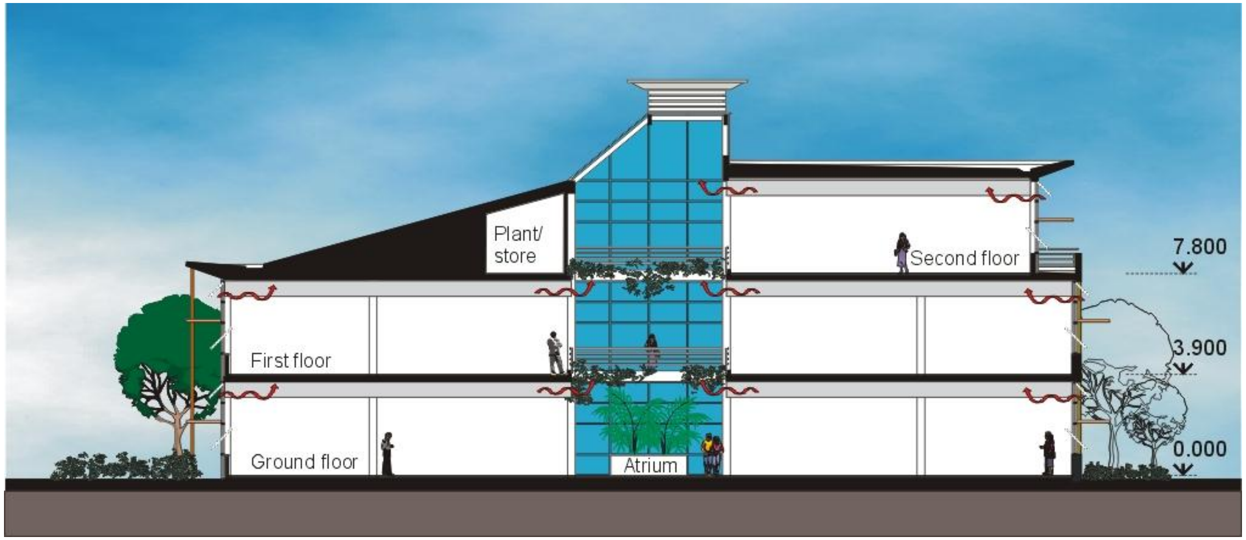


Complex Spaces

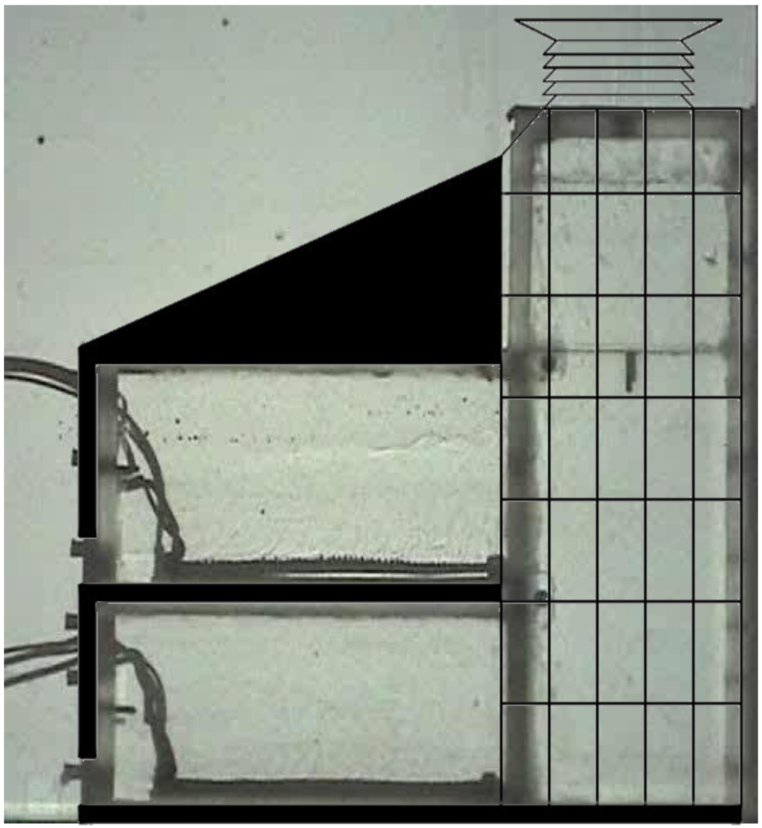
Which way does the air flow?

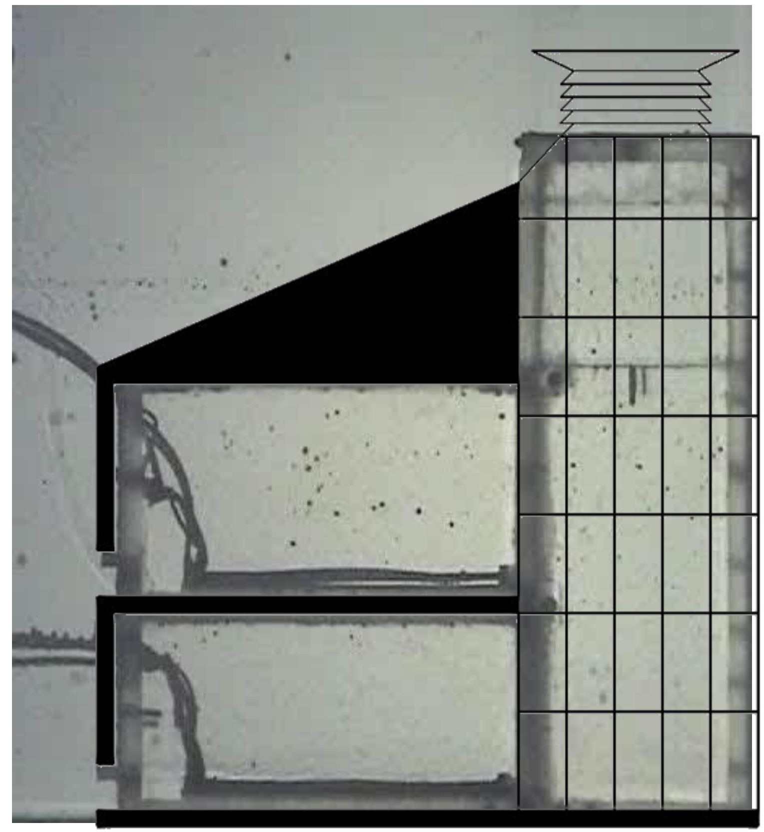


Complex Spaces – Houghton Hall



Water-bath Modelling

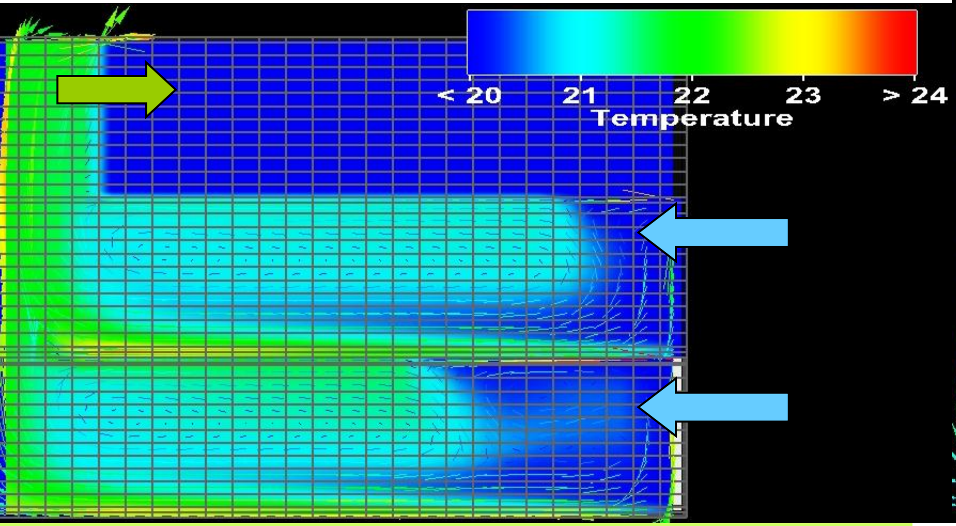




CFD Modelling

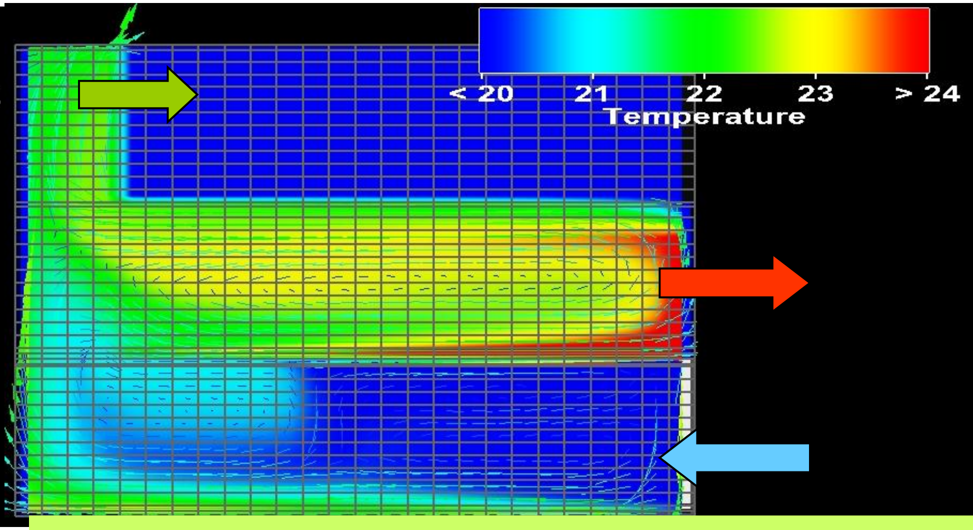
Multiple modes can be obtained with numerical modelling … but
- You need to know what you are looking for!
- Time consuming!

Uniform initial conditions (20^{o}C)



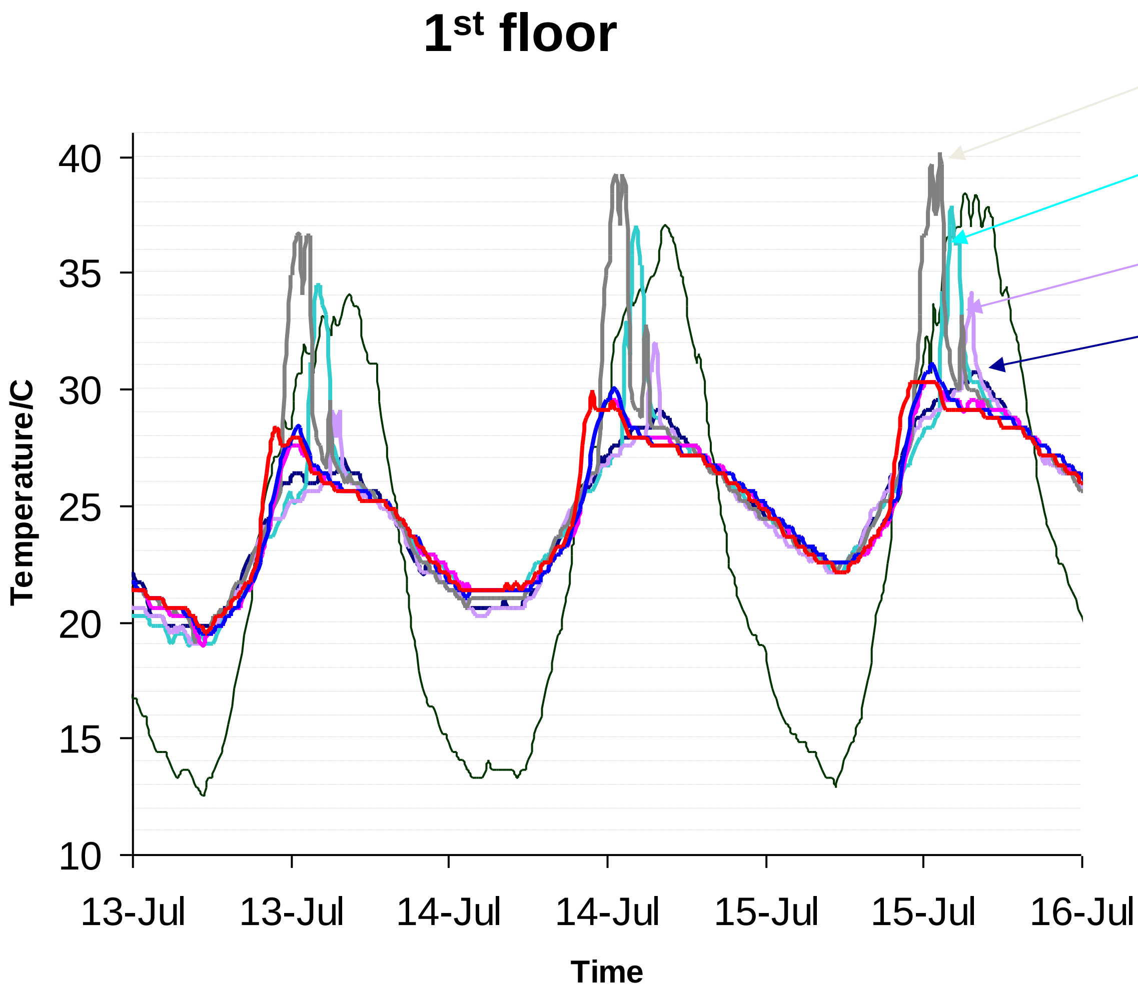
Air enters through 1st floor vents
→cool interior

1st floor initially hotter than ground



Air exits through 1st floor vents
→Hot 1st floor

Temperature Measurements

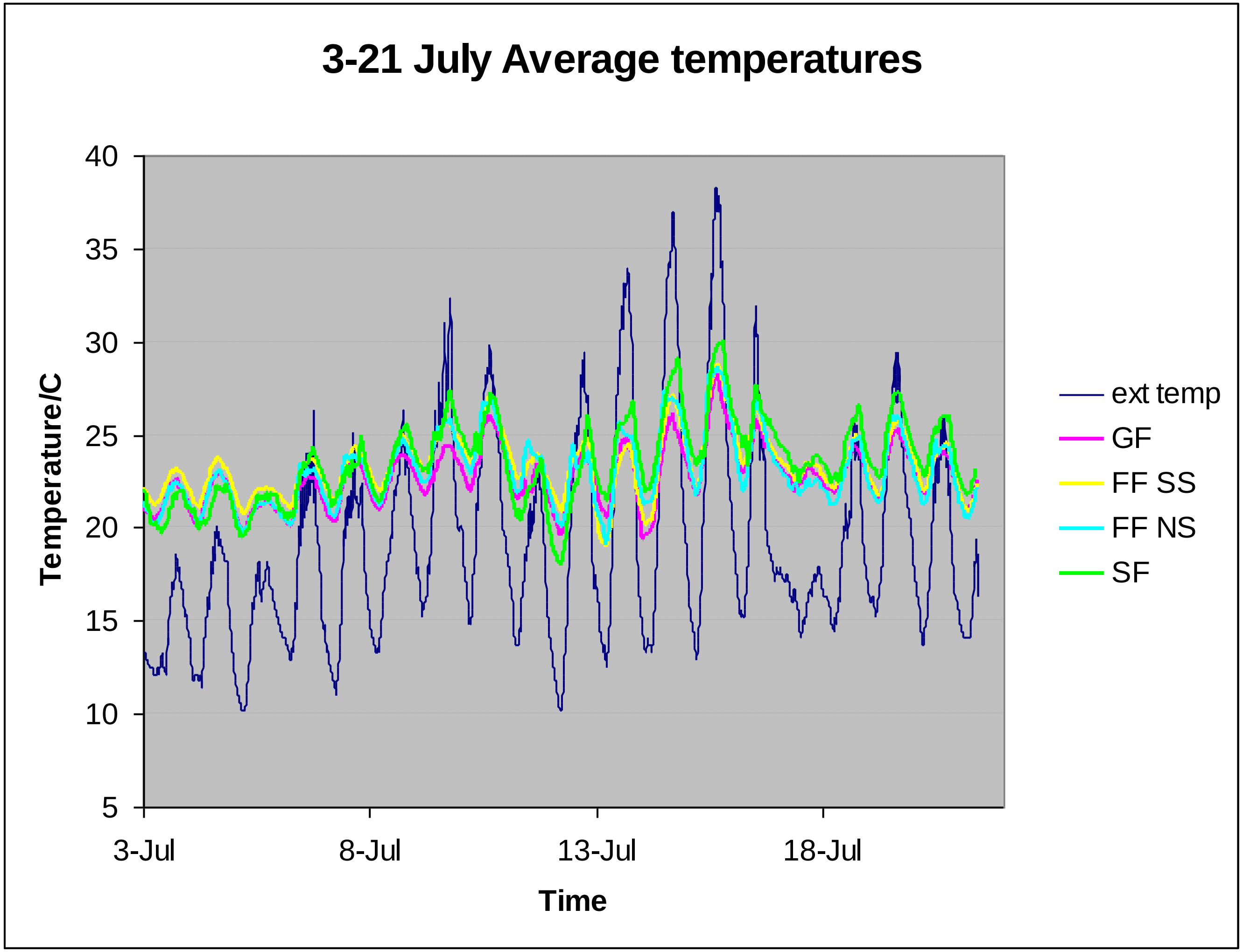


- North side of the atrium
- East end of the atrium
- South side of the atrium
- West end of the atrium (dark blue line, very small peak)
- Within main floor

Atrium peak temperatures follow exposure to sun

Region near/within atrium hotter than desk area under exposed concrete → benefit of thermal mass

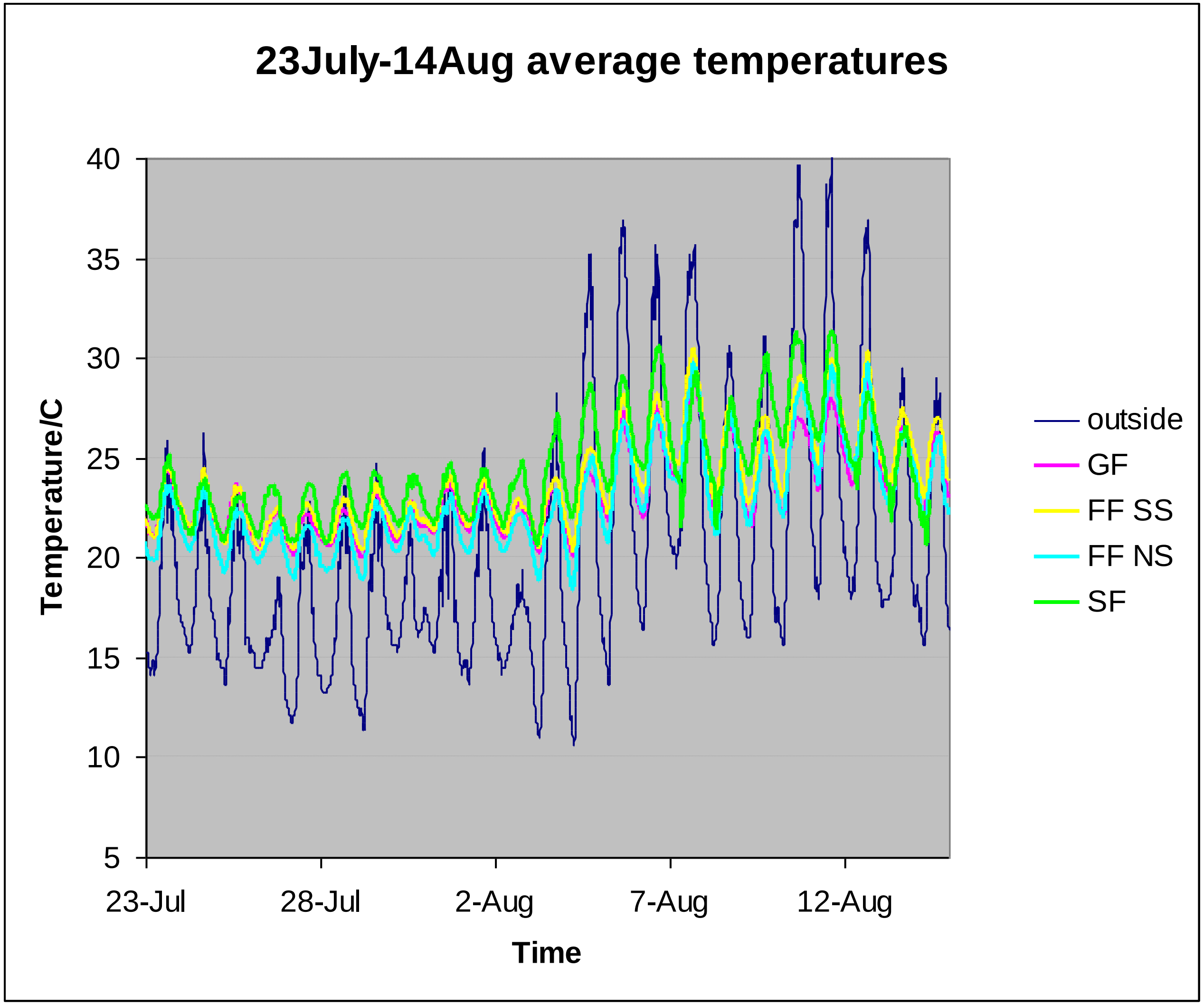
Temperature Measurements



Main floor temperatures less than outside and buffered by thermal mass…

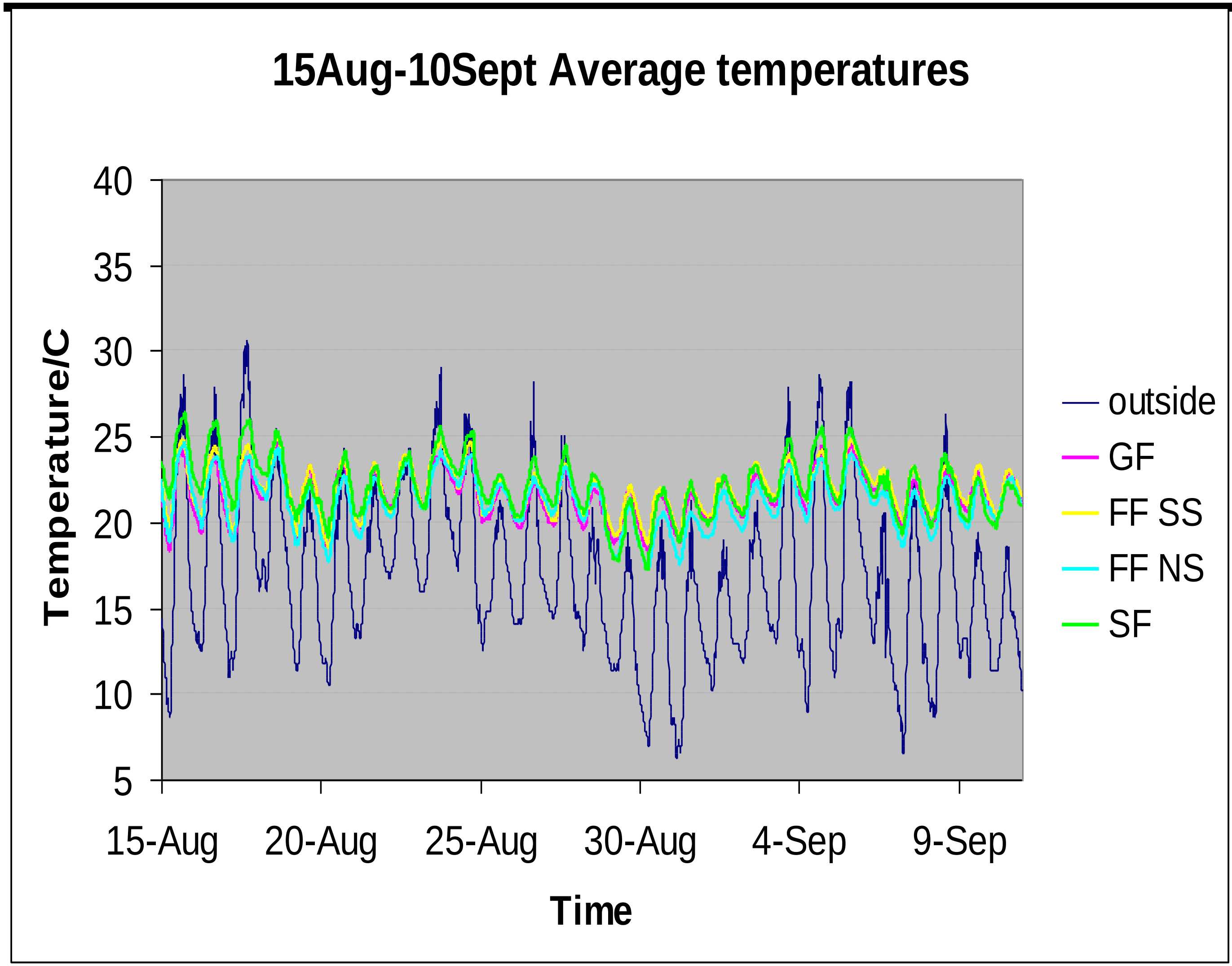
but still rather warm mid-July

Temperature Measurements



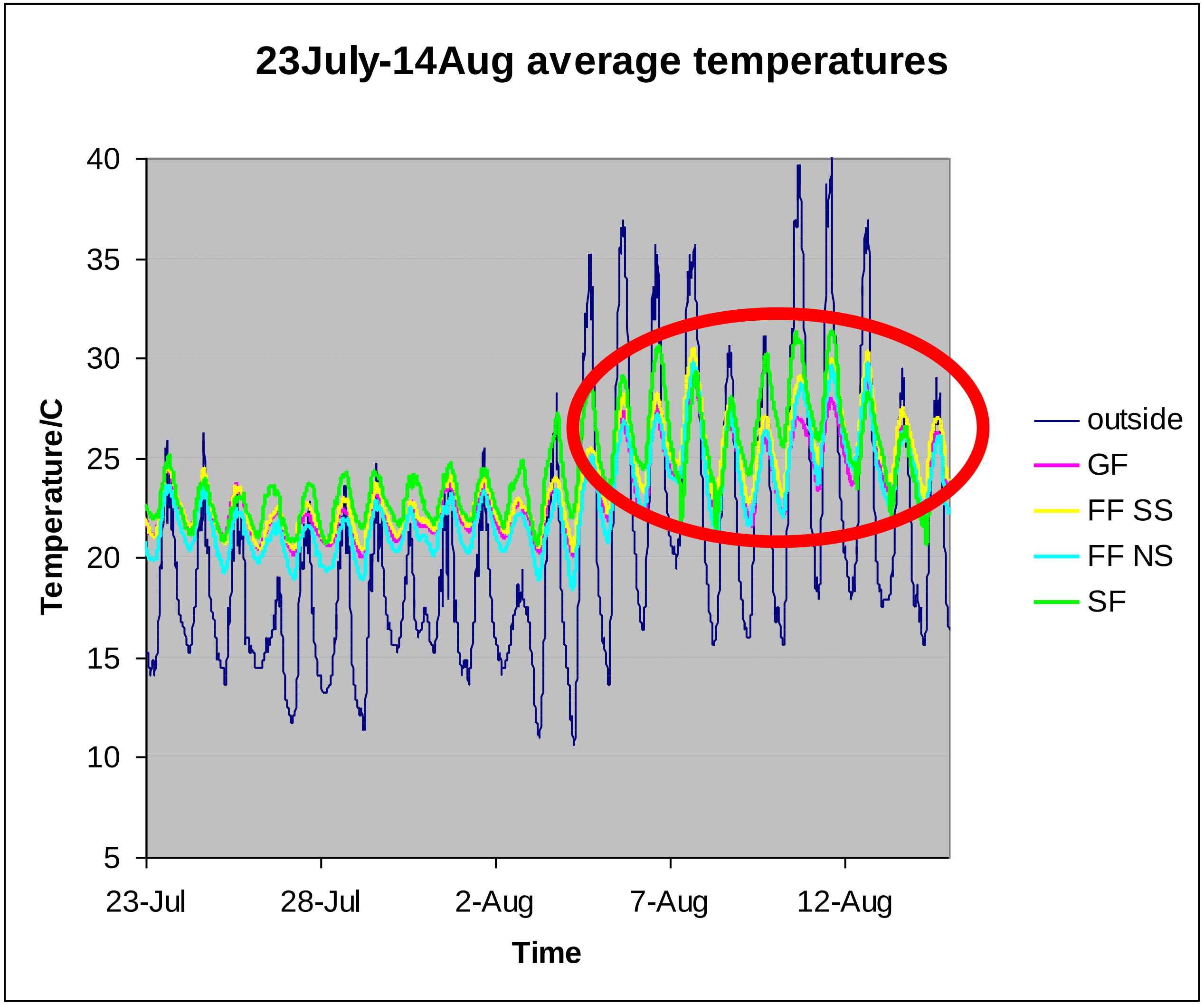
Warm inside again in early August

Temperature Measurements

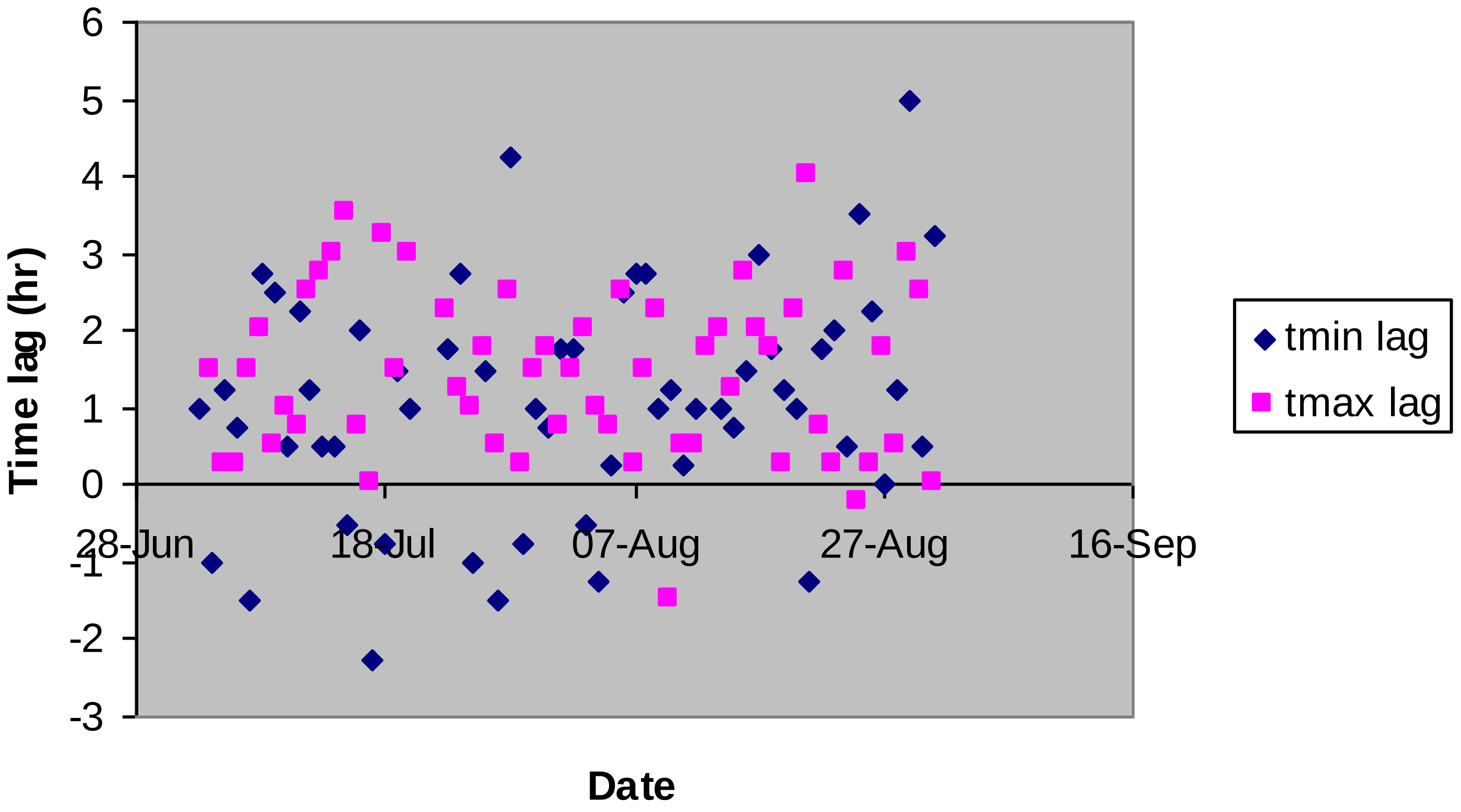


Cooler after mid-August

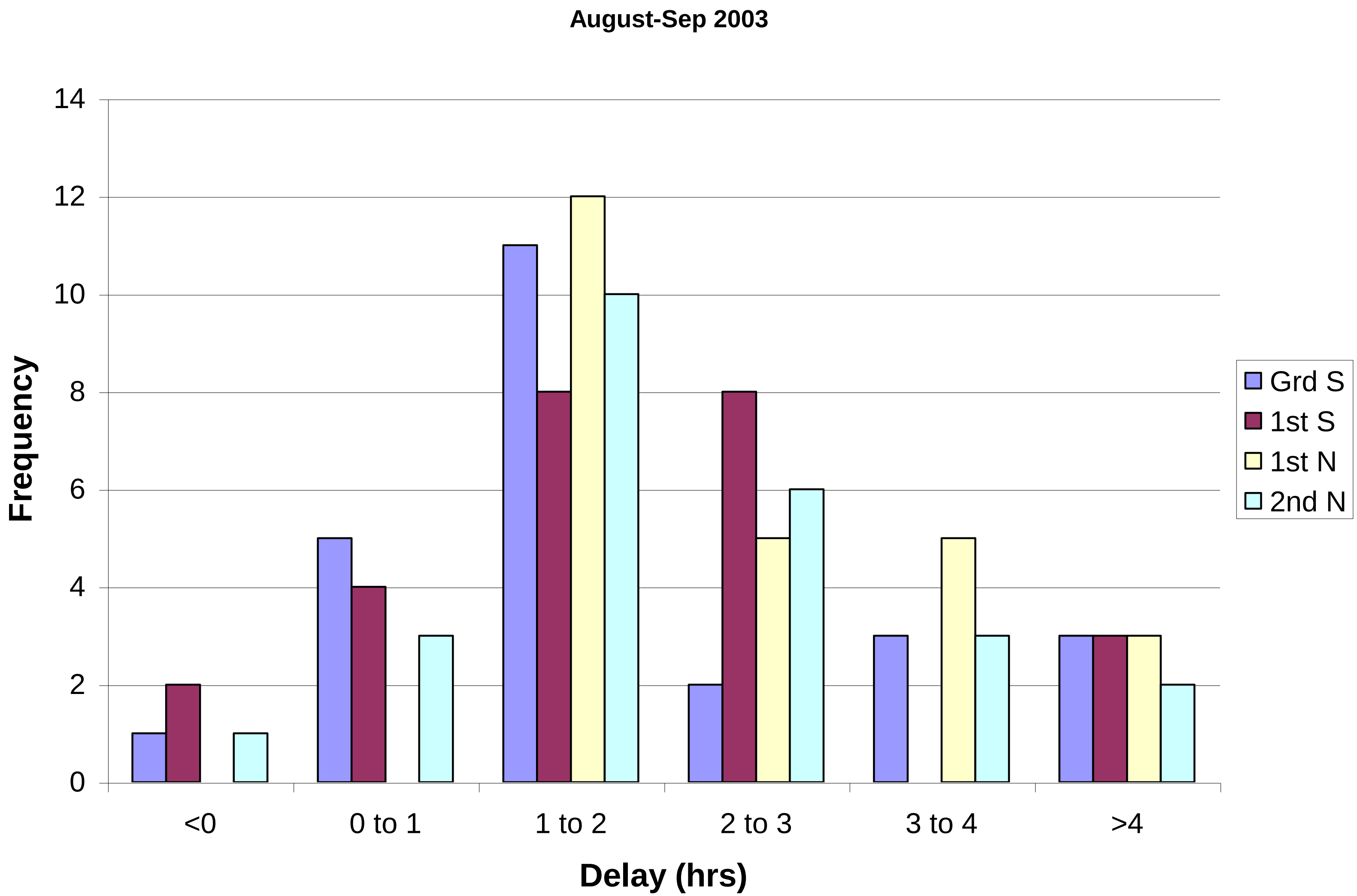
Can we improve performance?



Time Lags

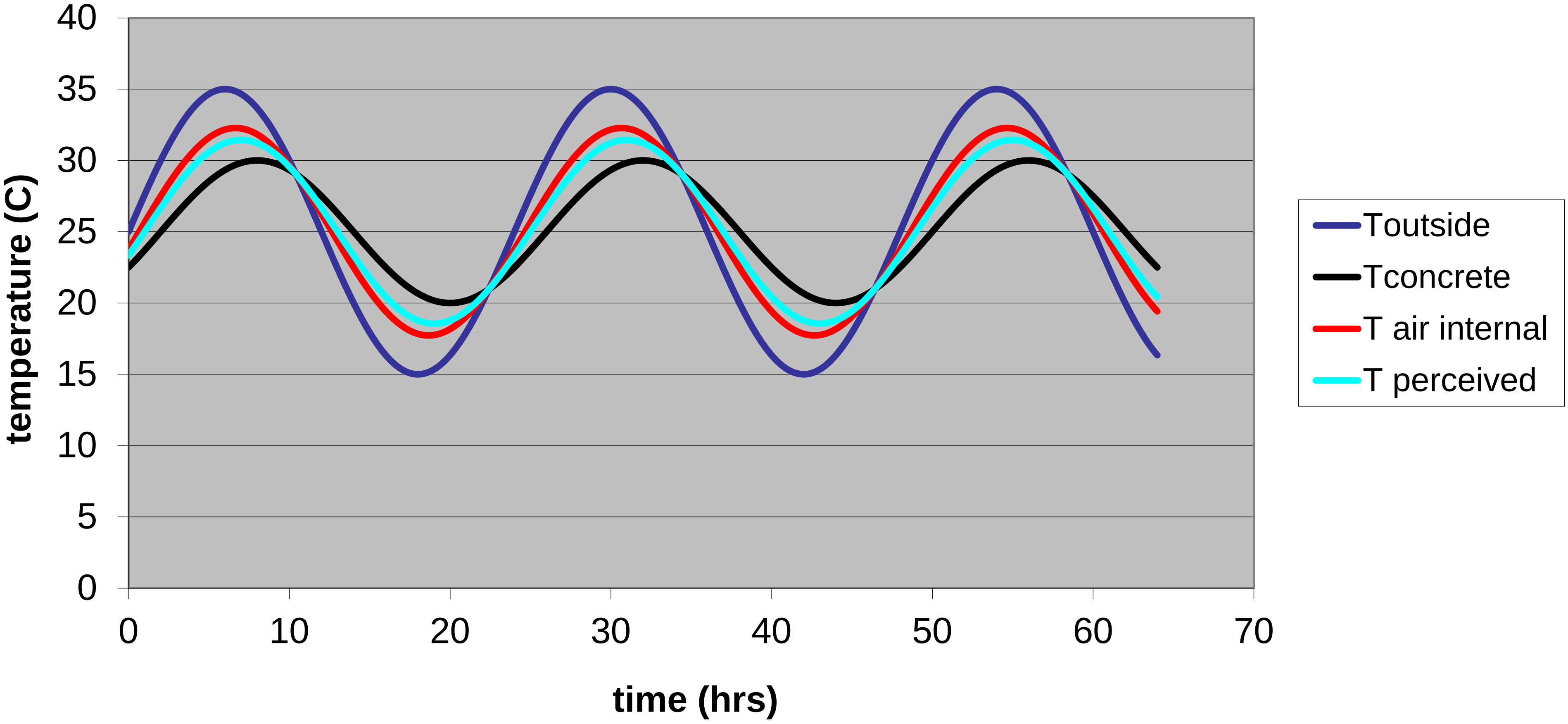


Range of time lag for building to reach max or min temp

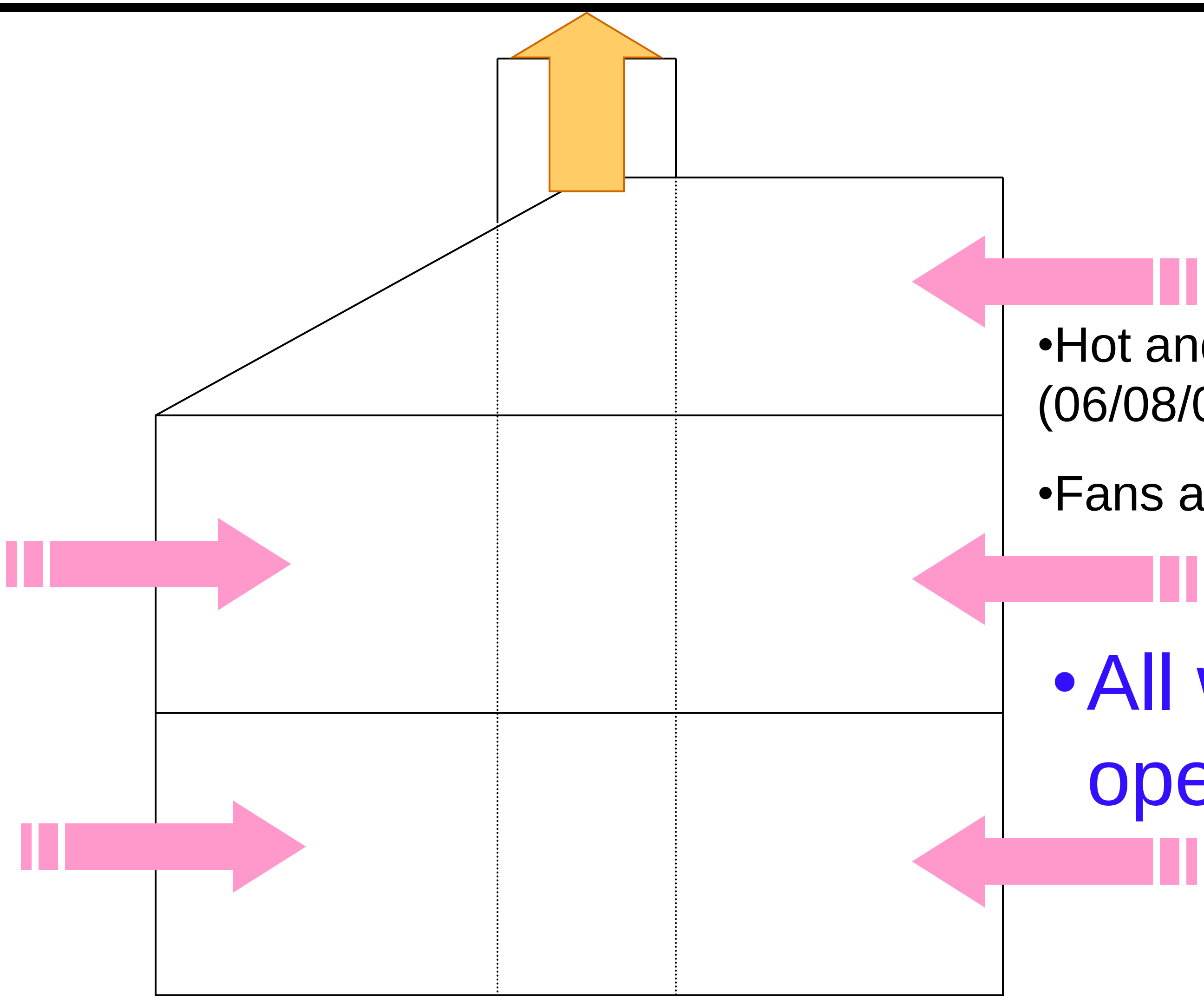


Buffer for max temp 1-3 hours

Maximising Effectiveness of Thermal Mass

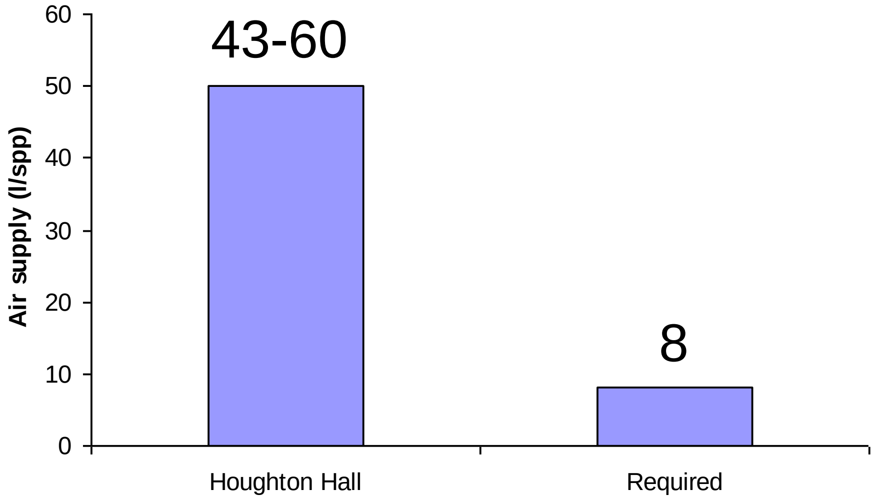


Air Flow Results



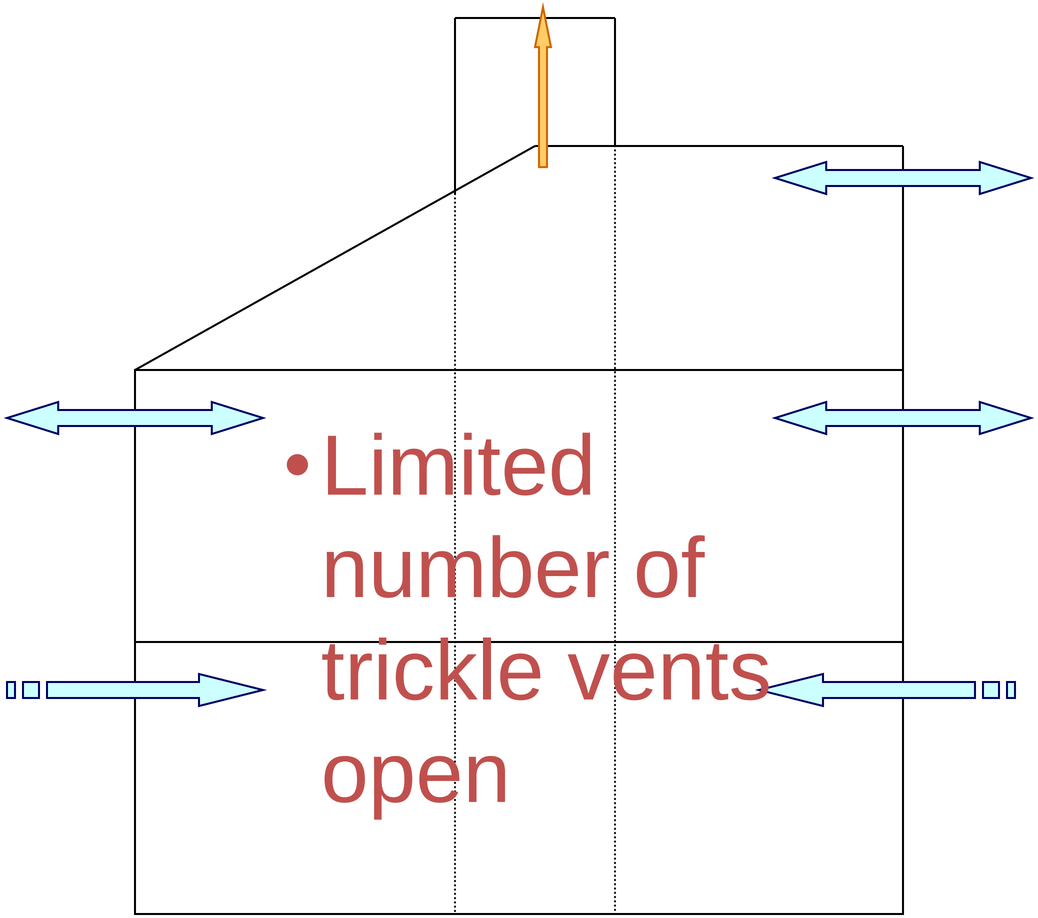
- Hot and still day (06/08/03)
- Fans are operating all day
- All windows open

Air Quality

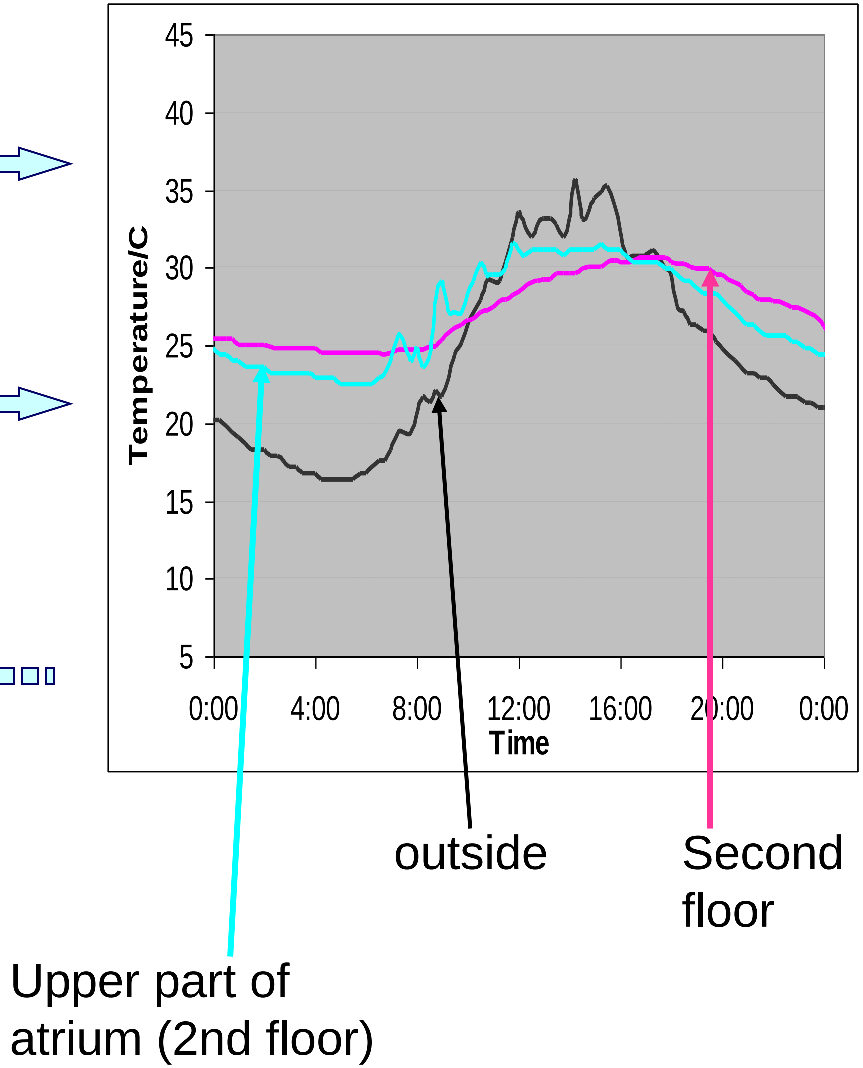


Measurements show fresh air supply well in excess of minimum required

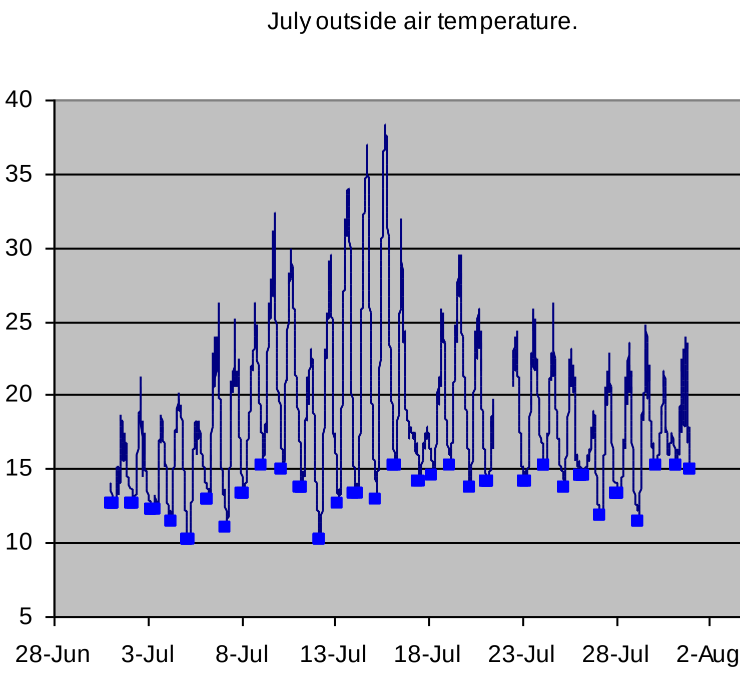
Night Time Operation

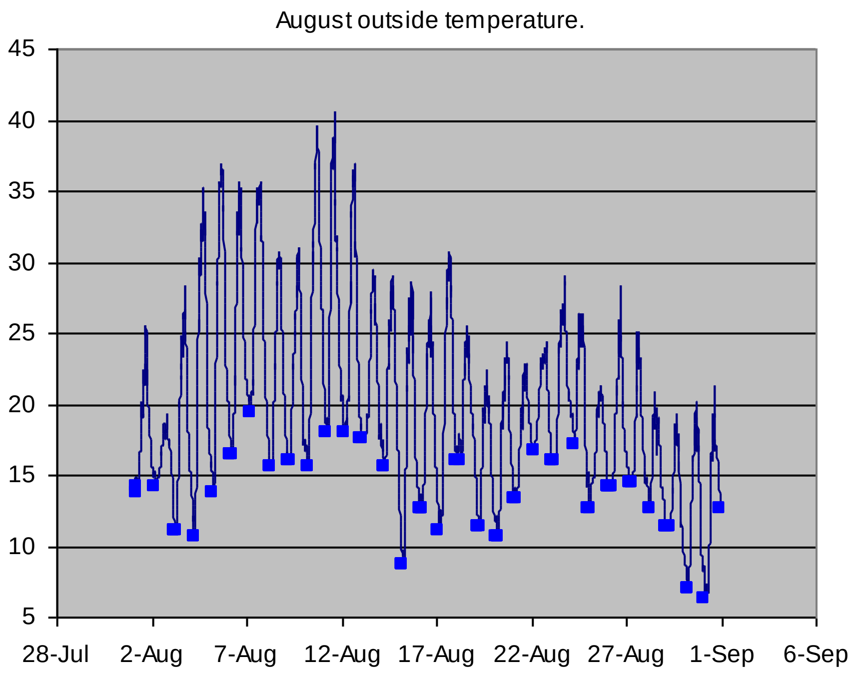


- Limited number of trickle vents open



Opportunity for Improvement



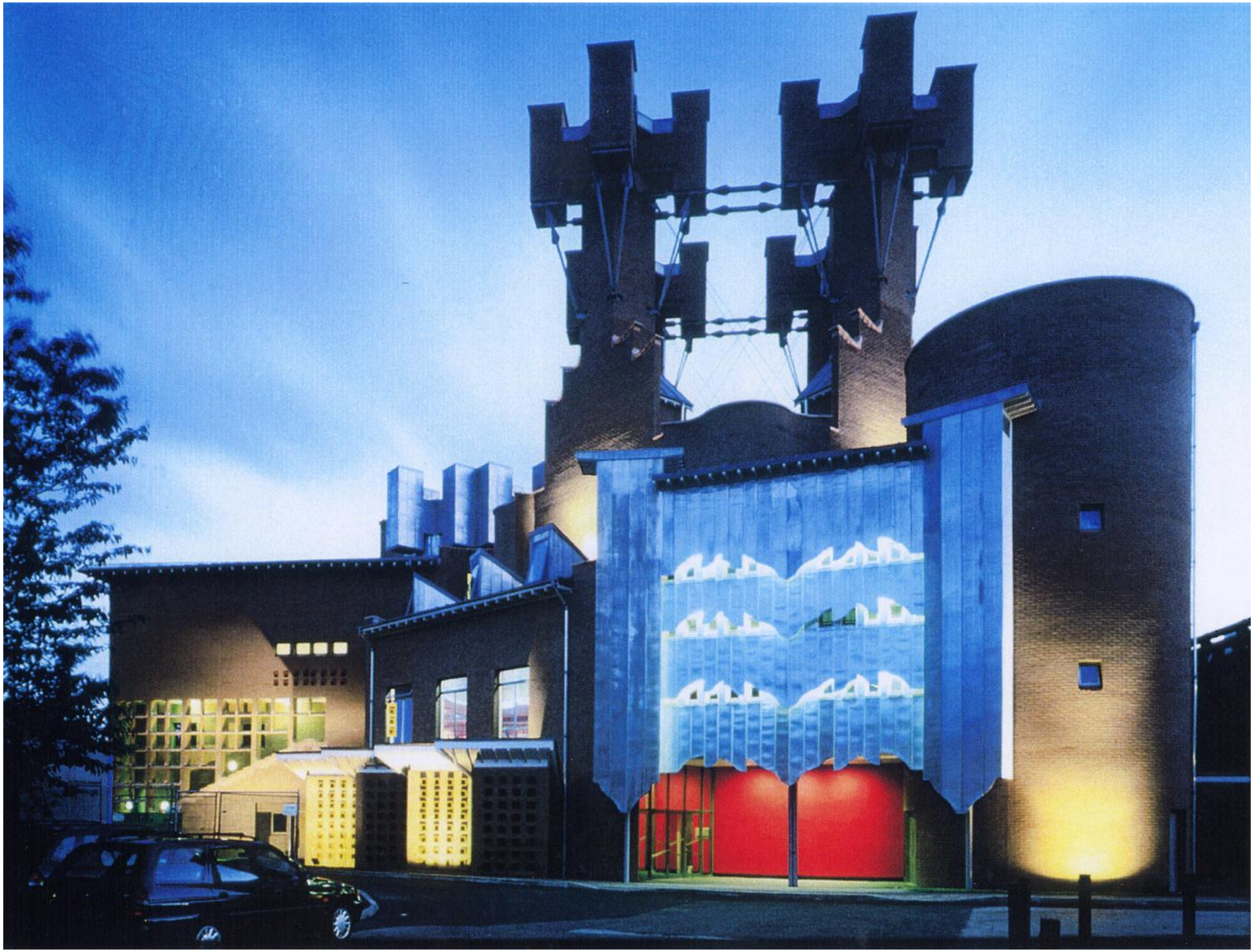


1. Opportunity to use cool air from outside during night **even more effectively** to reduce building temperature

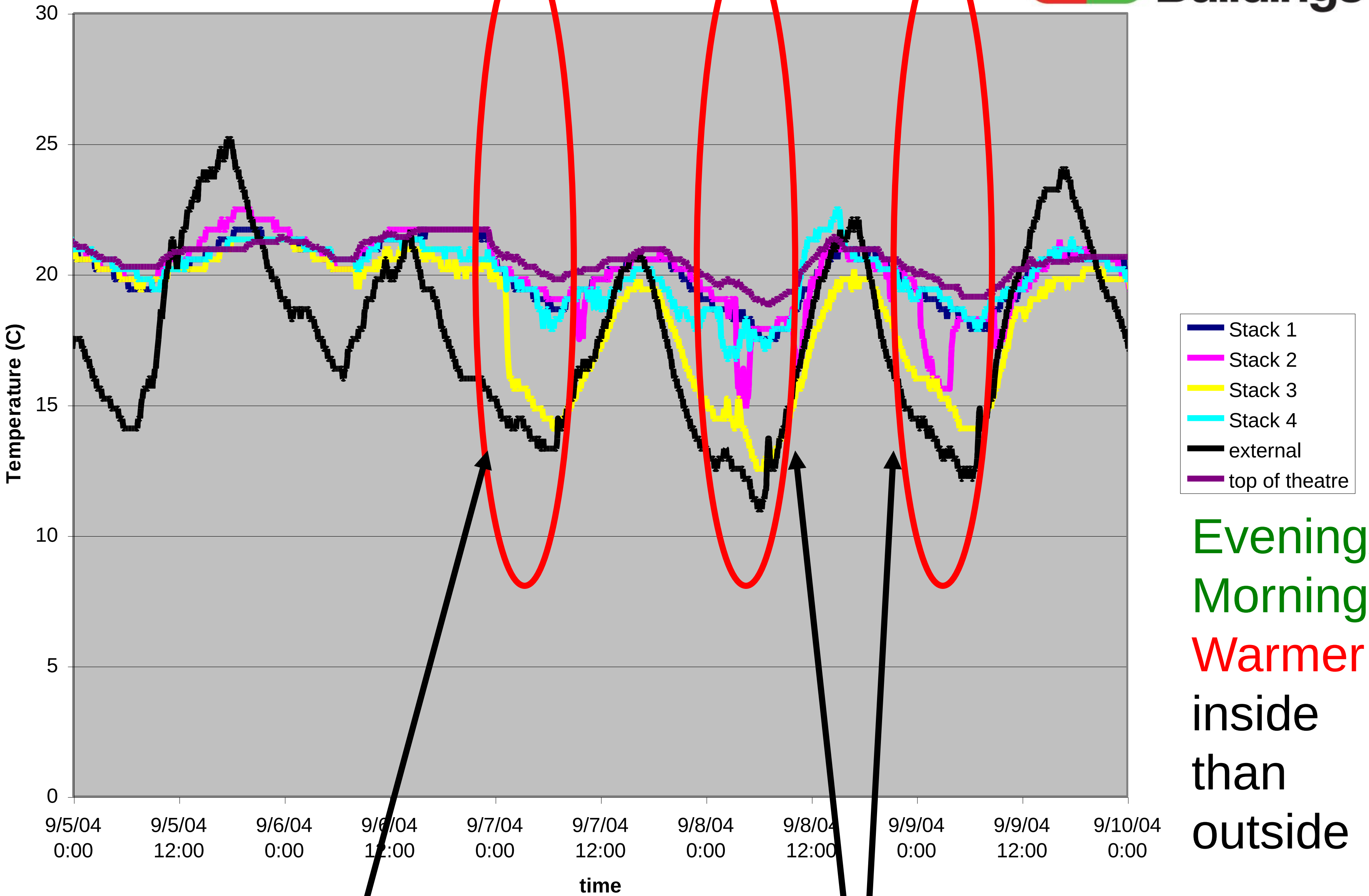
2. Reduce window openings during summer day to **maximise benefit of thermal mass**

Contact Theatre, after renovation

Breathing Buildings



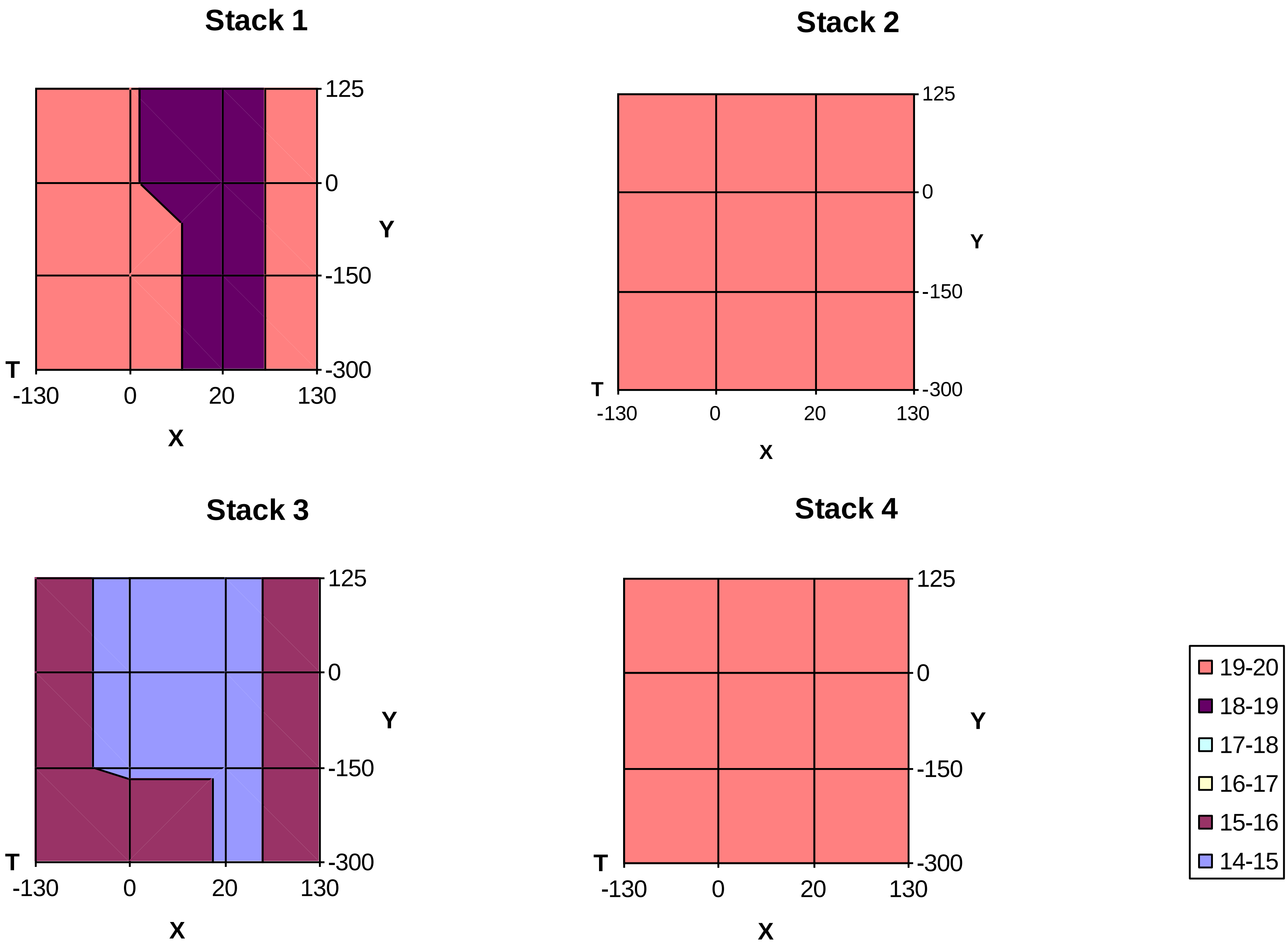
Contact Theatre, Studio



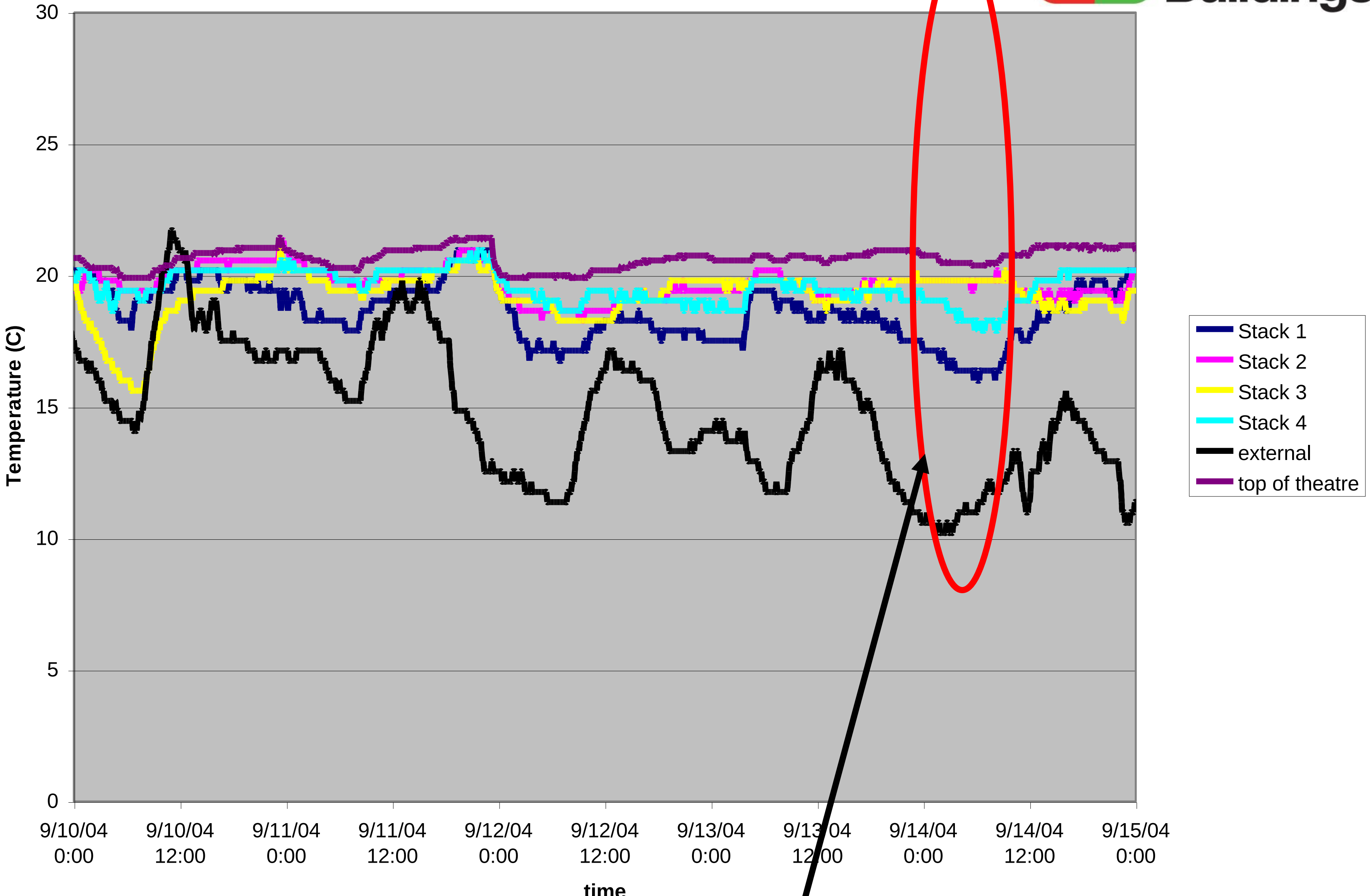
Evening/ Morning Warmer inside than outside

Stack 3 inflow?

Stack 2 also inflow later?

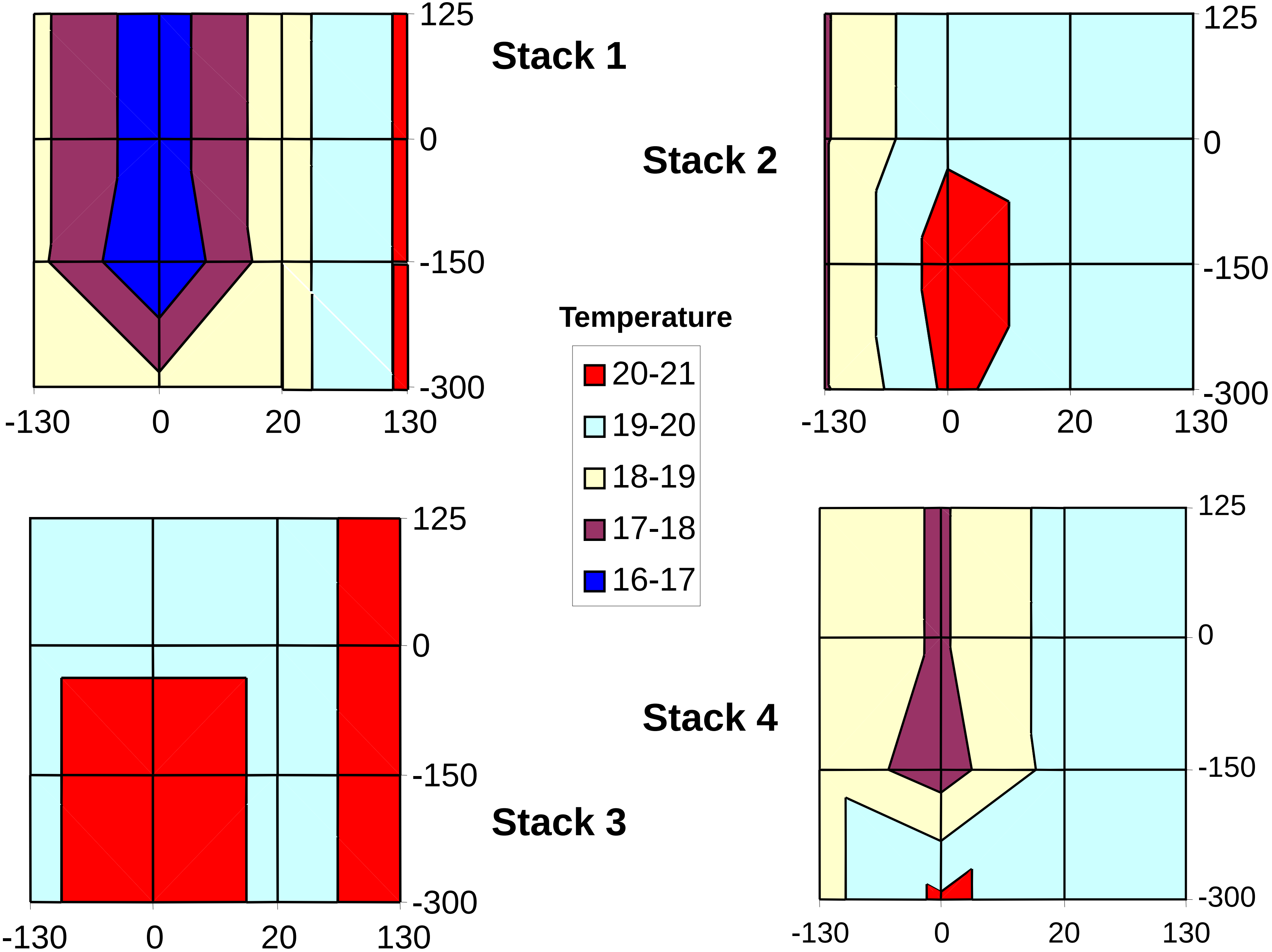


Stack 3 inflow → balance of base and stack areas

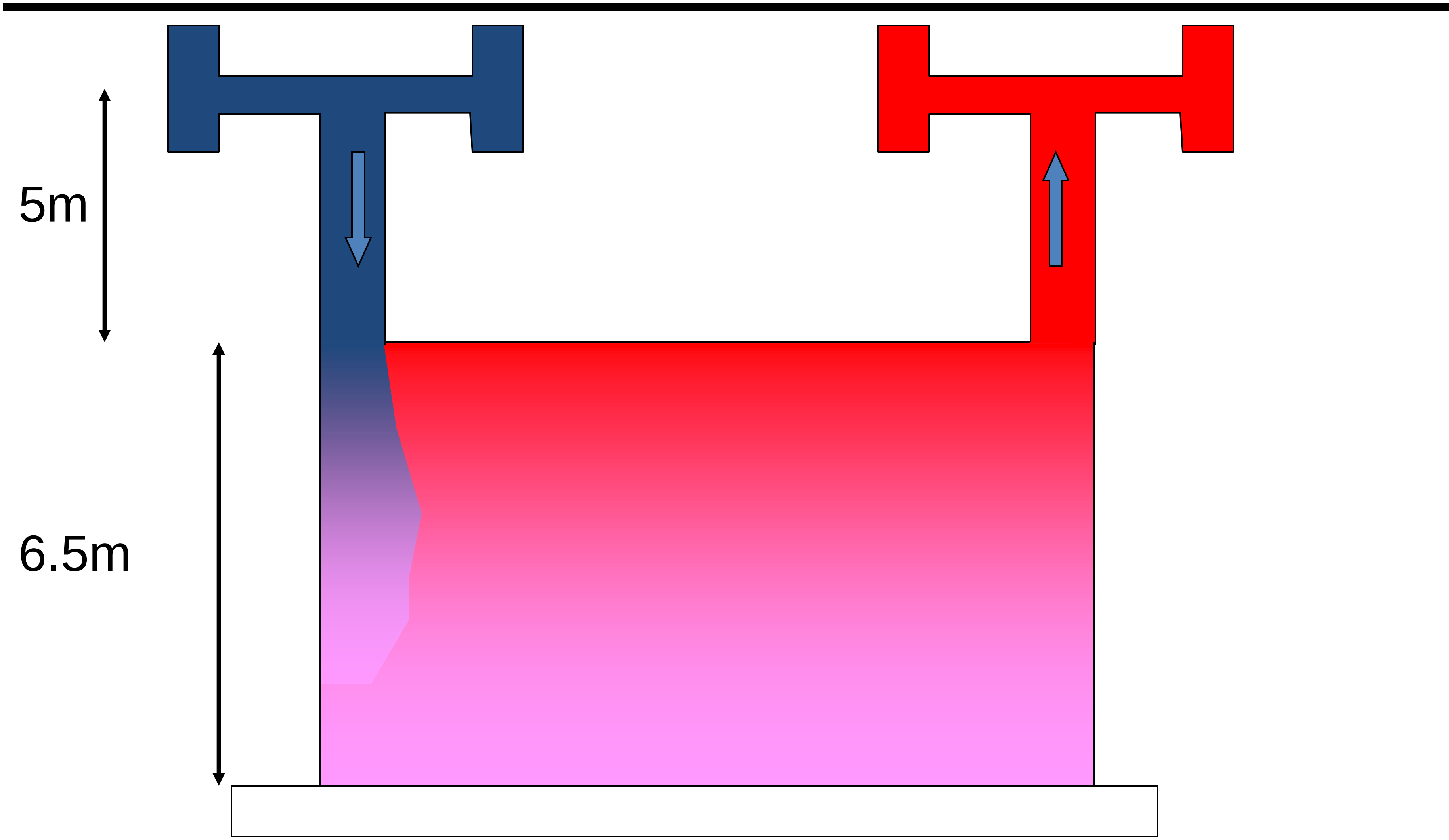


Mid-points of stacks 1 + 4 cooler than stacks 2 + 3

Counterflow in stacks 1 + 4



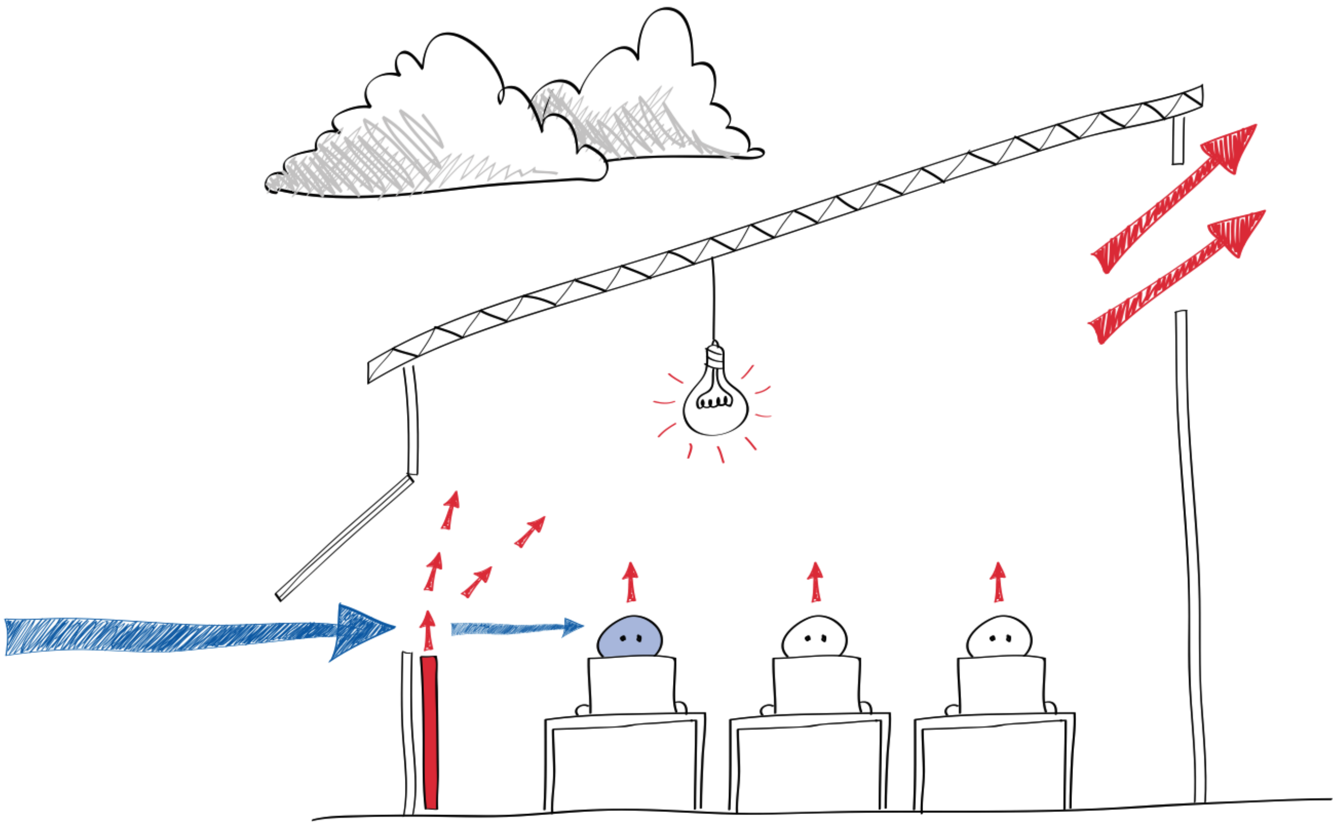
Contact Theatre, Studio



Mixing ventilation in practice when warmer inside and stack area >> base vent area

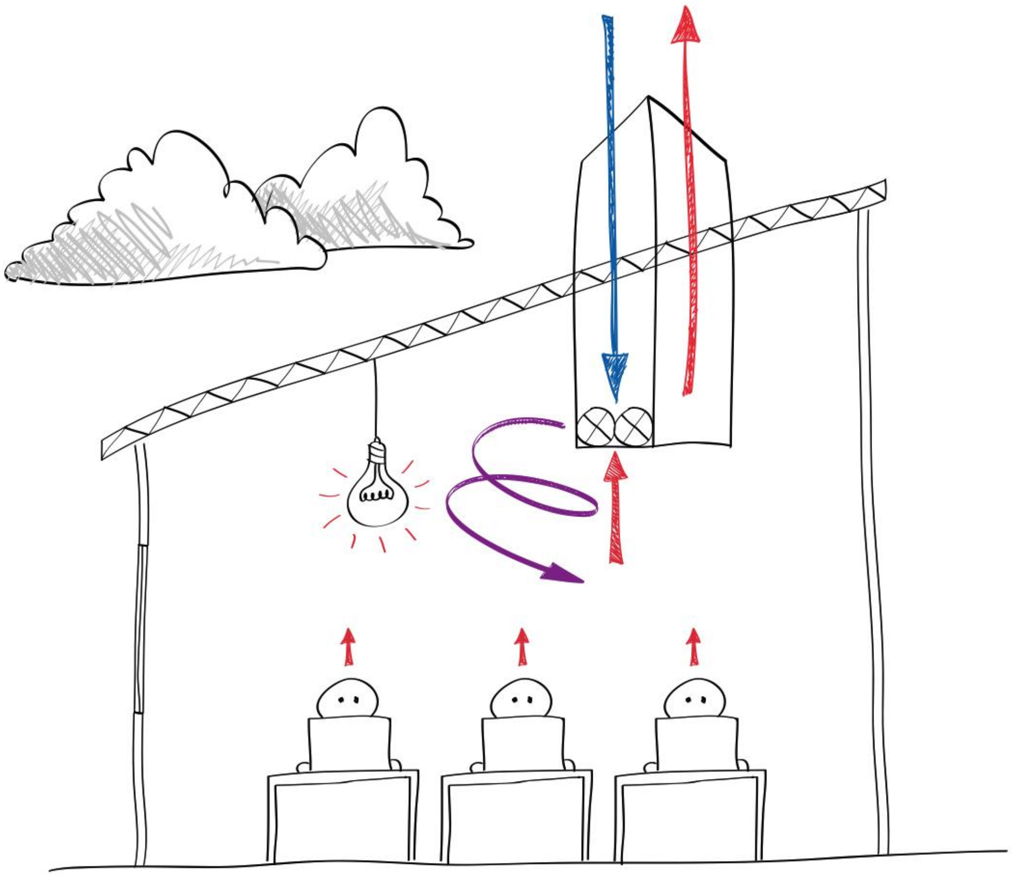
Conventional Natural Ventilation

Breathing Buildings



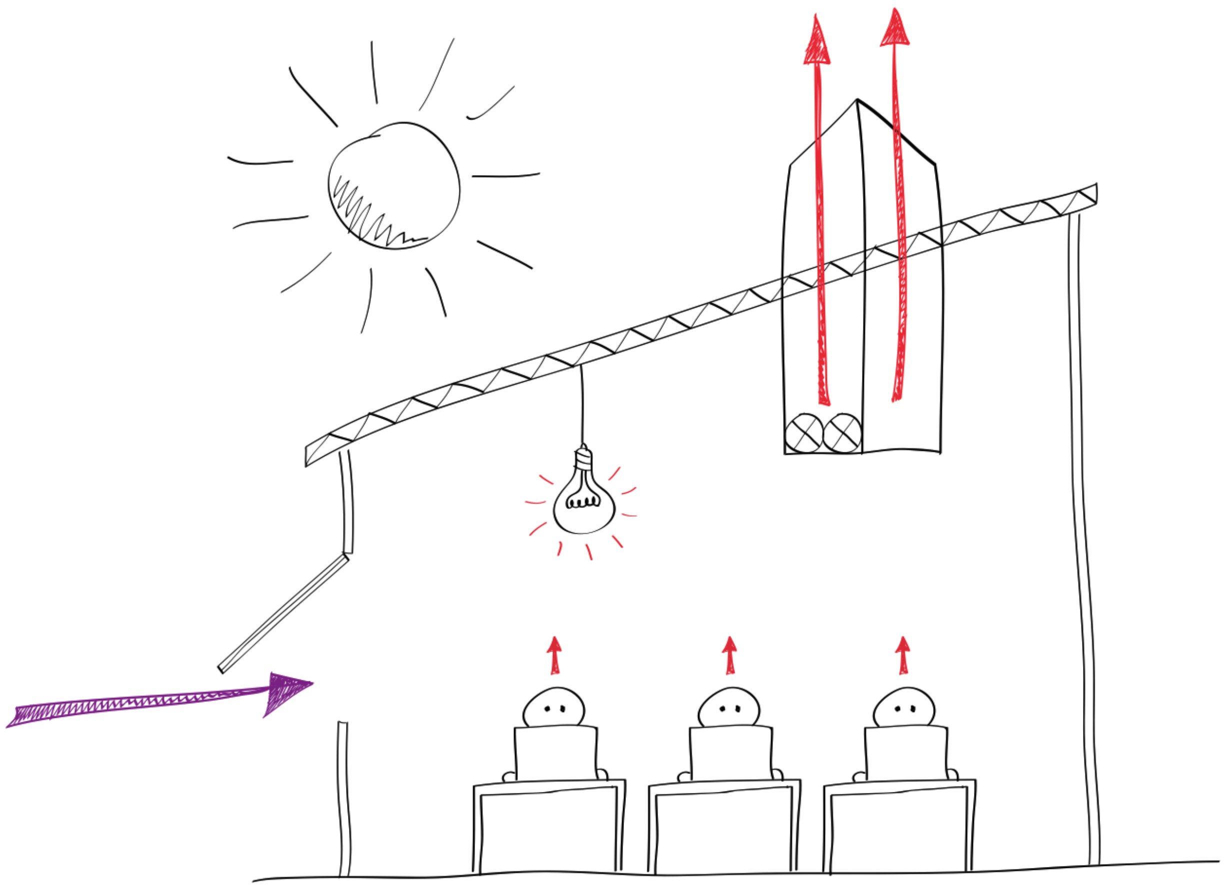
Winter – Upwards displacement ventilation

Recommended Winter Strategy



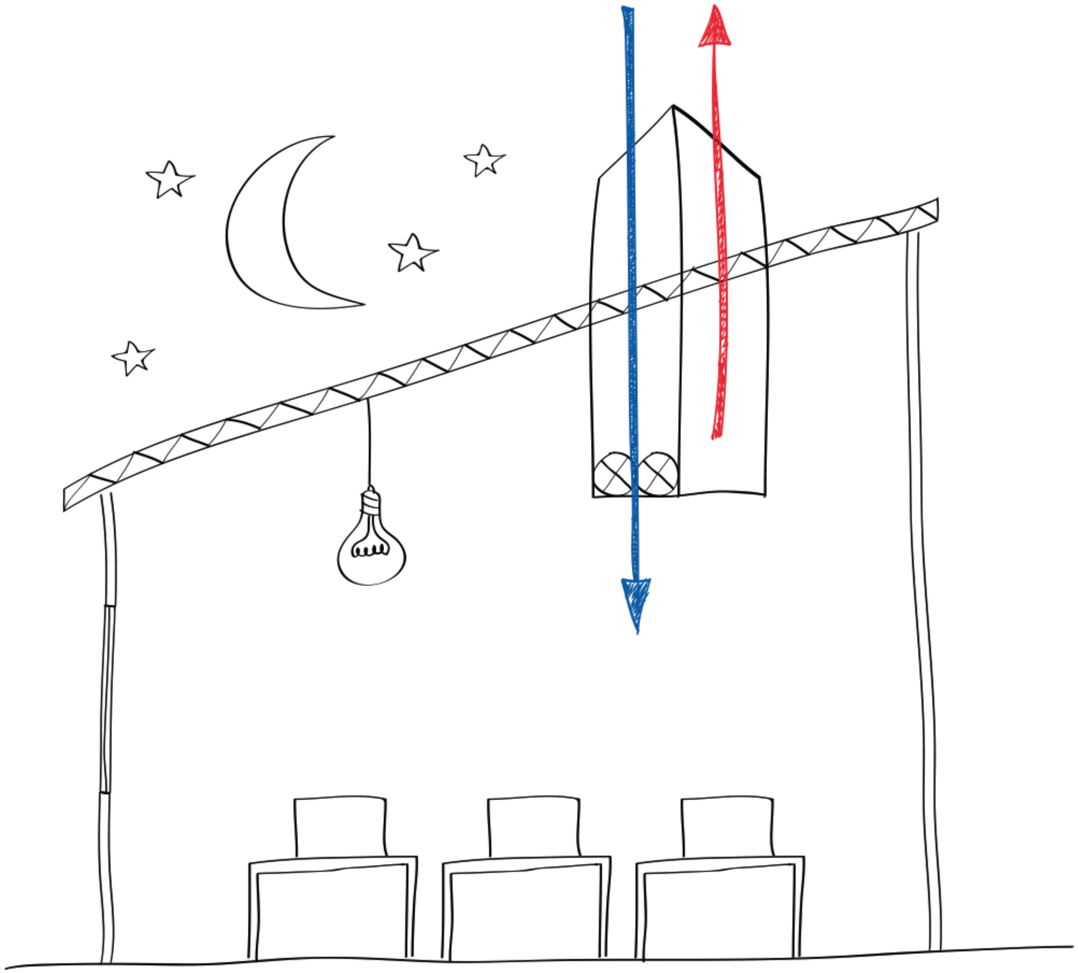
Winter – Mixing ventilation

Recommended Summer Strategy



Summer – Upwards displacement ventilation

Night Cooling



QAC, Birmingham

Breathing Buildings

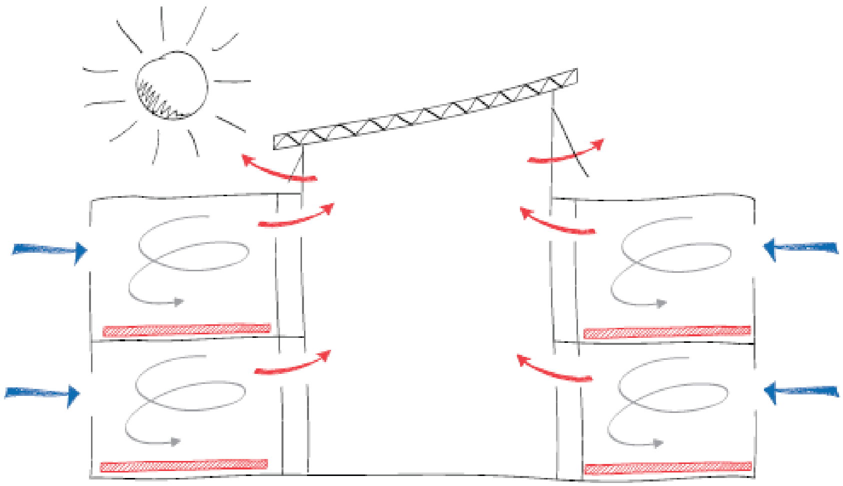
East Malling School, Kent

Pilgrim School, Kent

Control Interface

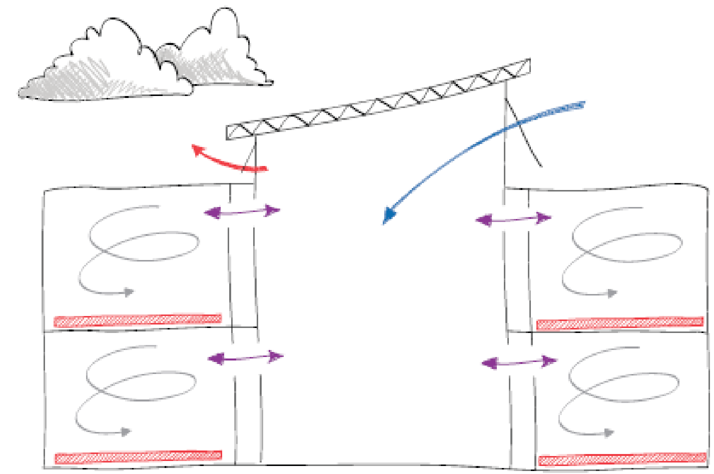
Exact interface can be adjusted for each project as required by the client

Atrium Design



Summer Strategy

Upwards Displacement Ventilation



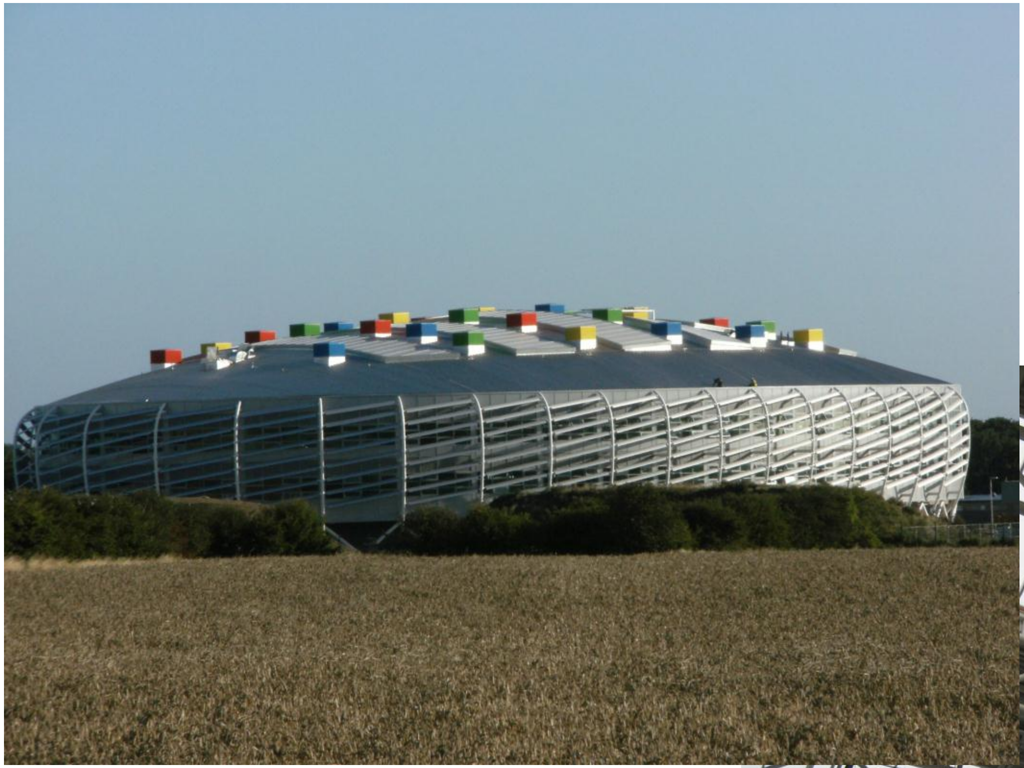
Winter Strategy

Winter Mixing Ventilation

Port Regis School, Dorset

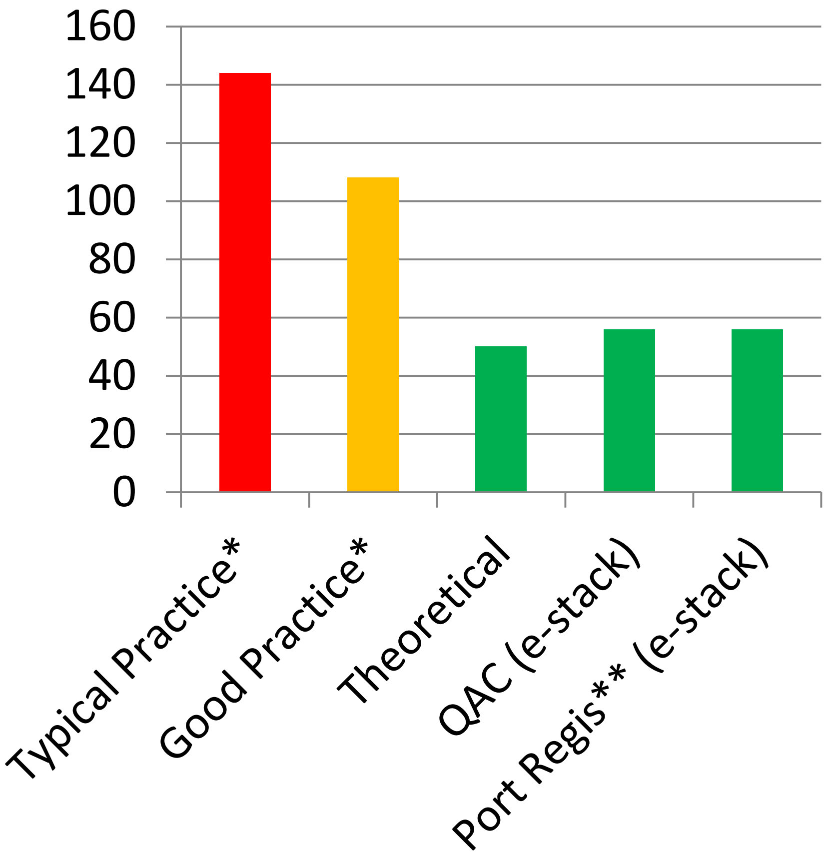
Breathing Buildings

Monkseaton School, Newcastle



Energy Savings

Fossil Fuels Energy Consumption kWh/m²/yr

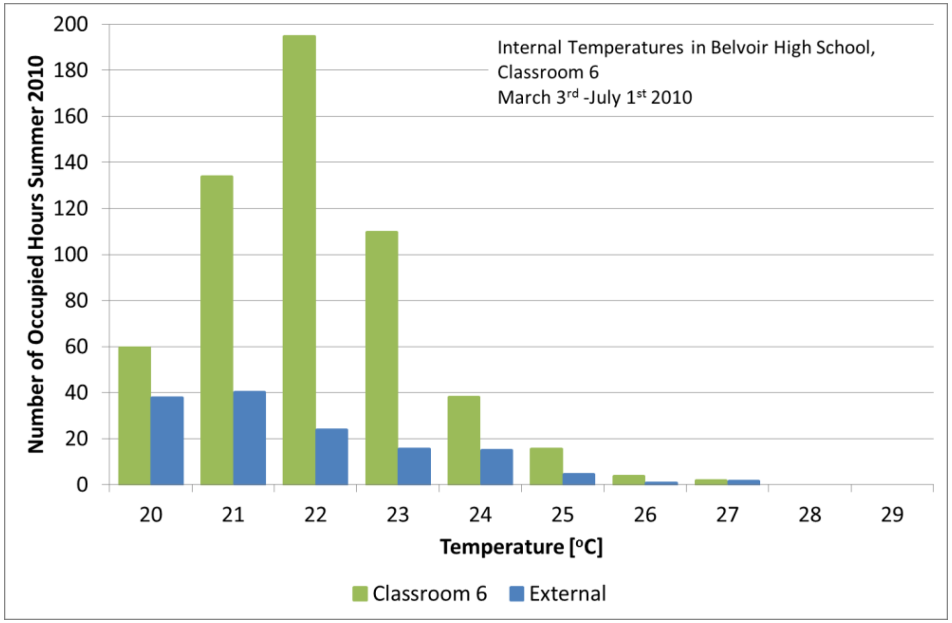


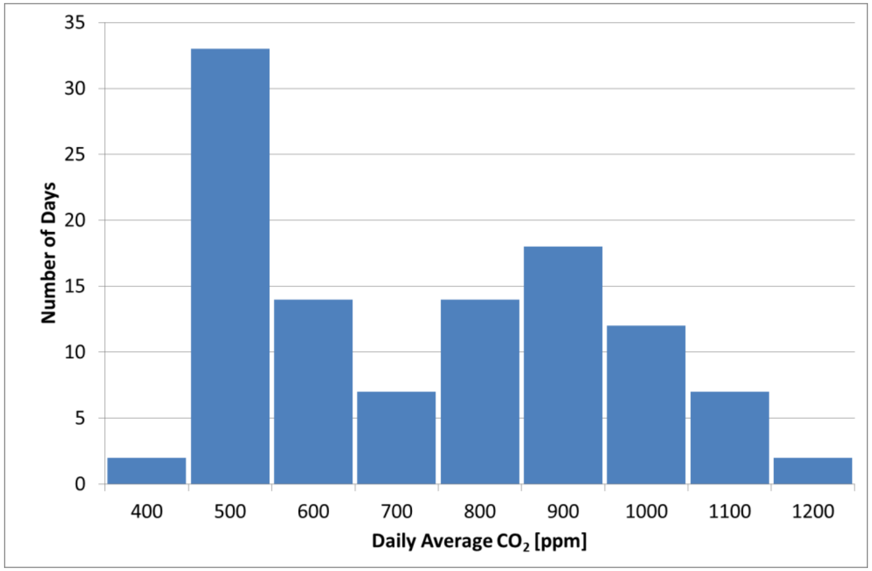
* CIBSE Guide F Table 20.1 Fossil fuel use in secondary schools
** Total energy consumption of building

QAC, Birmingham

Port Regis School

Internal Climate





The daily average CO_2 never exceeds 1500ppm

BB101 Standards

120 hours for which T_{room}>28°C

$(T_{room})_{max}$ = **32°C**

$(T_{room} - T_{external})_{max}$ = **5°C**

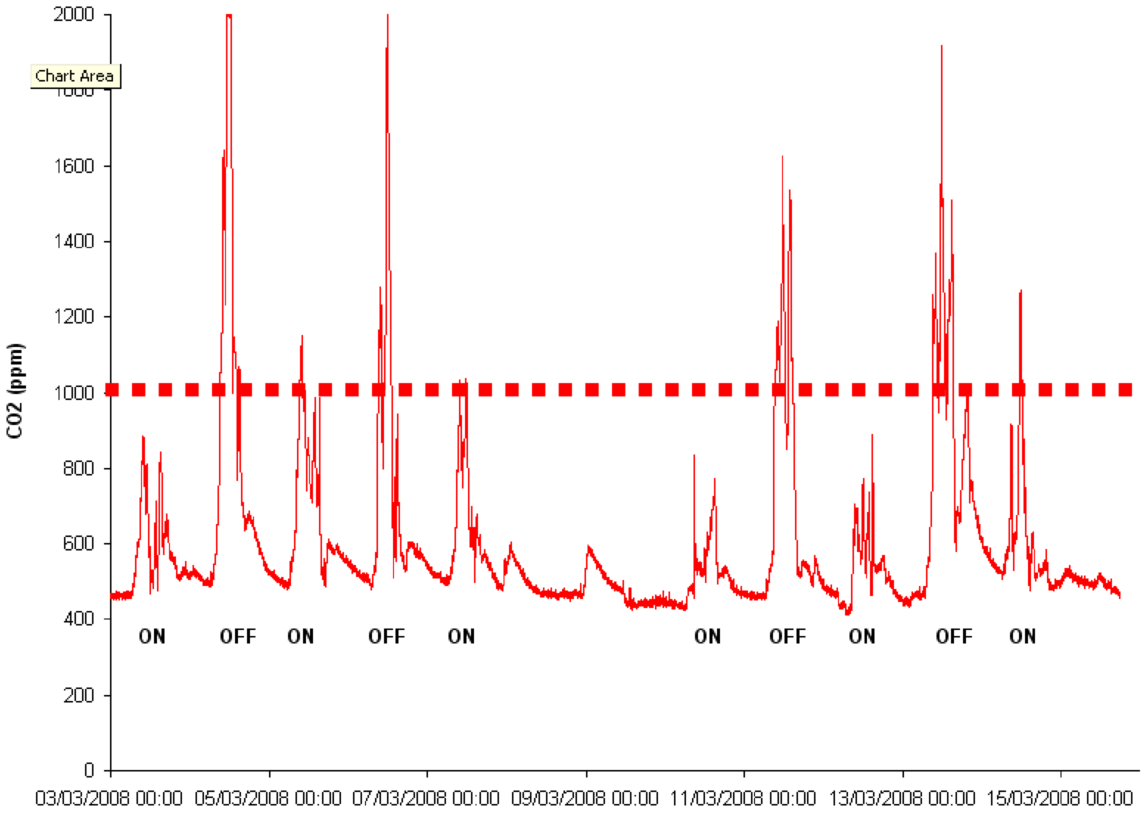
Belvoir High School

0 hours for which T_{room}>28°C

$(T_{room})_{max}$ = **27.5°C**

$(T_{room} - T_{external})_{max}$ = **2.3°C**

Internal Comfort



Harston Primary School

Before

After

Internal Comfort

Priority School Building Programme

Making sense of the new Priority School Output Specification from the Education Funding Agency. How is the output specification different from previous guidelines, how do the standard school designs meet the output specification and how Breathing Buildings can help you model the ventilation system energy use in IES.

Summary

- Natural ventilation low energy
- Design parameters
  - Vent area
  - Head
  - Thermal mass
  - Wind
- Control strategy
  - Mixing Winter
  - Displacement Summer