



Low Energy Cooling, Ventilation and Heat Recovery Systems

mathew.holloway@monodraught.com



Imperial College
London



Royal College of Art
Postgraduate Art & Design

CARBON
CONNECTIONS₂



Designs
for life

FEEL THE PLANET EARTH '08
CIFIAL DESIGN AWARD



1. The opportunity
2. Introduction of Cool Phase
3. Application of phase change materials (PCM)
4. Development of a steady state model
5. Dynamic modelling
6. Verification and case study



1) Cost



2) Environment



3) Practical



2. Introduction to Cool Phase



Reduce energy bills by up to 90%

2. Introduction to Cool Phase

- » Low service & maintenance cost
- » Meets Building Regs. & BREAM
- » Improves indoor air quality
- » No requirement for external units
- » Modular, scalable & adaptable
- » Uses no toxic coolants, e.g. R22



PARAFFIN:



Advantages:

- Stable
- Encapsulation
- Super cooling

Disadvantages:

- Expensive
- Flammable
- Thermal conductivity

SALT HYDRATES:



Advantages:

- Cost
- Energy density
- Sustainable

Disadvantages:

- Corrosive (plastic & metals)
- Thermal conductivity
- Segregation

3. Application of PCMs

- Easy to retrofit, intelligent thermal mass
- 1kg of Phase Change Material (PCM) ~ 200kg of Concrete
- Actively dissipates heat built up during the day



1. Creation of a Design Tool

- Model of basic heat exchangers
- Simple environmental model
- Simple phase change temperature

Heating/Cooling System using a Phase Change Material

Simplified Room Model

Width of N/S walls	2.2	m
Width of E/W walls	10.5	m
Room Height	3.5	m
Window width	1	m
Window height	3	m

Wall thickness: 12 inches
Window glazing: Double
Room Area: 23.1 m²
Month of year: August
Window blinds: Off

Number of Occupants: 33
Number of Computers: 0
Solar Heating Load: On
Artica PCM Cooling: On
% external air supply: 10

	From	To
Number of Occupants	10.00	16.00
Number of Computers	8.30	16.30

Percentage external air when Toutside > Troo

Local Air Conditions

Time of Peak Temp	15.00	24 hours
Maximum Air Temp	28	degC
Minimum Air Temp	15	degC
Average Air temp	21.5	degC
Temperature variation	Sinusoidal	

Building External

Time of Peak Temp	15.00	24 hours
Maximum Air Temp	30.375	degC
Minimum Air Temp	20.625	degC
Average Air temp	25.5	degC
Temperature variation	Sinusoidal	

Building Internal

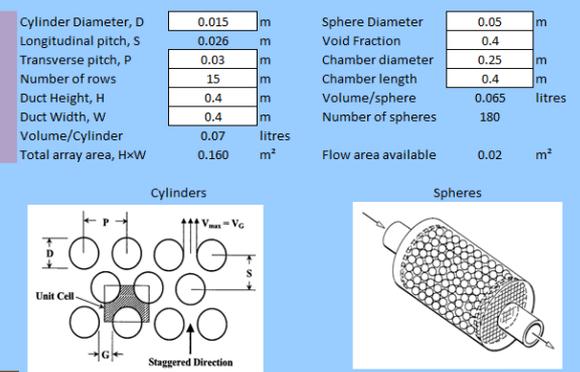
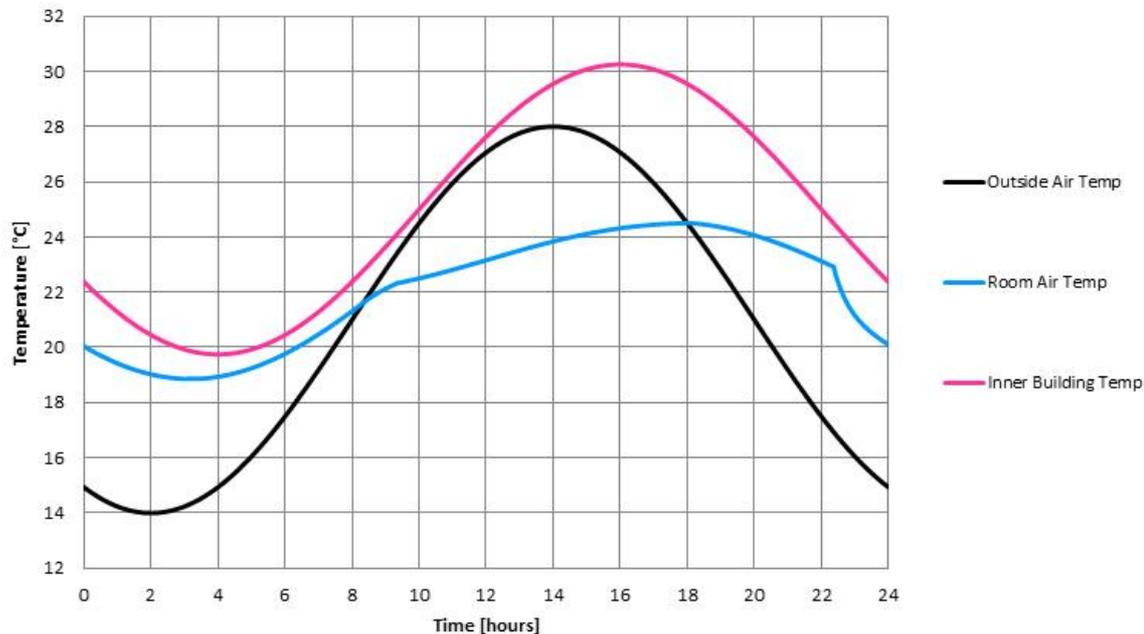
Time of Peak Temp	15.00	24 hours
Maximum Air Temp	30.375	degC
Minimum Air Temp	20.625	degC
Average Air temp	25.5	degC
Temperature variation	Adiabatic	
PCM Module	On	

Component Geometry

PCM Module

Cylinder Diameter, D	0.015	m
Longitudinal pitch, S	0.026	m
Transverse pitch, P	0.03	m
Number of rows	15	
Duct Height, H	0.4	m
Duct Width, W	0.4	m
Volume/Cylinder	0.07	litres
Total array area, HxW	0.160	m ²

Sphere Diameter	0.05	m
Void Fraction	0.4	
Chamber diameter	0.25	m
Chamber length	0.4	m
Volume/sphere	0.065	litres
Number of spheres	180	
Flow area available	0.02	m ²

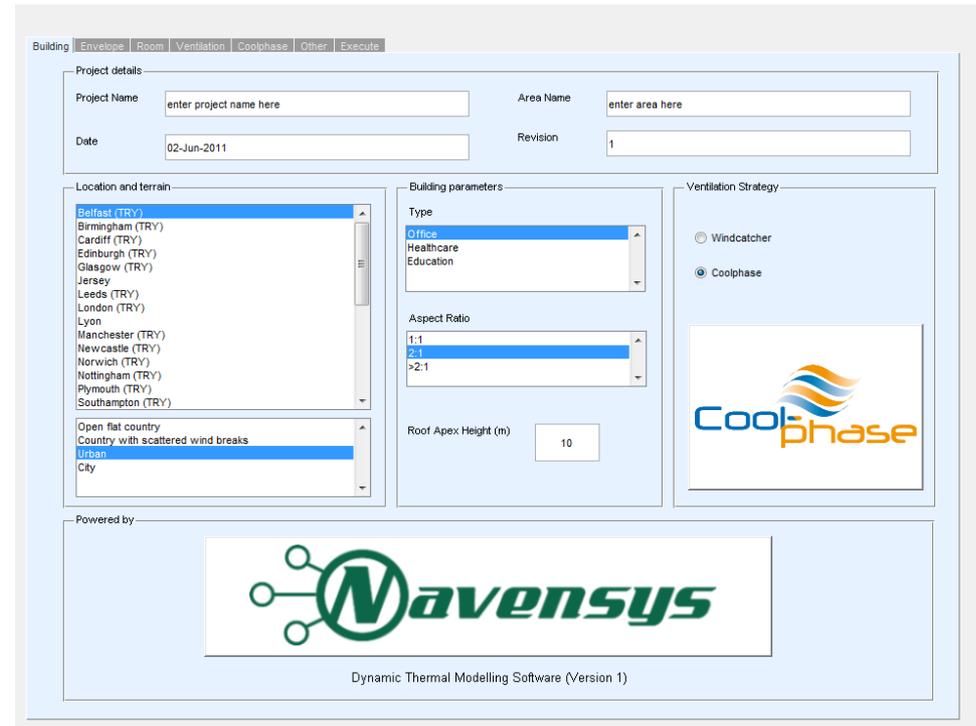


1. Creation of a Design Tool

- Model of basic heat exchangers
- Simple environmental model
- Simple phase change temperature

2. Creation of a Specification Tool

- Incorporation into Navensys
- Improved PCM model
- Improved HE model
- Comparison to CFD

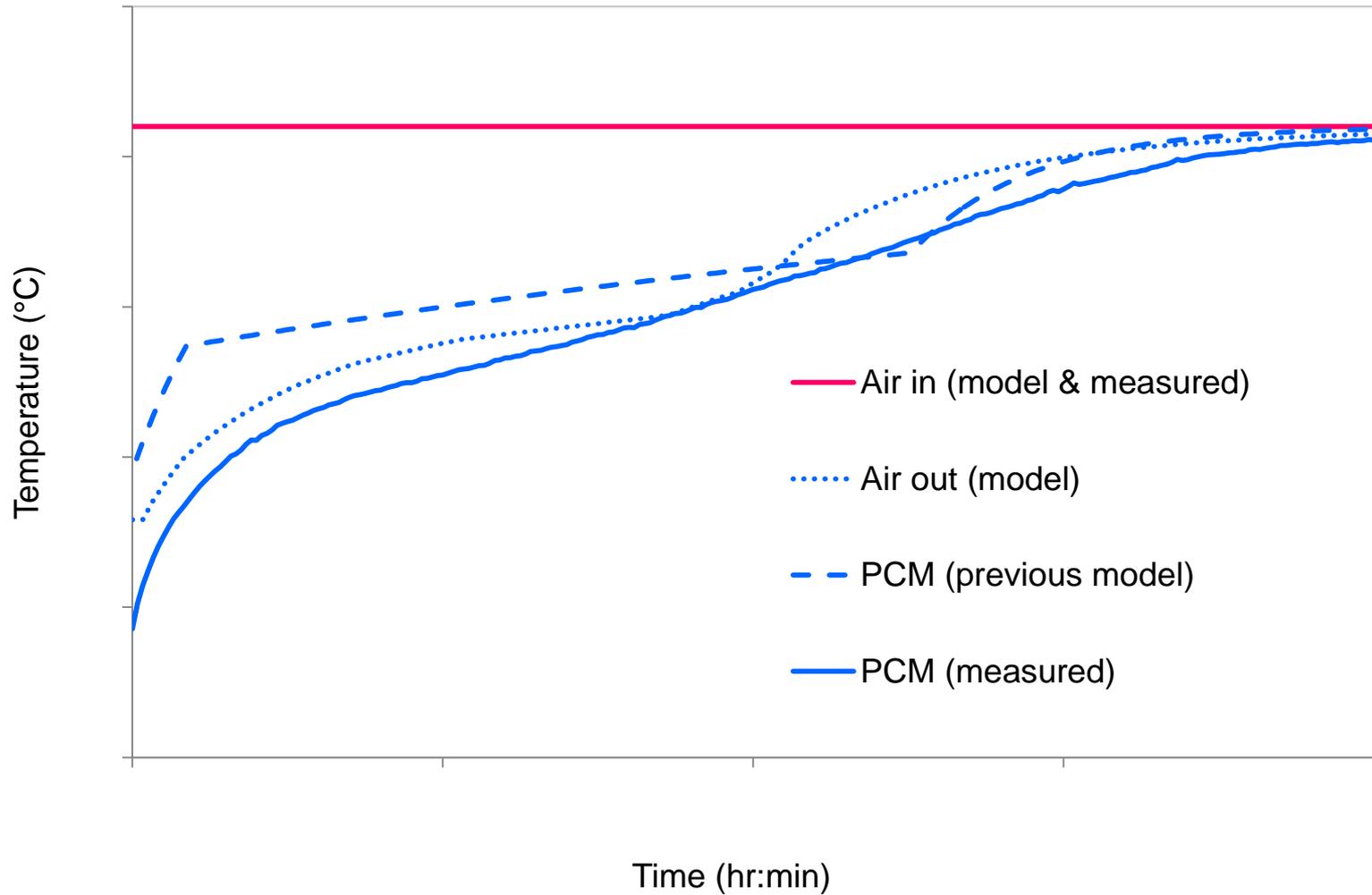


The screenshot displays the Coolphase software interface, which is a dynamic thermal modelling tool. The interface is organized into several sections:

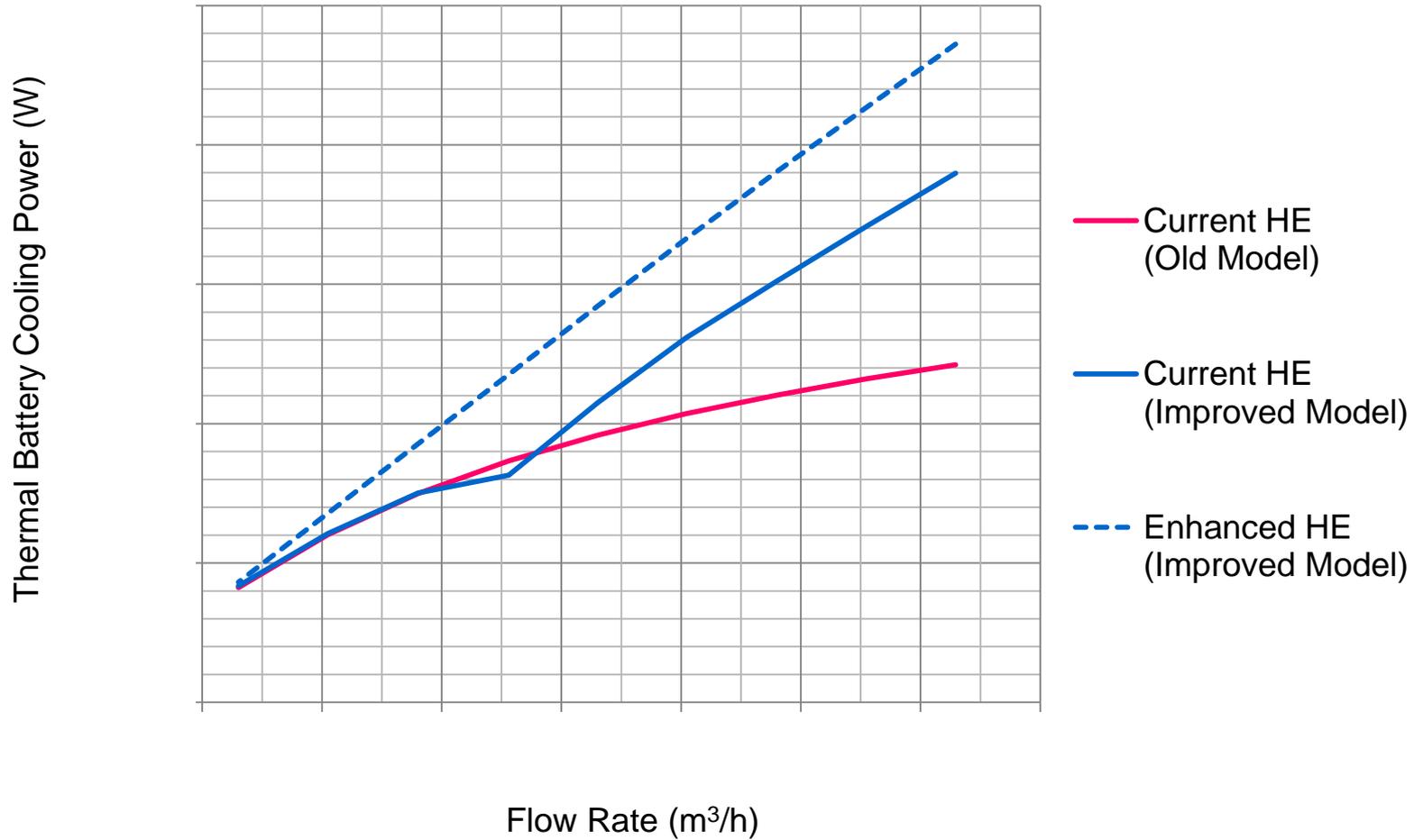
- Project details:** Includes fields for Project Name (placeholder: "enter project name here"), Area Name (placeholder: "enter area here"), Date (02-Jun-2011), and Revision (1).
- Location and terrain:** A list of locations with a scroll bar, including Belfast (TRY), Birmingham (TRY), Cardiff (TRY), Edinburgh (TRY), Glasgow (TRY), Jersey, Leeds (TRY), London (TRY), Lyon, Manchester (TRY), Newcastle (TRY), Norwich (TRY), Nottingham (TRY), Plymouth (TRY), and Southampton (TRY). Below this list are options for "Open flat country", "Country with scattered wind breaks", "Urban", and "City".
- Building parameters:** Includes a "Type" dropdown menu with options "Office", "Healthcare", and "Education"; an "Aspect Ratio" dropdown menu with options "1:1", "2:1", and ">2:1"; and a "Roof Apex Height (m)" input field with the value "10".
- Ventilation Strategy:** Features two radio buttons: "Windcatcher" and "Coolphase", with "Coolphase" selected.
- Powered by:** A section at the bottom featuring the Navensys logo and the text "Dynamic Thermal Modelling Software (Version 1)".

The interface also includes a menu bar at the top with options: Building, Envelope, Room, Ventilation, Coolphase, Other, and Execute.

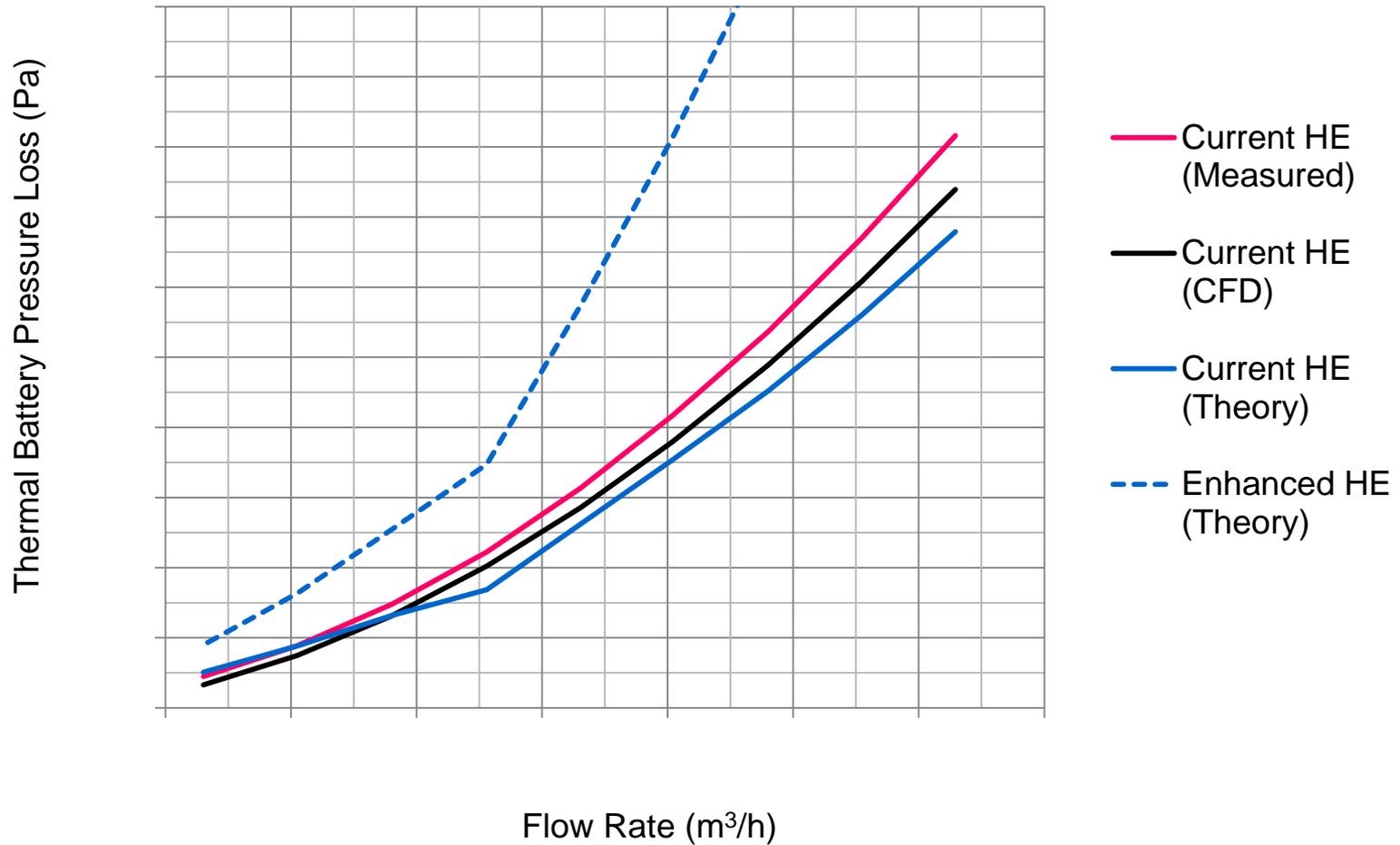
4. Development of a steady state model



4. Development of a steady state model

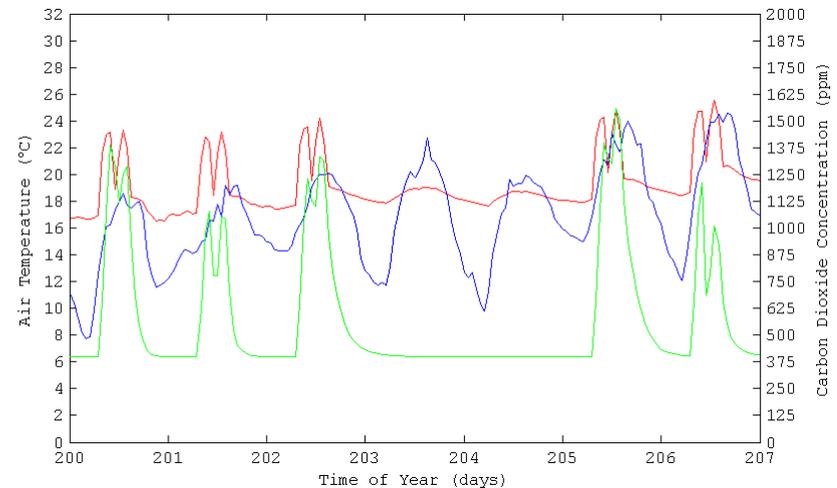


4. Development of a steady state model



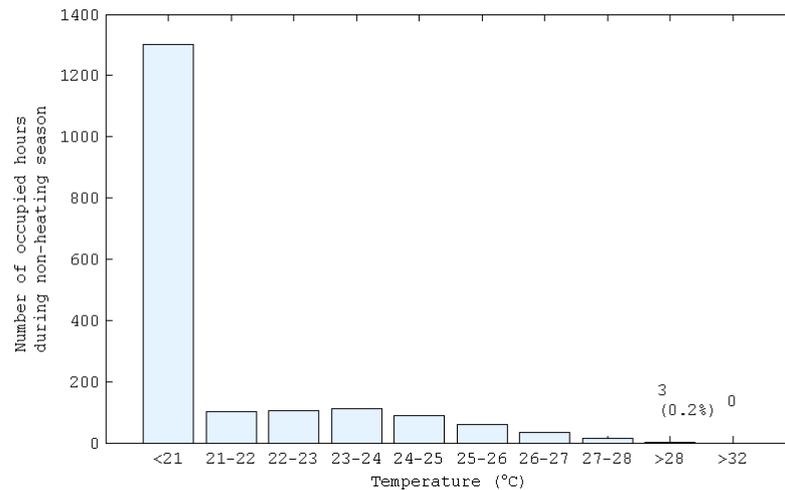
1. Creation of a Design Tool

- Model of basic heat exchangers
- Simple environmental model
- Simple phase change temperature



2. Creation of a Specification Tool

- Incorporation into Navensys
- Improved PCM model
- Improved HE model
- Comparison to CFD

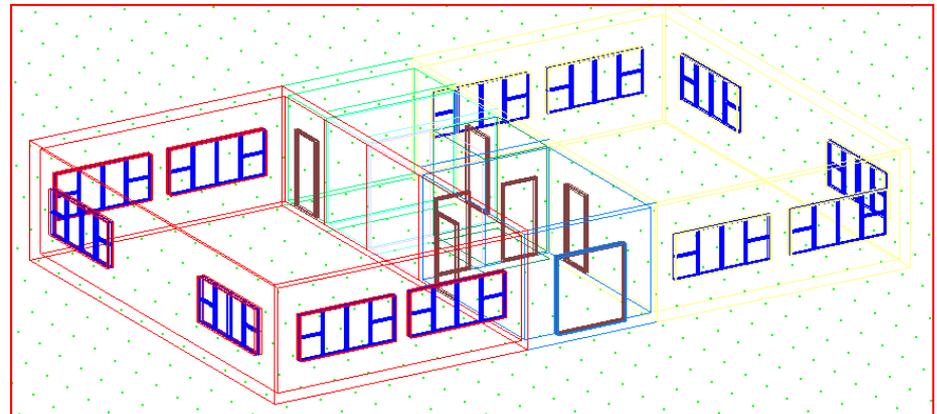
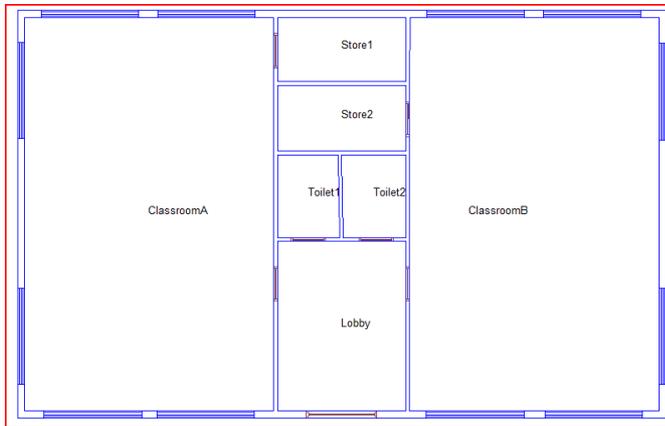
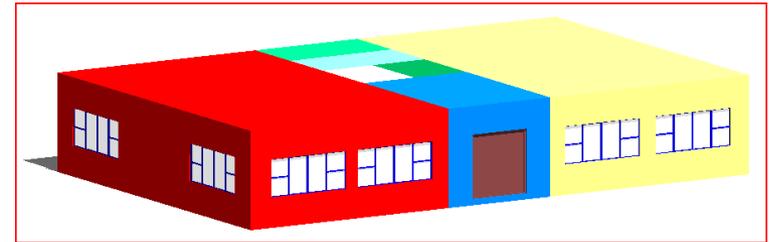


- Detailed modelling using analytical and numerical techniques
- Based on proven results and testing in the lab and on site

Allows creation of '**macro performance parameters**'

Therefore you can model the system more easily...

... and complex models are not needed every time a room simulation is run



Macro performance parameters:

- Relationships of system performance to variables, e.g. external temperature, CO2...
- These variables can be used to control the performance of the system
- Simple physical and engineering relationships allow any system to be simulated
- System performance abstracted and reduced to 'formula profiles' in IES or control functions in TAS

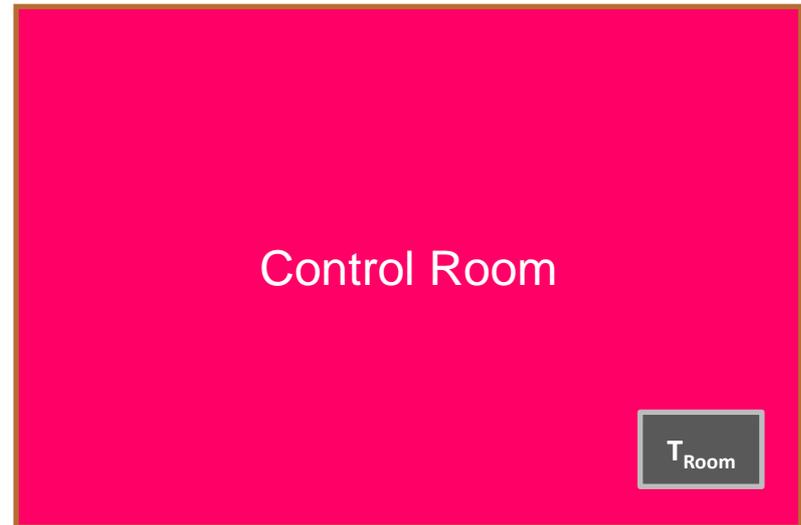
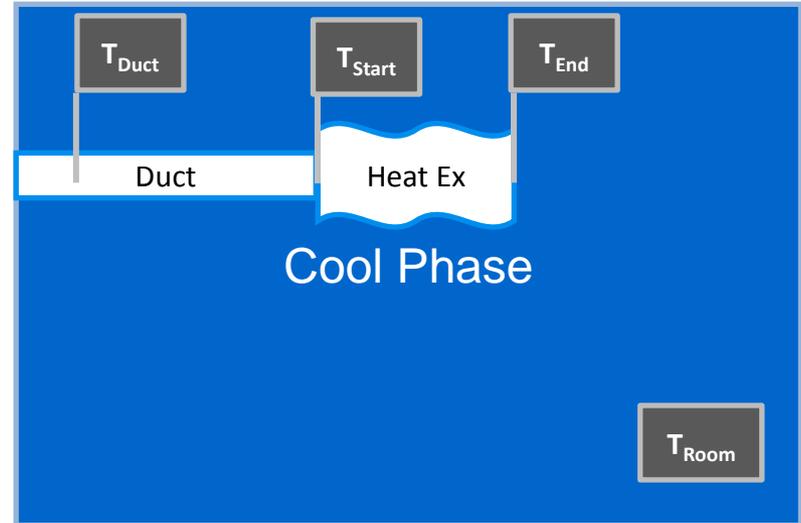
For example:

- On a very basic level we can use 'building heat gain' to charge and provide cooling
- Complexity can be added through the effects of internal temp, CO2, fan speed...
- By combining simple rules an accurate model and control strategy can be built up for a complex system.

External	Internal	Cooling	Cum. Cooling
26.5	30	0	0
28.8	25	4083.75	4083.75
30	25	3618.19	7701.94
30.7	25	3908.73	11610.67
31.6	25	4079.65	15690.32
31.8	30..	279.3	16000

Verification

- Data logging
- Lab tests
- Comparison to other systems



Workspace PLC:

- ~ 125 properties within M25
- ~ 700,000 m2 rentable floor space
- Serviced offices and light industrial units
- 'Secondary' locations
- £70m turnover (2009)

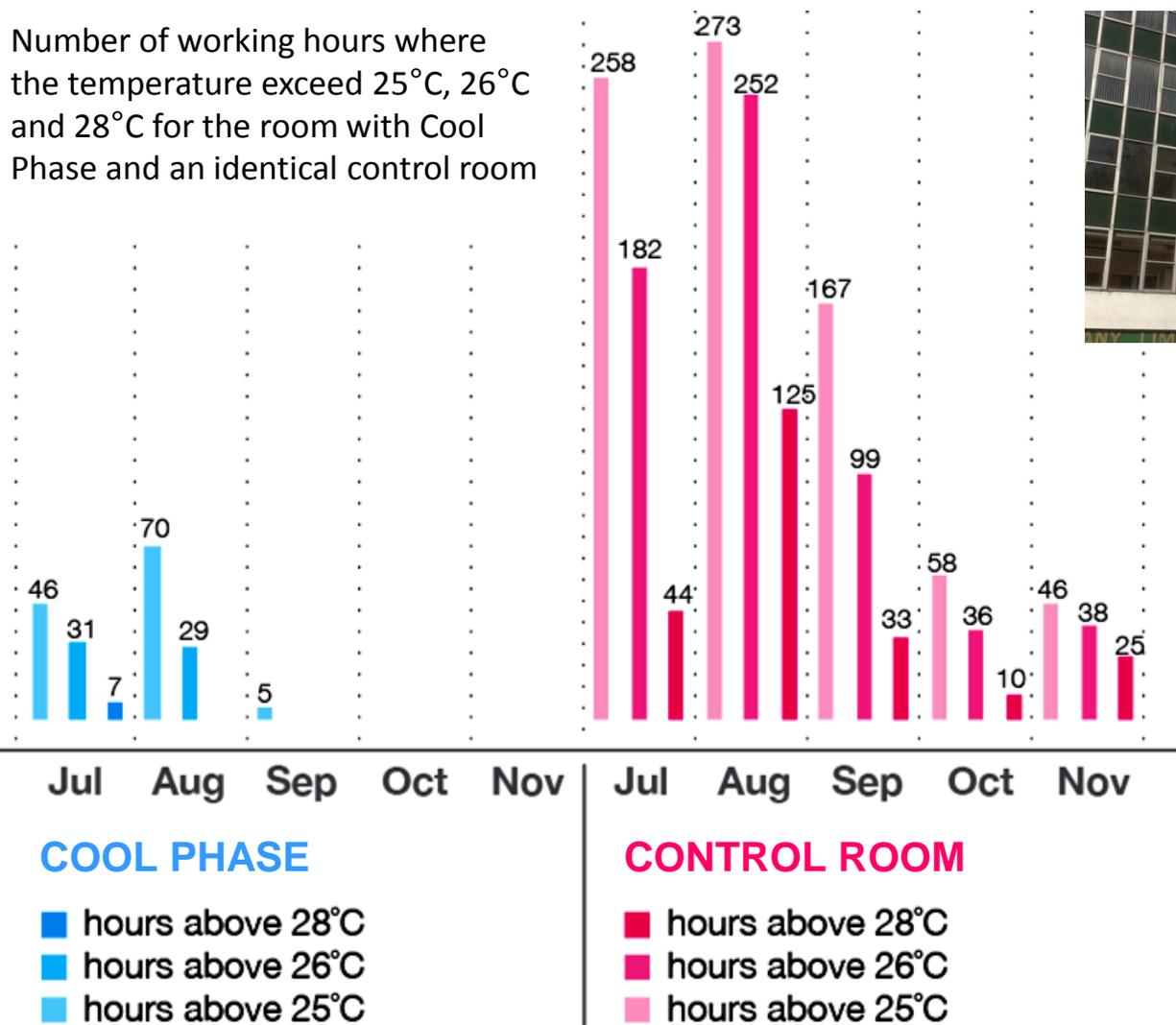


Workspace Group

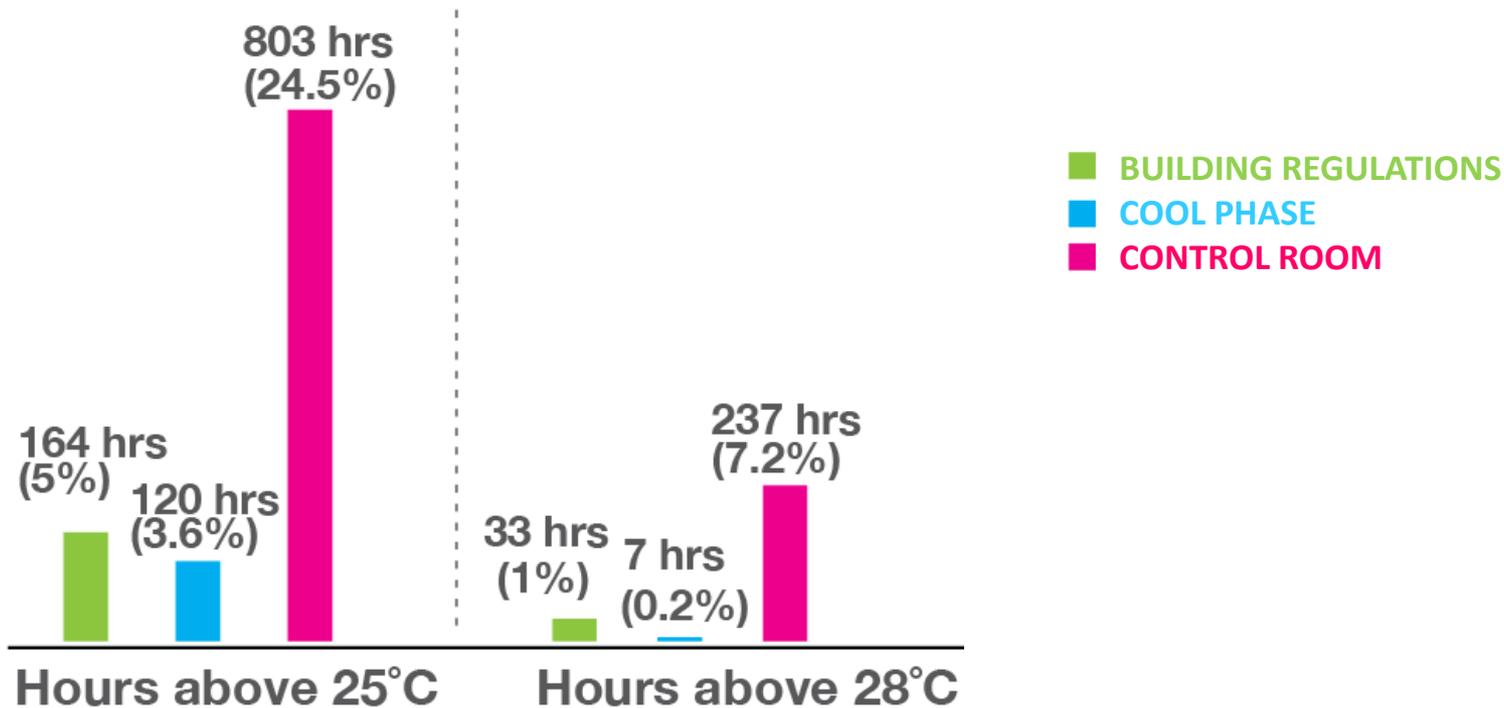


6. Workspace case study

Number of working hours where the temperature exceeded 25°C, 26°C and 28°C for the room with Cool Phase and an identical control room



6. Workspace case study



- The peak summer temperatures were reduced by an average of 5°C
- Energy usage was reduced by **86%** over 6 months
- Air quality was noticeably improved

1. The opportunity
2. Introduction of Cool Phase
3. Application of phase change materials (PCM)
4. Development of a steady state model
5. Dynamic modelling
6. Verification and case study



Low Energy Cooling, Ventilation and Heat Recovery Systems

mathew.holloway@monodraught.com



Imperial College
London



Royal College of Art
Postgraduate Art & Design

CARBON
CONNECTIONS
2



Designs
for life

FEEL THE PLANET EARTH '08
CIFIAL DESIGN AWARD

THE GOOD
ENTREPRENEUR
ONE IDEA TO CHANGE THE WORLD

