nZero.2020 / multiple perspectives

Operation and performance

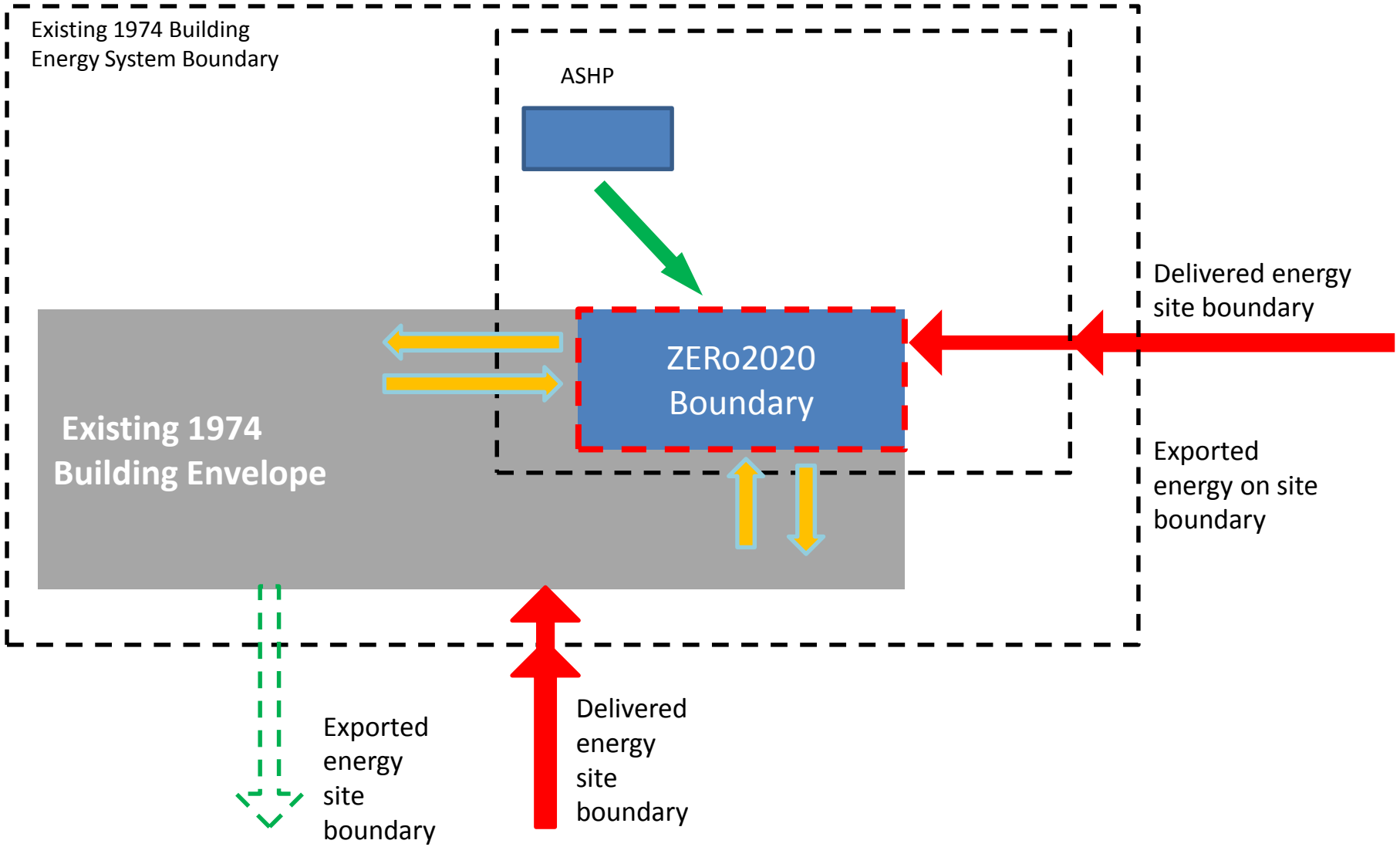
Paul D O'Sullivan / MeSSO //STL 2015 // Architecture Factory

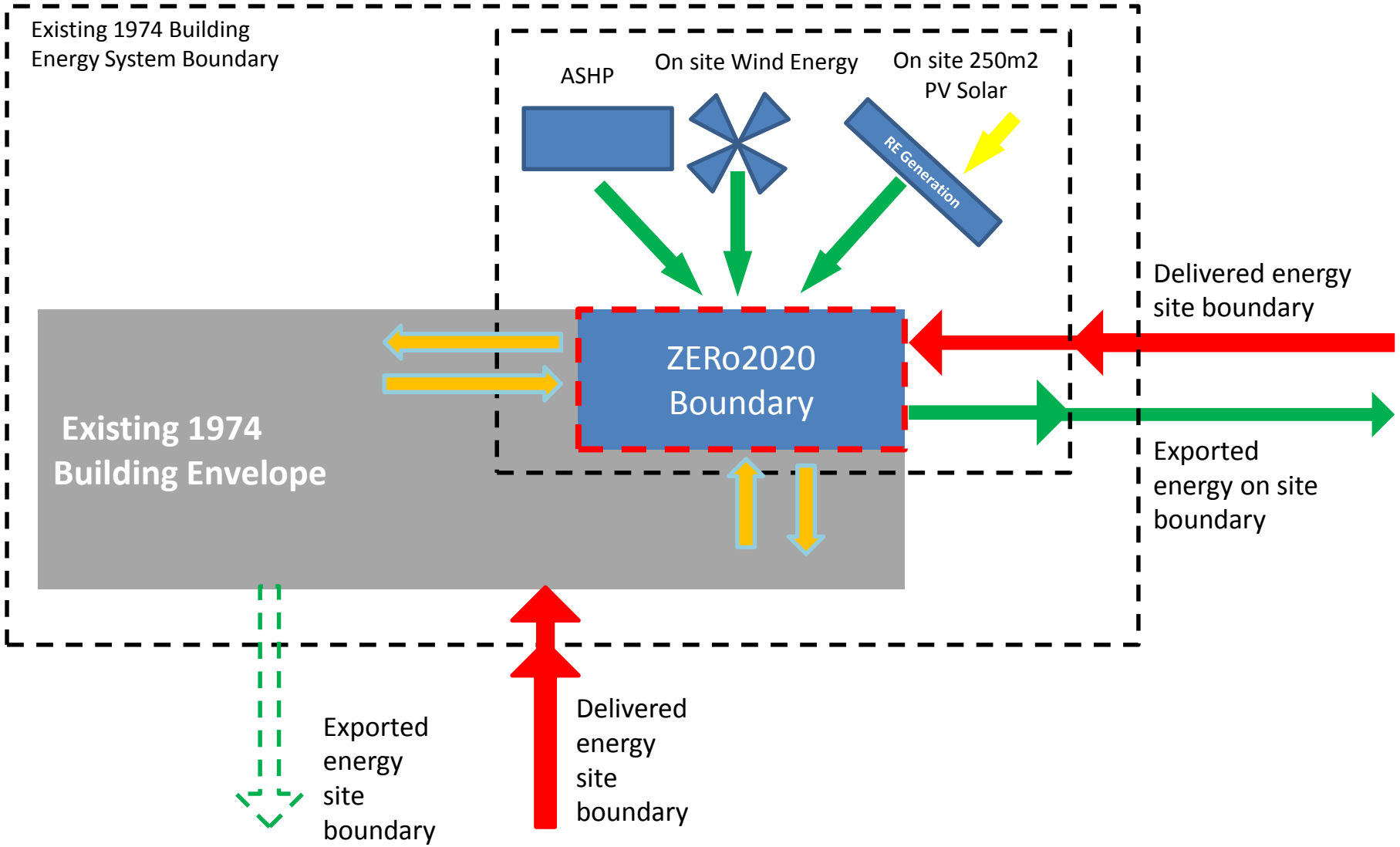
nZero.2020 / features & performance

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Agenda

1. Features
2. Asset rating & PHPP
3. Energy end use performance 2013
4. PHPP vs. measured data
5. Ventilation strategy
6. Long term indoor air temperatures 2013 & 2015
7. Thermal comfort evaluation
8. What are we learning...


Existing 1974 Building
Energy System Boundary
ASHP
ZERo2020
Boundary
Existing 1974
Building Envelope
Delivered energy
site boundary
Exported
energy on site
boundary
Exported
energy
site
boundary
Delivered
energy
site
boundary


Existing 1974 Building
Energy System Boundary
ASHP
On site Wind Energy
On site 250m2
PV Solar
RE Generation
Delivered energy
site boundary
ZERo2020
Boundary
Existing 1974
Building Envelope
Exported
energy on site
boundary
Exported
energy
site
boundary
Delivered
energy
site
boundary

nZero.2020 / testbed features

20kWp PV Installation with 1kW wind turbine and Micro Grid

nZero.2020 / testbed features

20kW dimplex dual compressor air source heat pump

nZero.2020 / testbed features

manual & automated purpose provided
ventilation openings with insulated doors

nZero.2020 / testbed features

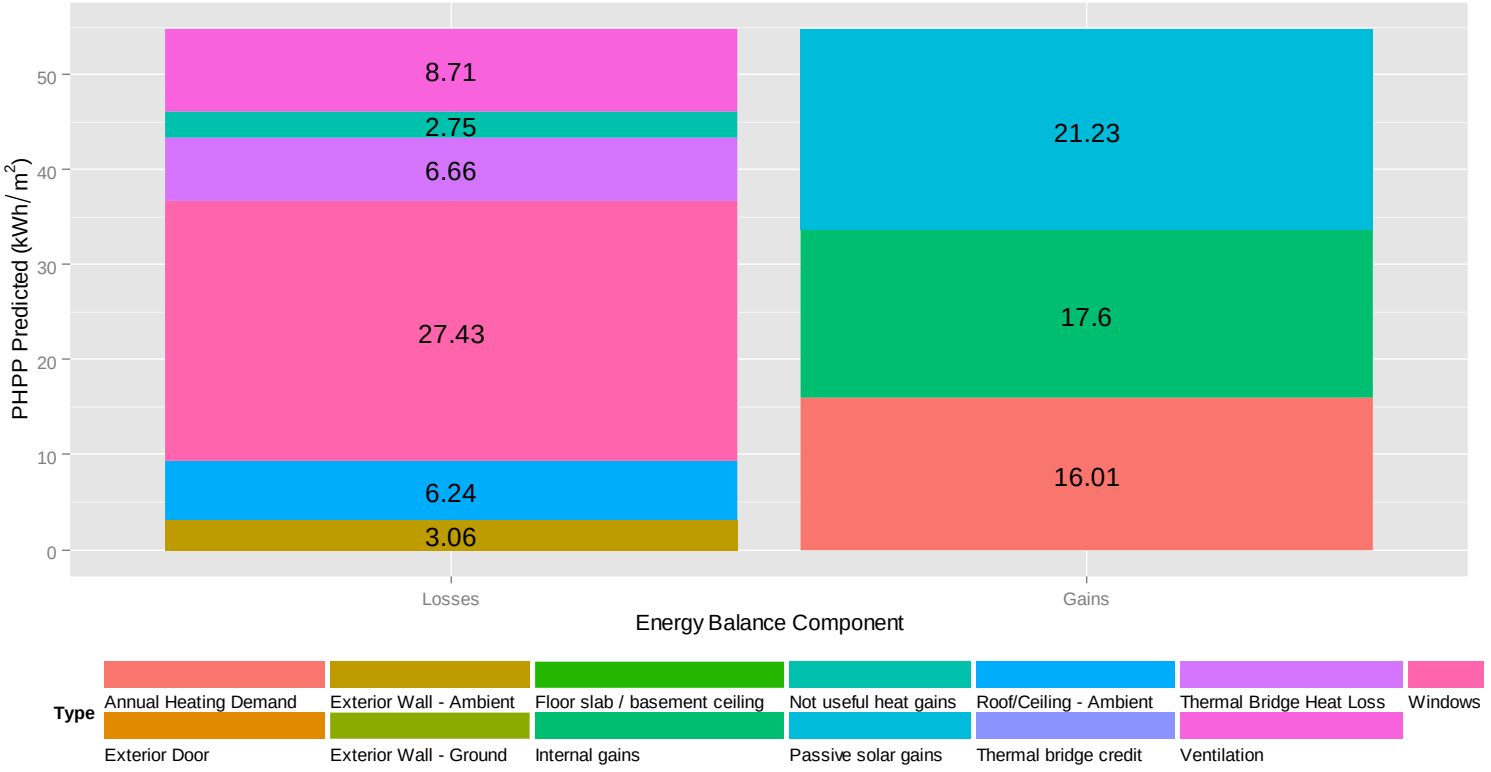
wireless Hanwell radio frequency based data logging system

Energy Performance

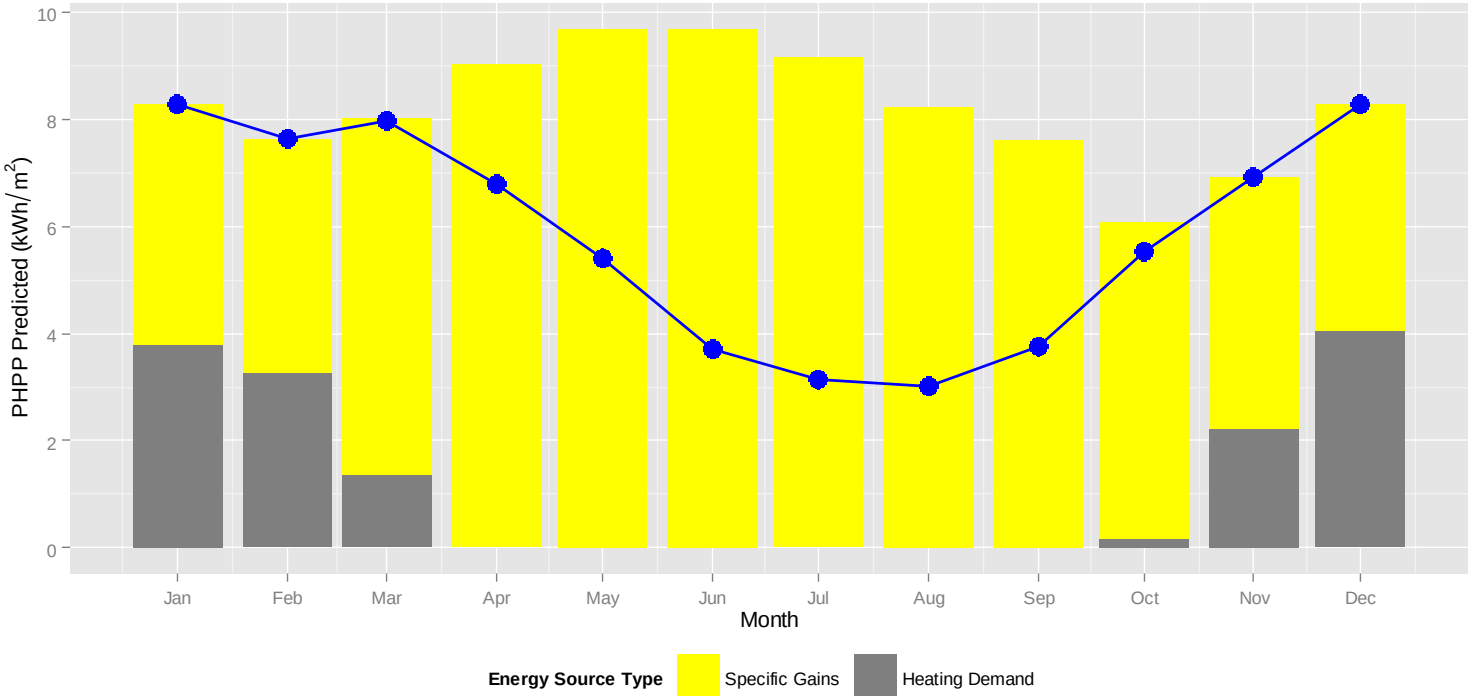
How does the zero2020 retrofit solution compare with the existing building on an equivalence basis?

Building	Heating ($kWh/m^2/yr$)	Lighting ($kWh/m^2/yr$)	Auxiliary ($kWh/m^2/yr$)	Hot Water ($kWh/m^2/yr$)	Total ($kWh/m^2/yr$)
1974	386.83	46.43	3.24	16.4	452.57
Zero2020	14.25	45.47	1.91	2.51	64.14

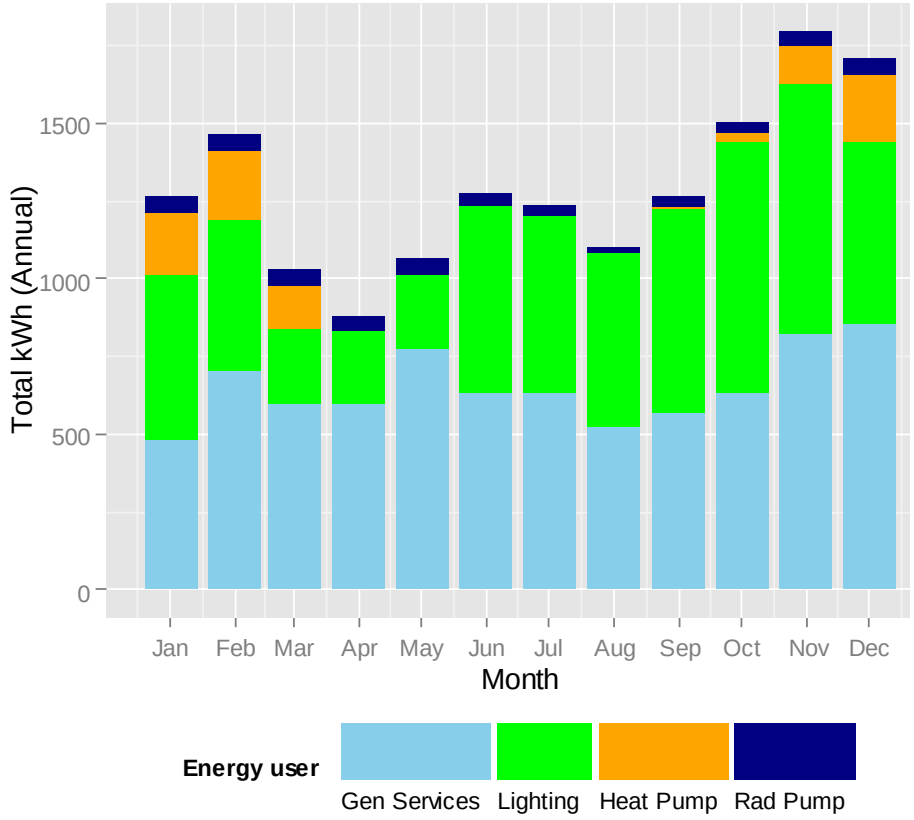
A PHPP model has been developed to investigate how the various losses & gains contribute to the reduction in heating demand

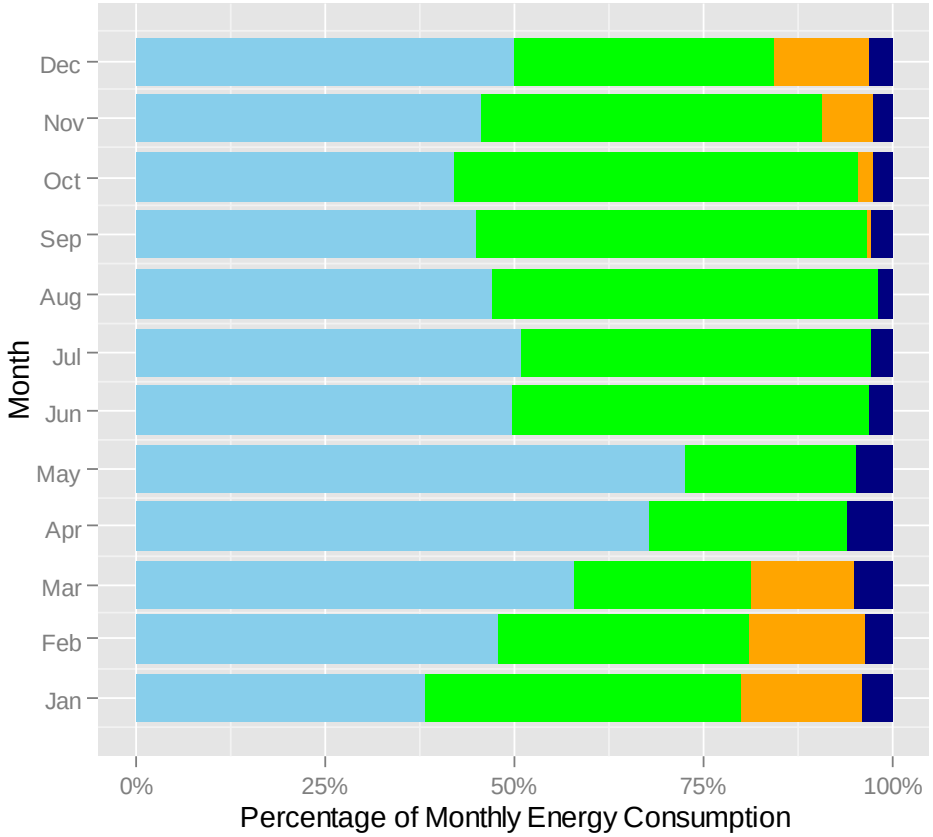


PHPP model shows a high solar gain contribution throughout the extended cooling season

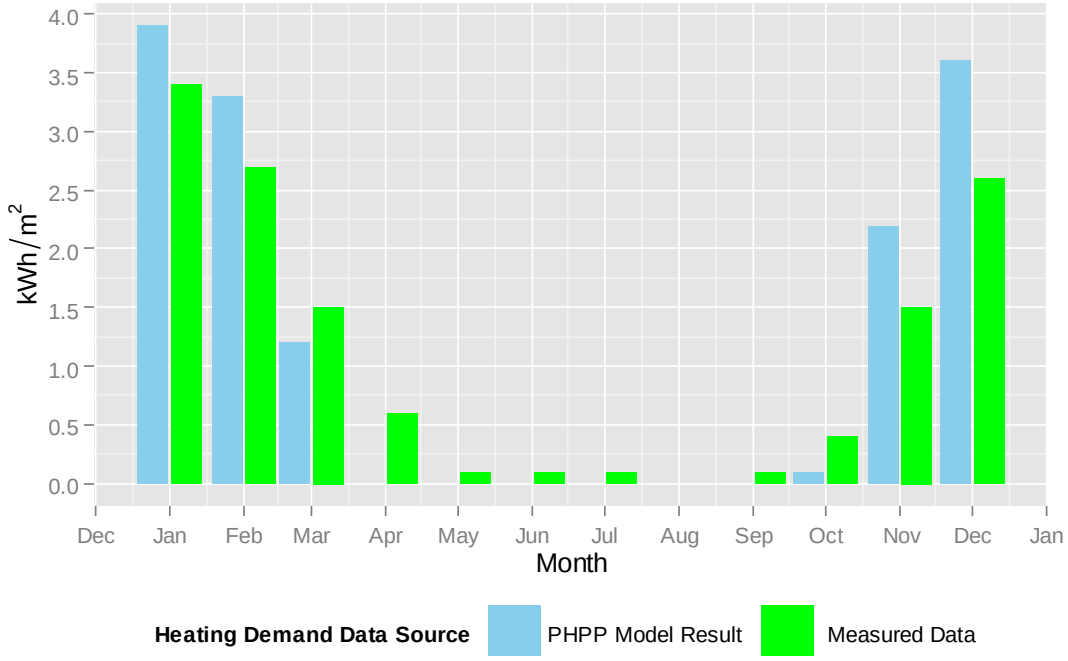


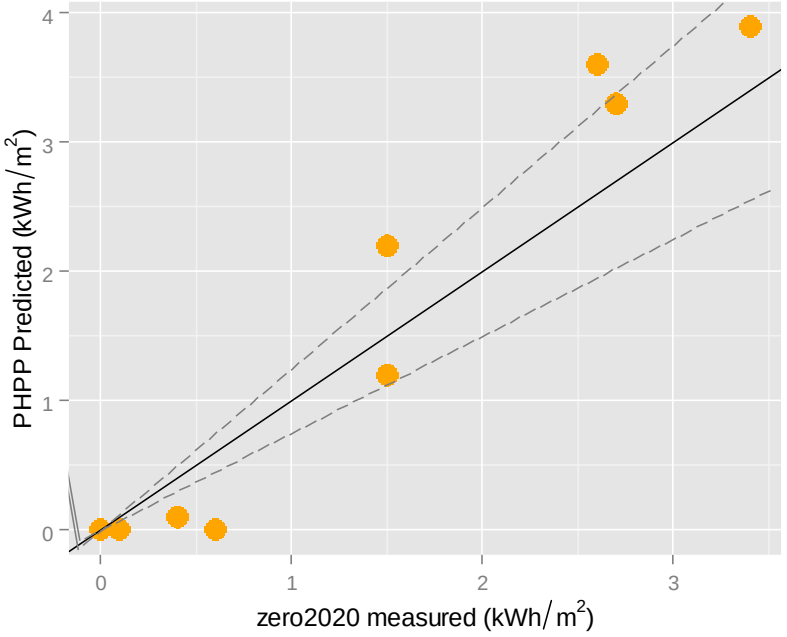
2013 Monthly Totalised Energy Consumption per end use





2013 Monthly Totalised Energy Consumption per end use





nZero.2020 / PHPP Prediction Performance

2013 z2020 Delivered Heating Energy = 13.3 kWh/m^2 annual

2013 PHPP Delivered Heating Energy = 14.7 kWh/m^2 annual

Specific building demands with reference to the treated floor area — use: Monthly method

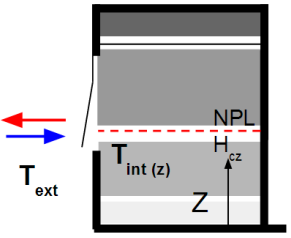
				Requirements	Fulfilled?*
	Treated floor area	222.5	m^2		
Space heating	Annual heating demand	**14**	**kWh/(m^{2}a)**	25 kWh/(m²a)	**yes**
	Heating load	**25**	**W/m^2**	-	**-**
Space cooling	Overall specific space cooling demand		**kWh/(m^{2}a)**	-	**-**
	Cooling load		**W/m^2**	-	**-**
	Frequency of overheating (> 25 °C)	0.0	%	-	**-**
Primary Energy	Space heating and cooling, dehumidification, household electricity.		**kWh/(m^{2}a)**	120 kWh/(m²a)	
	DHW, space heating and auxiliary electricity		kWh/(m^{2}a)	-	**-**
	Specific primary energy reduction through solar electricity	0	kWh/(m^{2}a)	-	**-**
Airtightness	Pressurization test result n_{50}	**1.6**	**1/h**	1 1/h	**no**

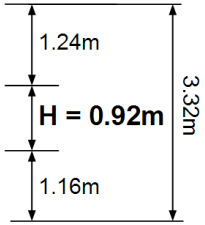
* empty field: data missing; '-': no requirement

Single Sided Natural Ventilation Rates

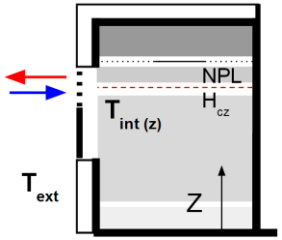
Manual & Automated Ventilation Configurations

CS.01

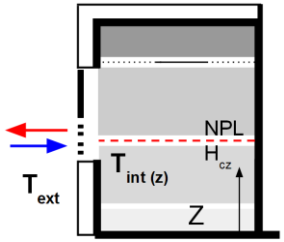




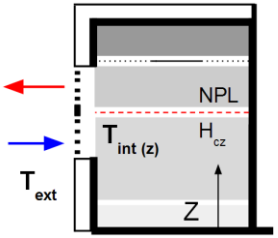
RS.02

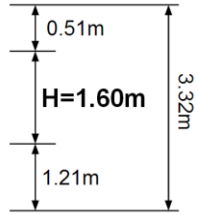


RS.03

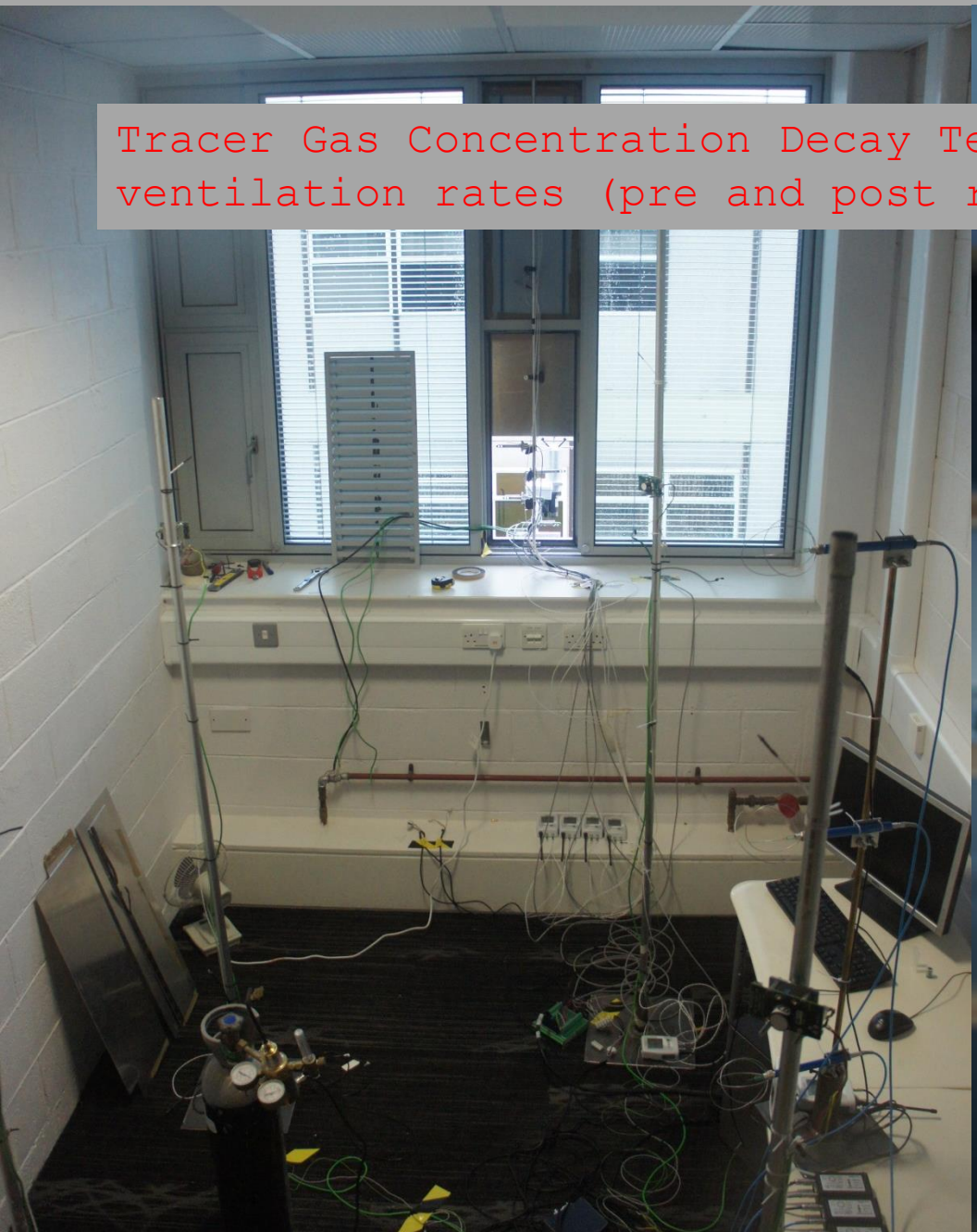


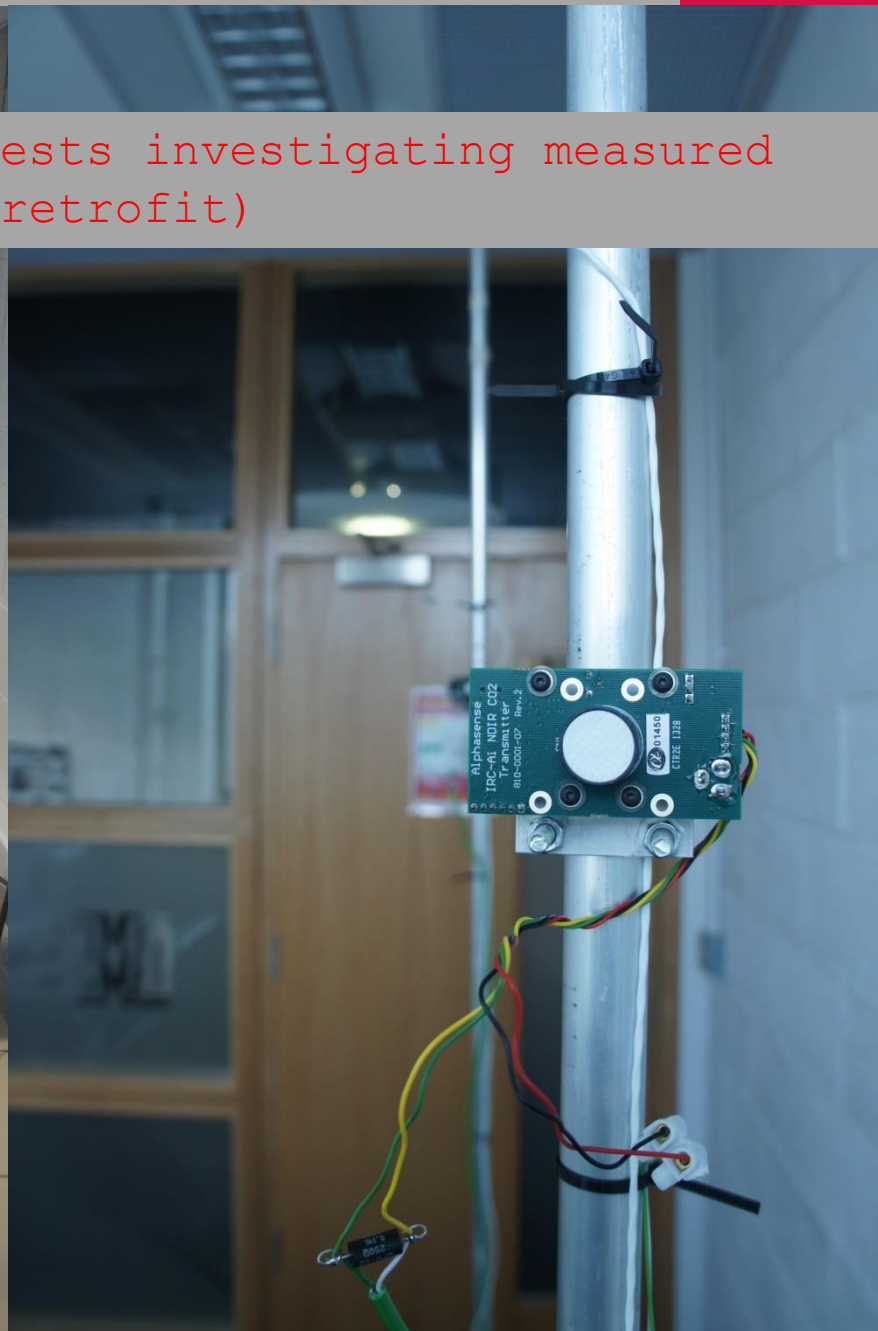
RS.04



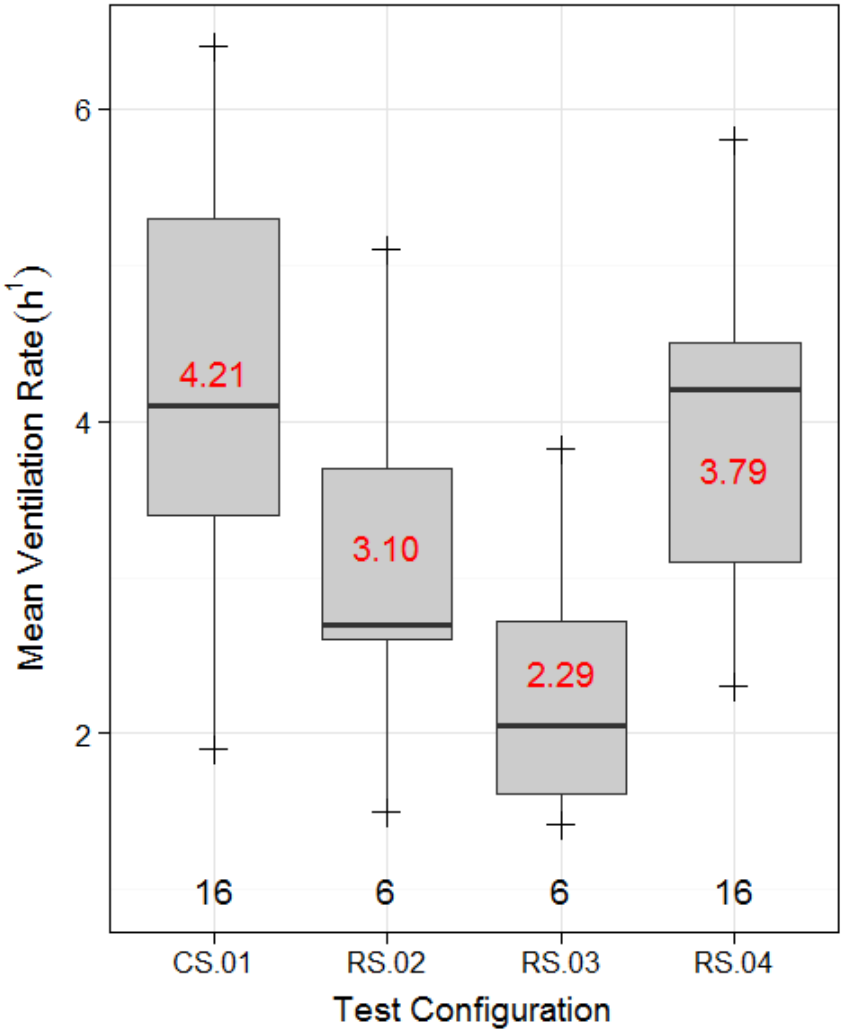


Tracer Gas Concentration Decay Tests investigating measured ventilation rates (pre and post retrofit)



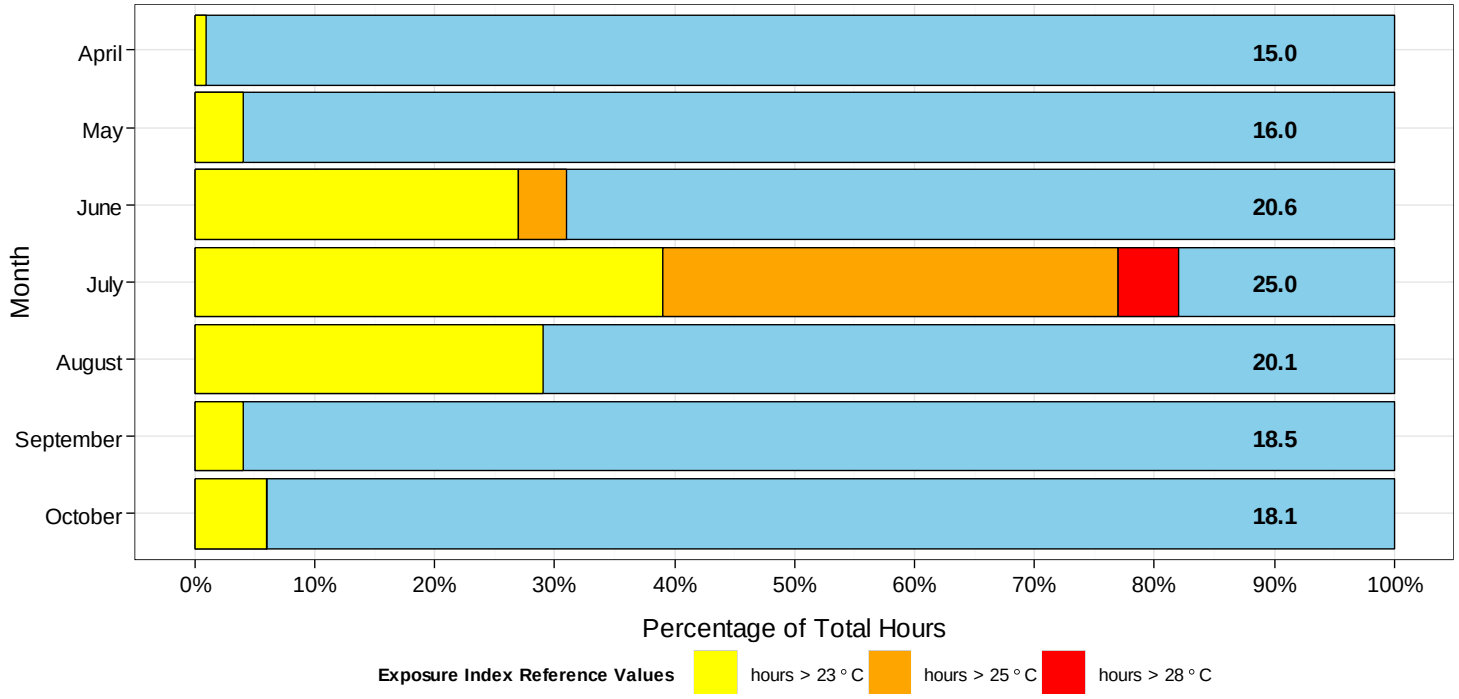


Boxplot distributions of Single Sided ventilation ACH according to configurations

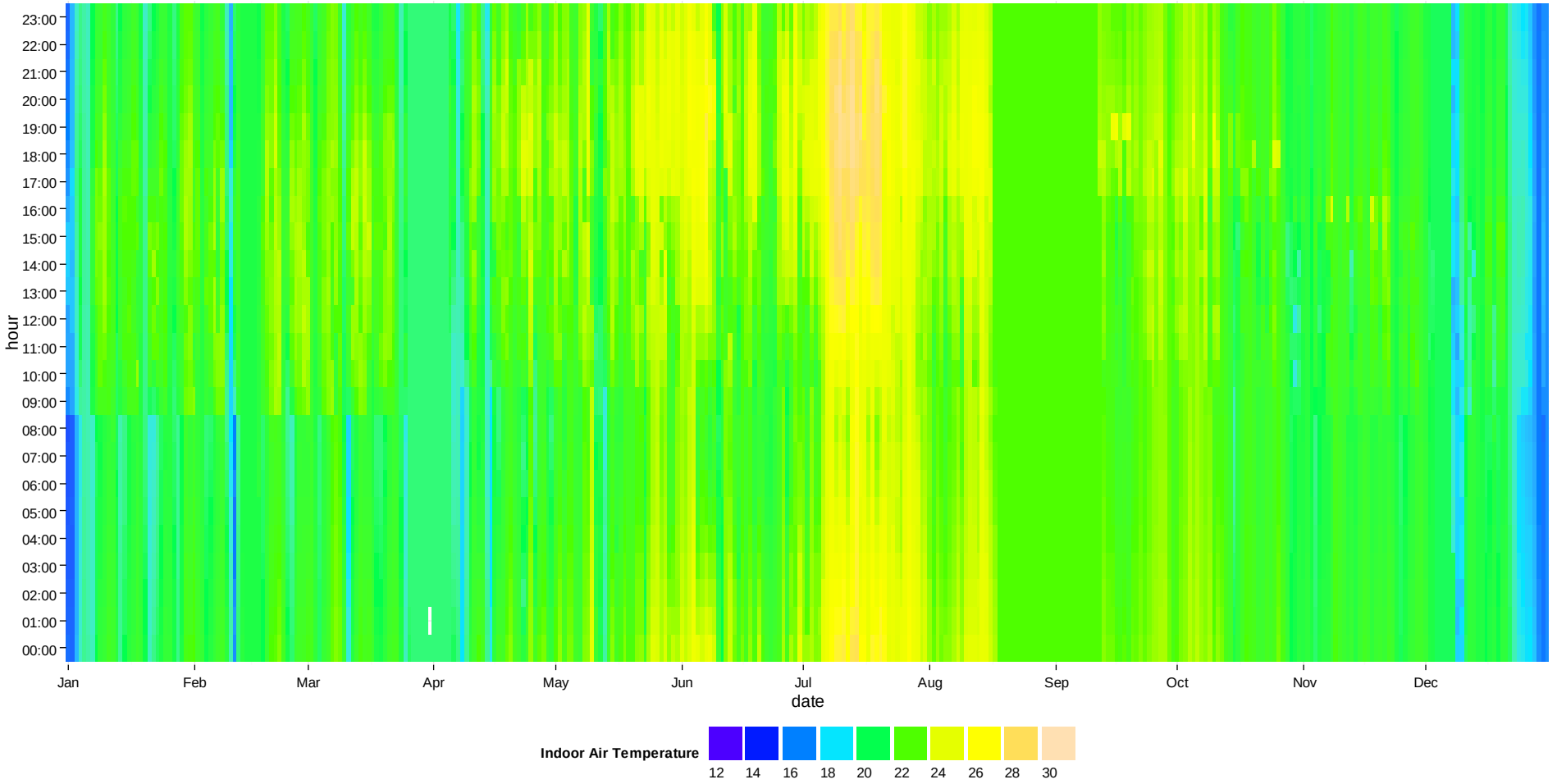


Indoor Air Temperature & Overheating Risk

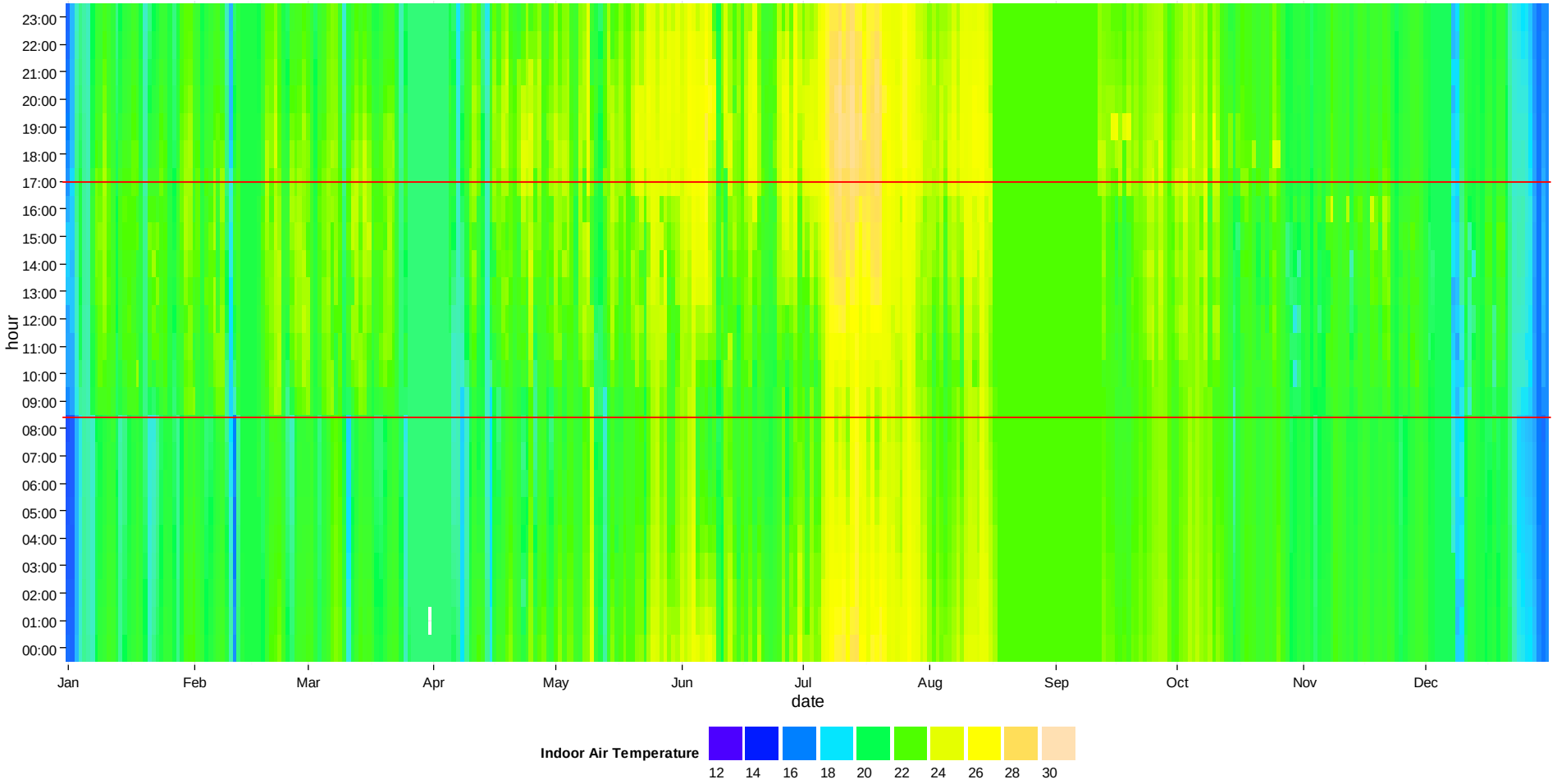
% of Total Monthly Hours for Indoor Air Temperature 2013



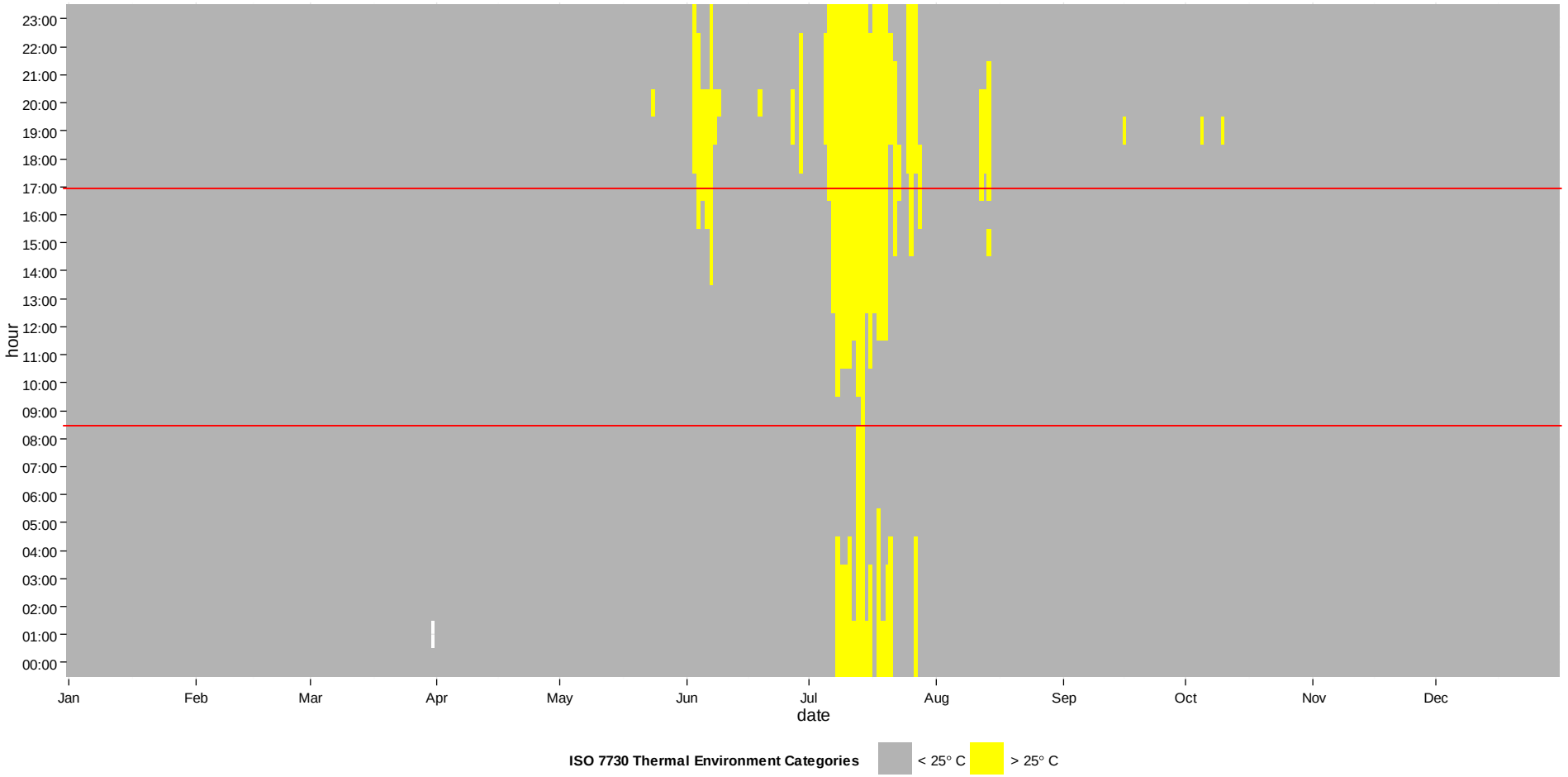
Heat map Open Plan office 2013



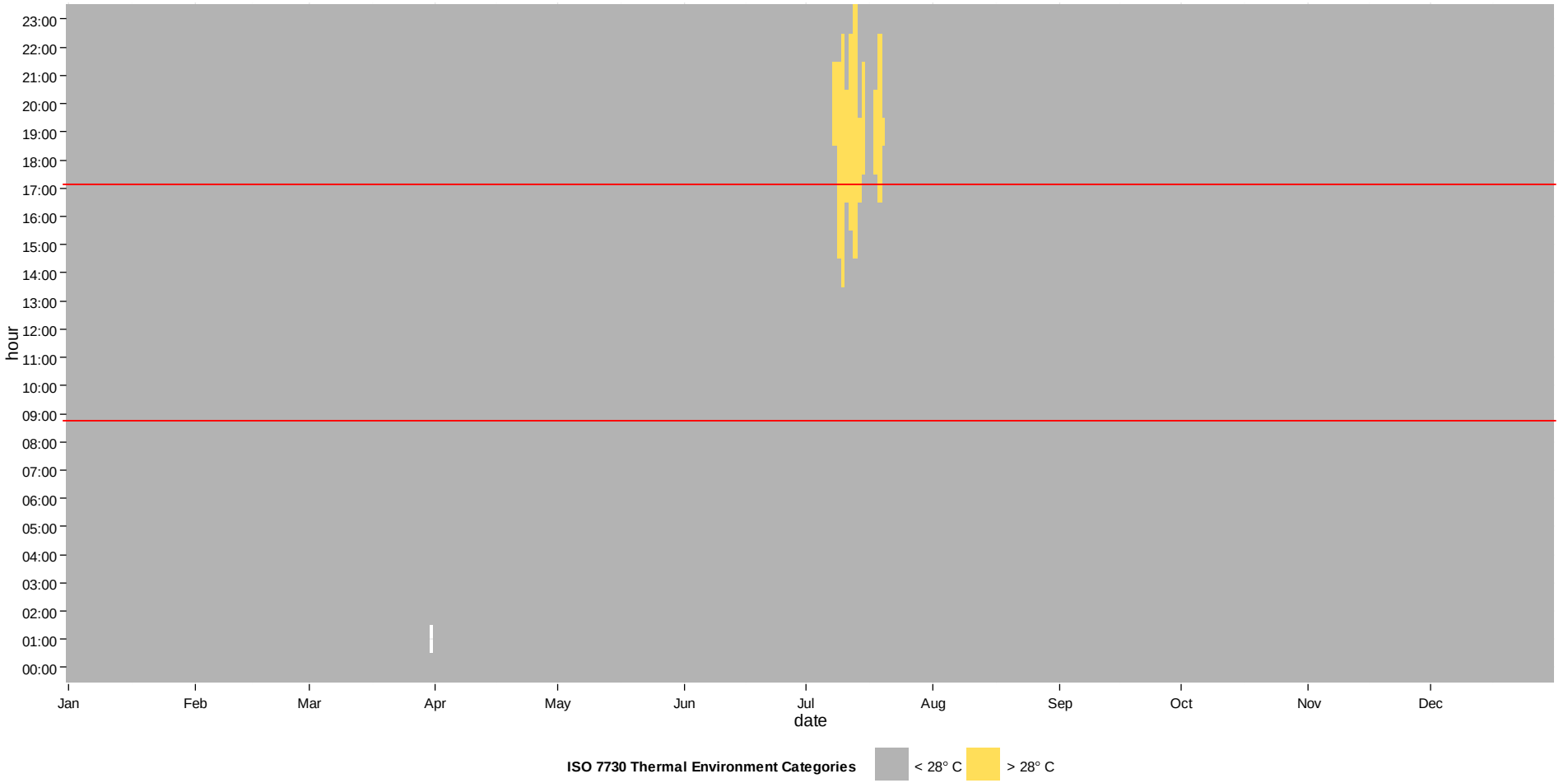
Heat map Open Plan office 2013



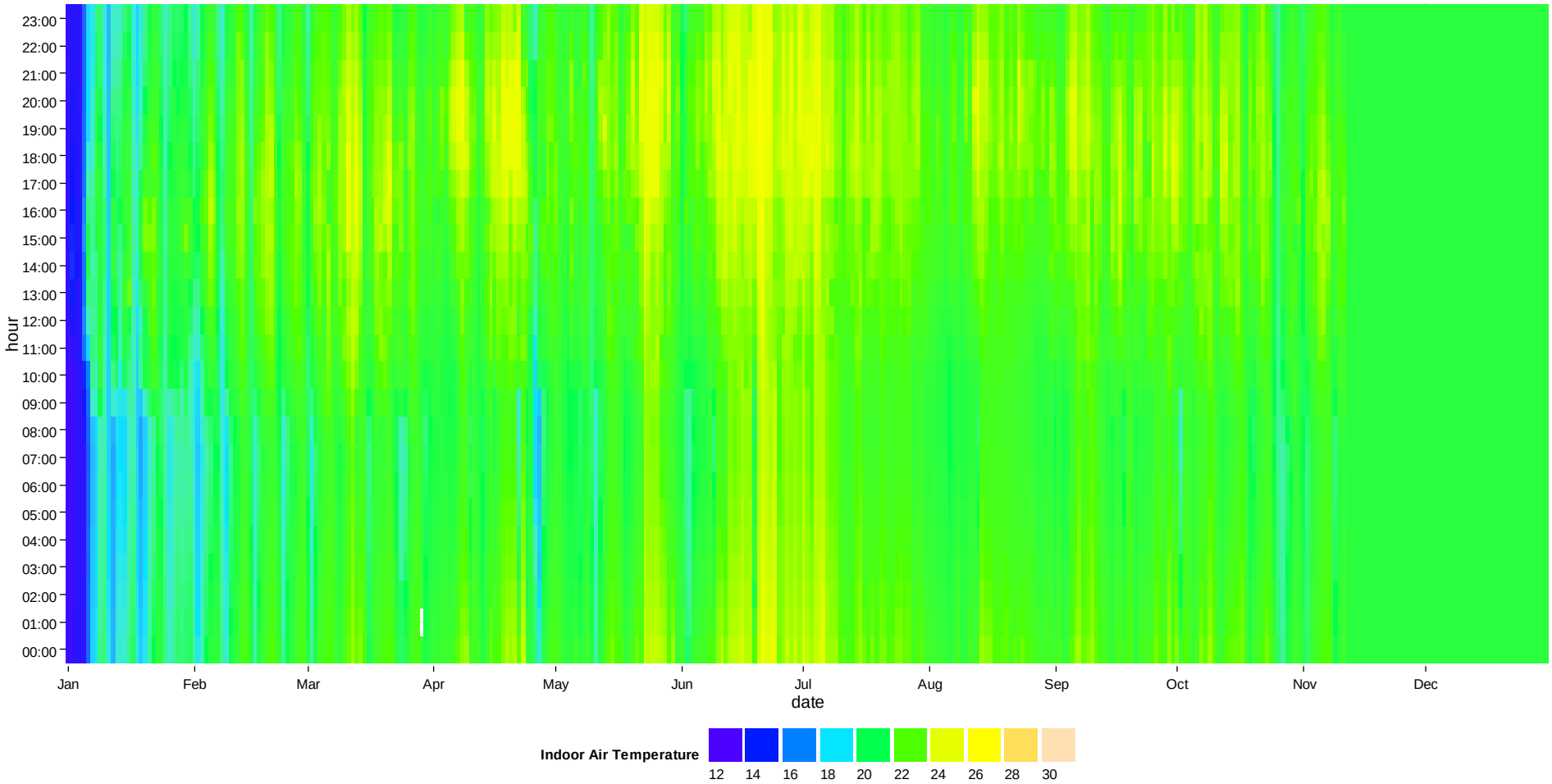
Heat map > 25°C Open Plan office 2013



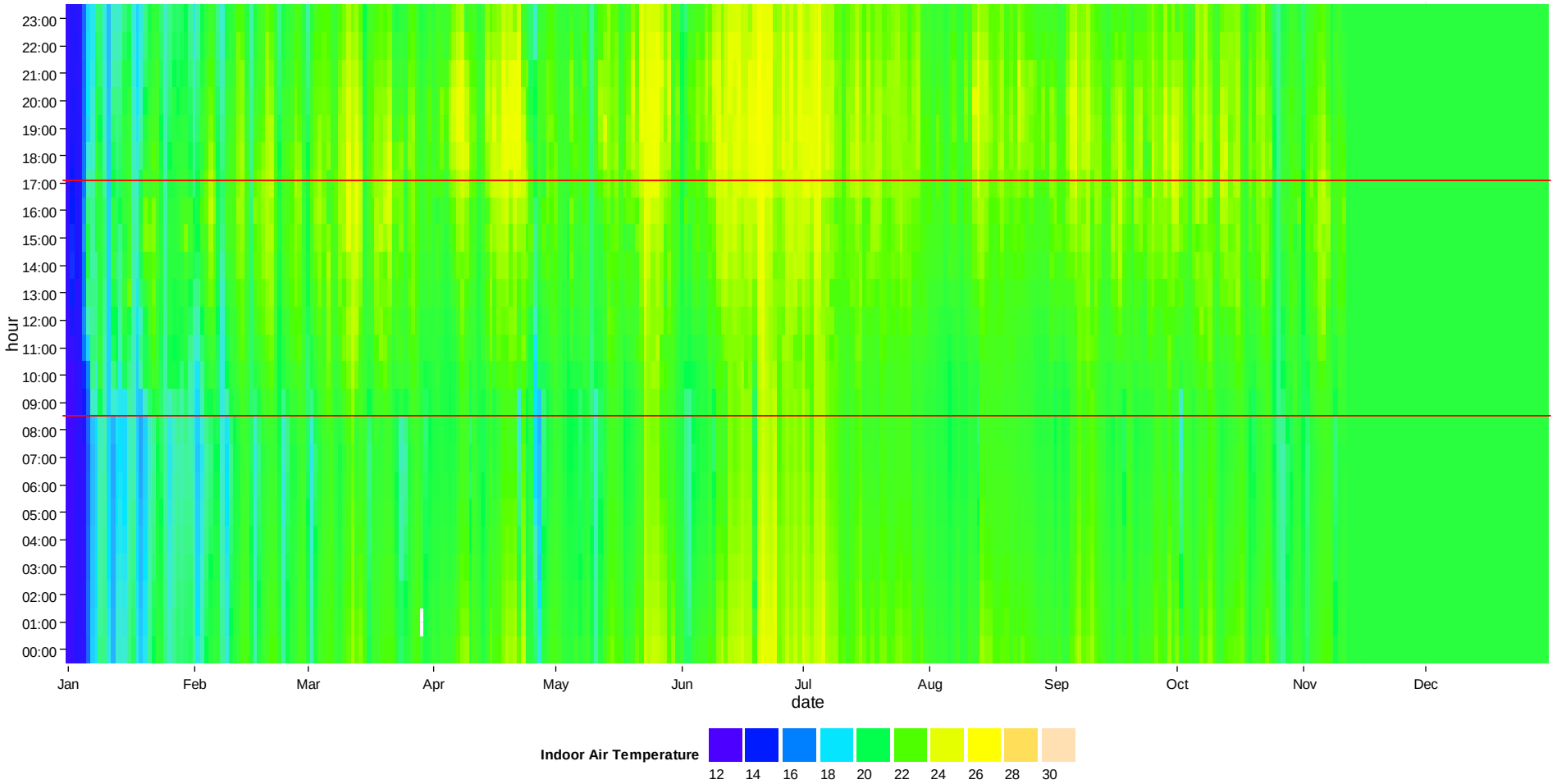
Heat map > 28°C Open Plan office 2013



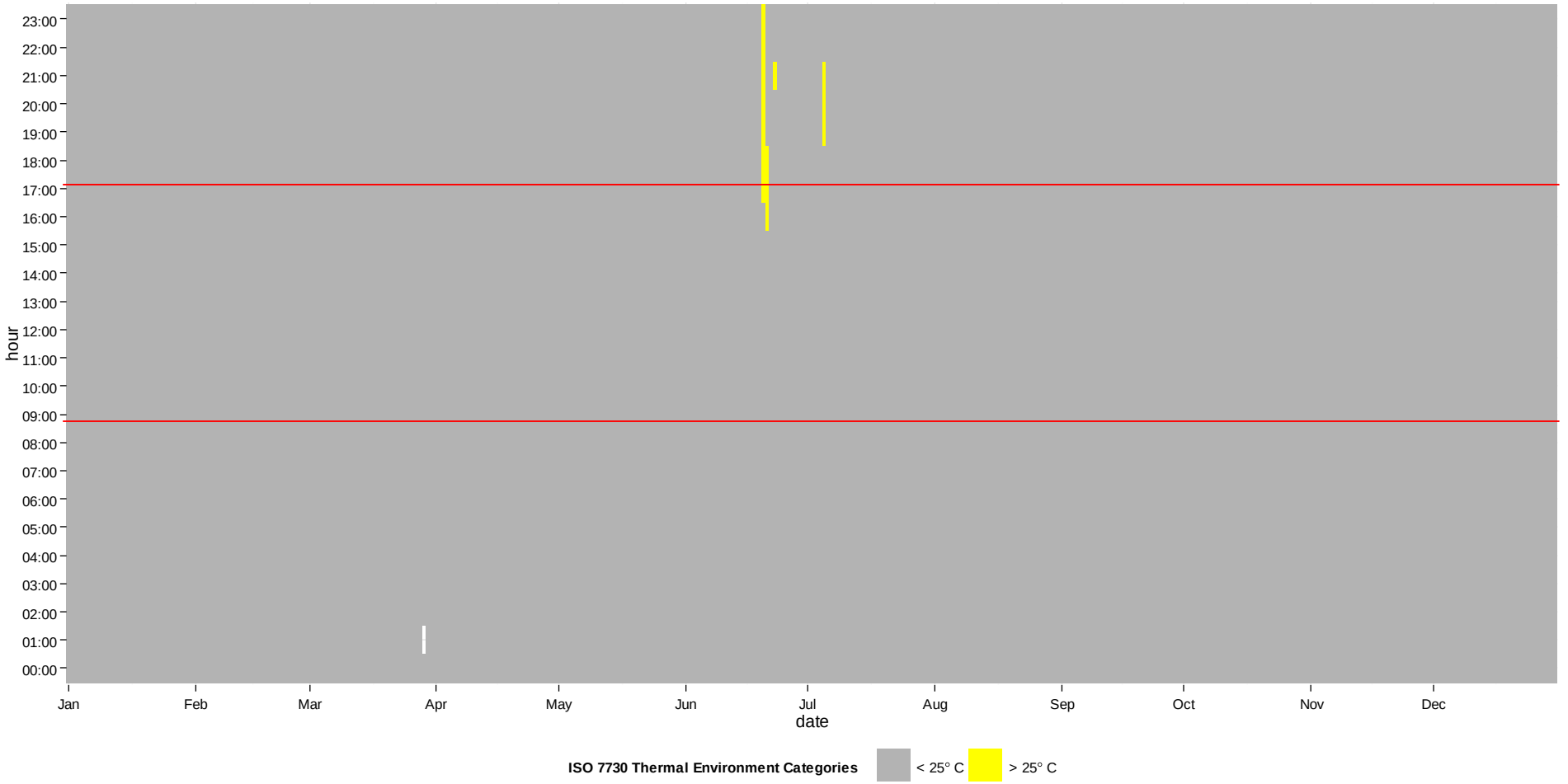
Heat map Open Plan office 2015



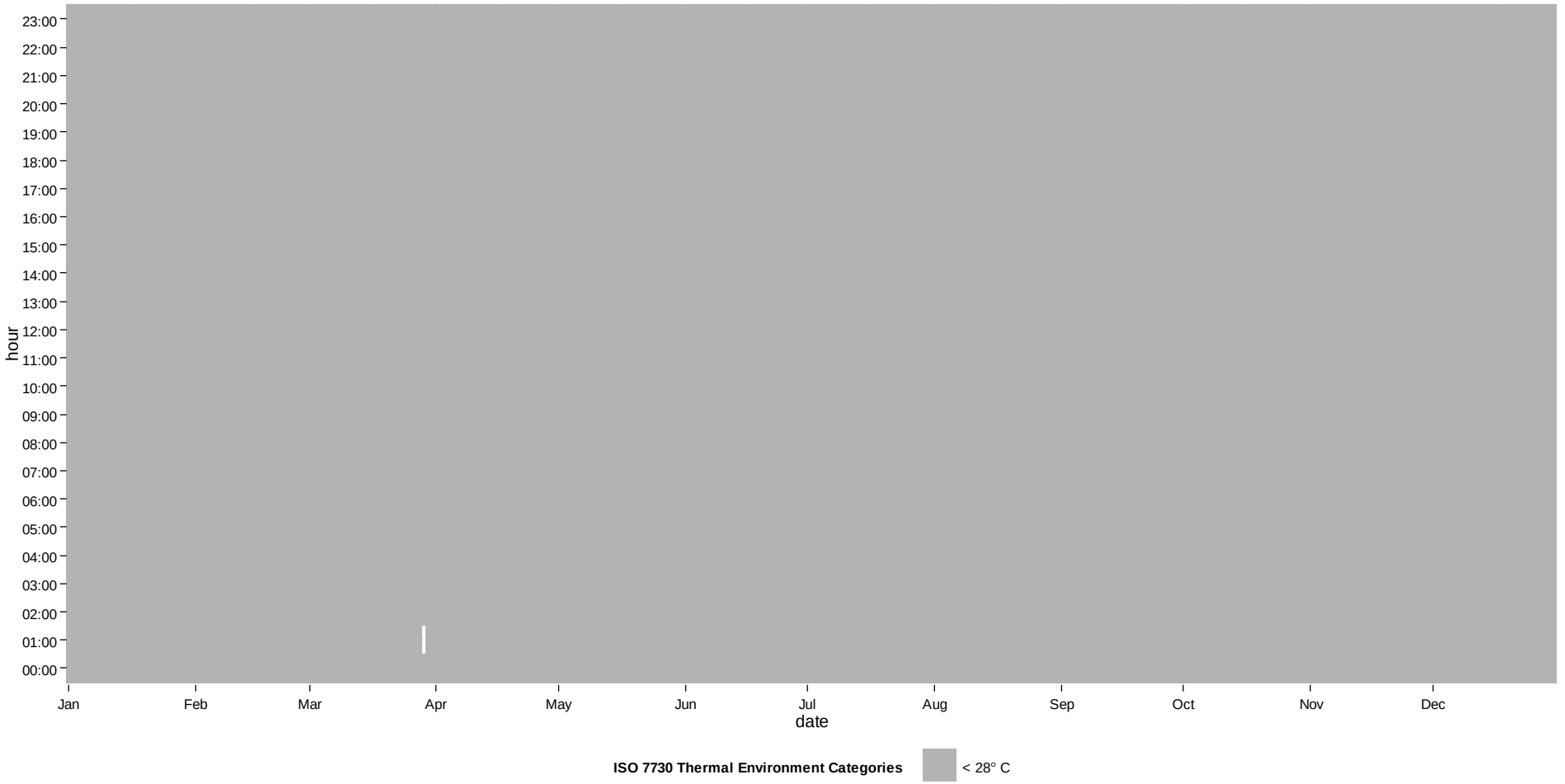
Heat map Open Plan office 2015



Heat map > 25°C Open Plan office 2015



Heat map > 28°C Open Plan office 2015



Summary Open Plan (All hours) office 2013

2013 Total Hours

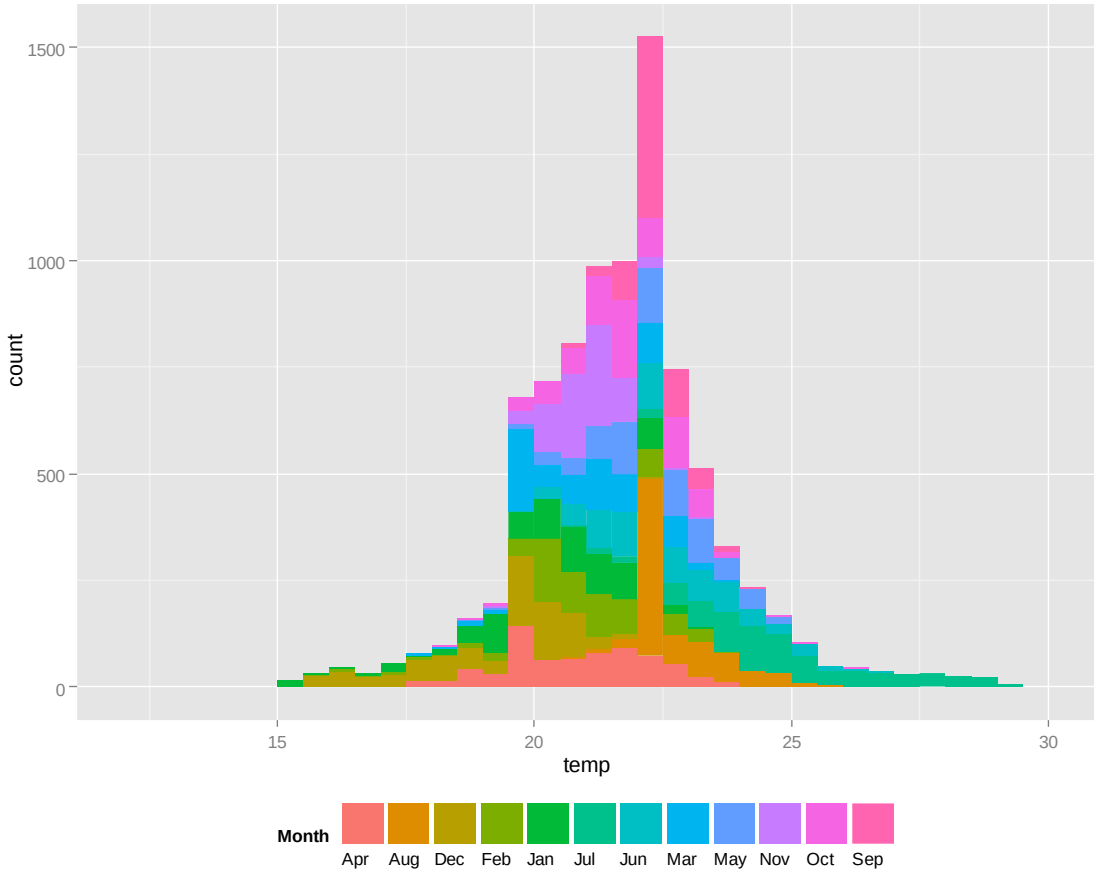
No. hrs > 25 = 3.9%

No. hrs > 28 = 0.6%

2013 Occupied Hours

No. hrs > 25 = 5.5%

No. hrs > 28 = 0.72%



Summary Open Plan (All hours) office 2013 & 2015

2015 Total Hours

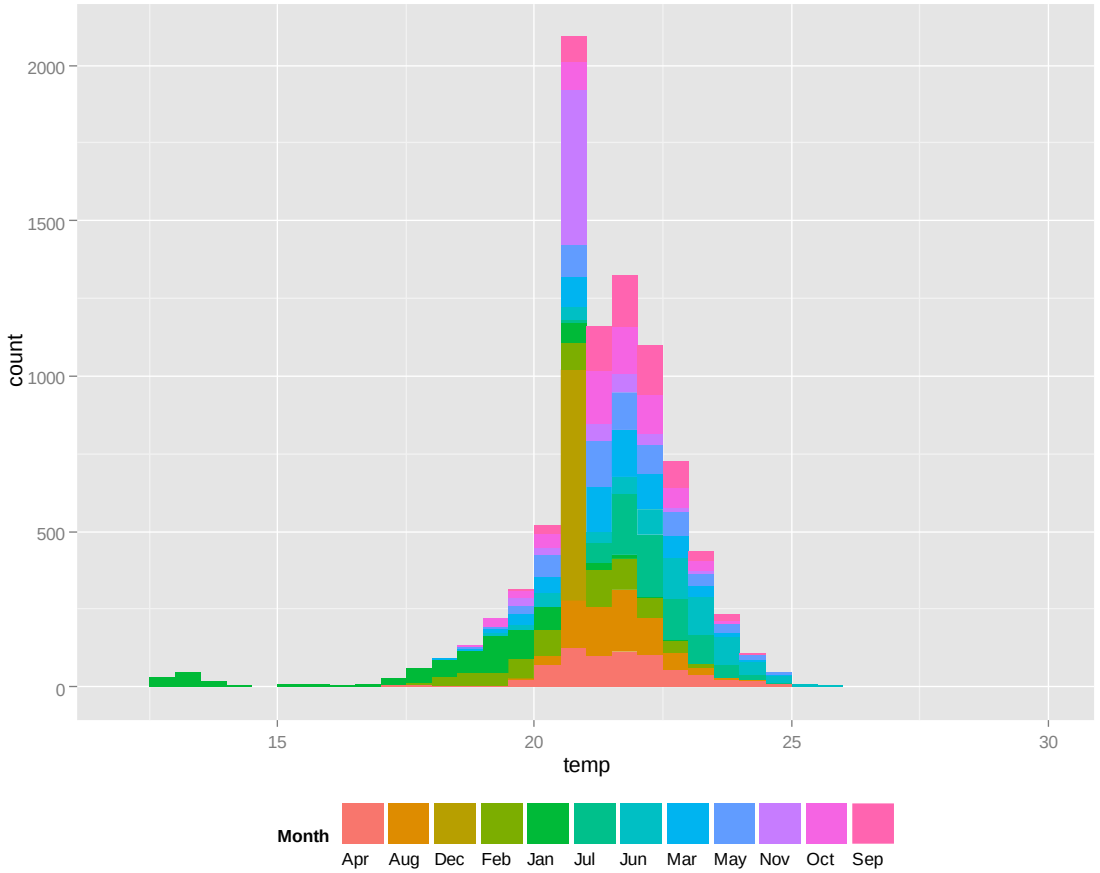
No. hrs > 25 = 0.15%

No. hrs > 28 = 0%

2015 Occupied Hours

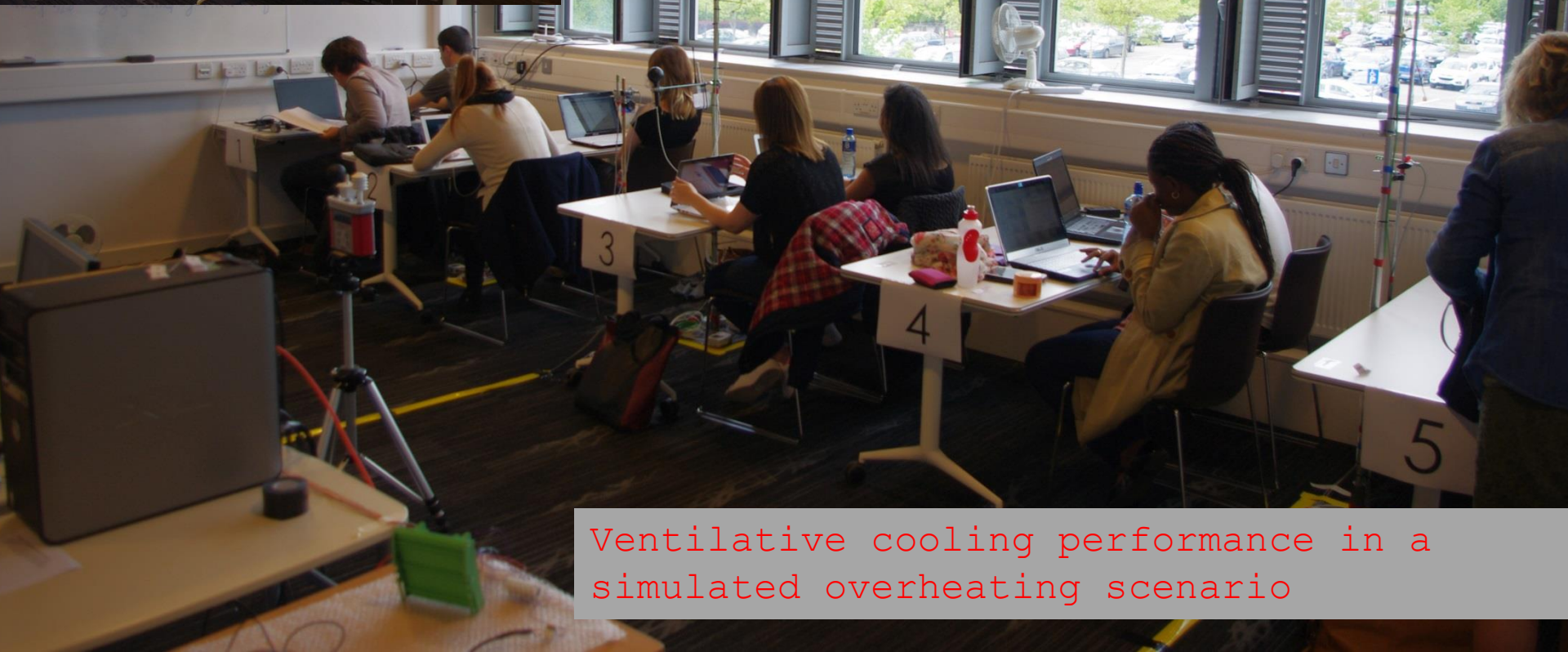
No. hrs > 25 = 0.034%

No. hrs > 28 = 0%

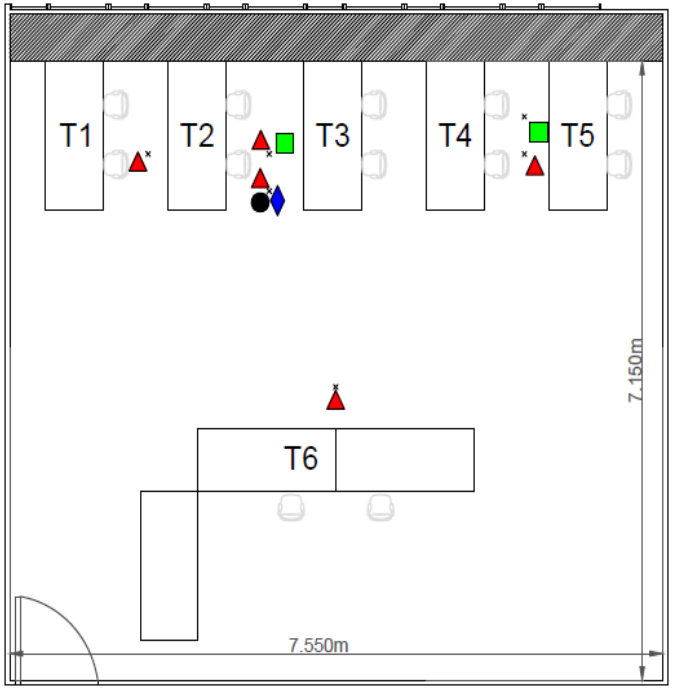


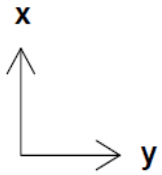
Thermal Comfort

nZero.2020 / Thermal Comfort Evaluation

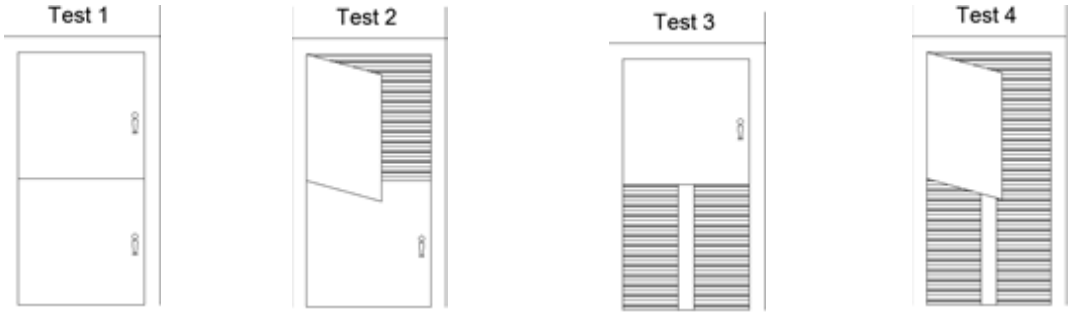


Ventilative cooling performance in a simulated overheating scenario

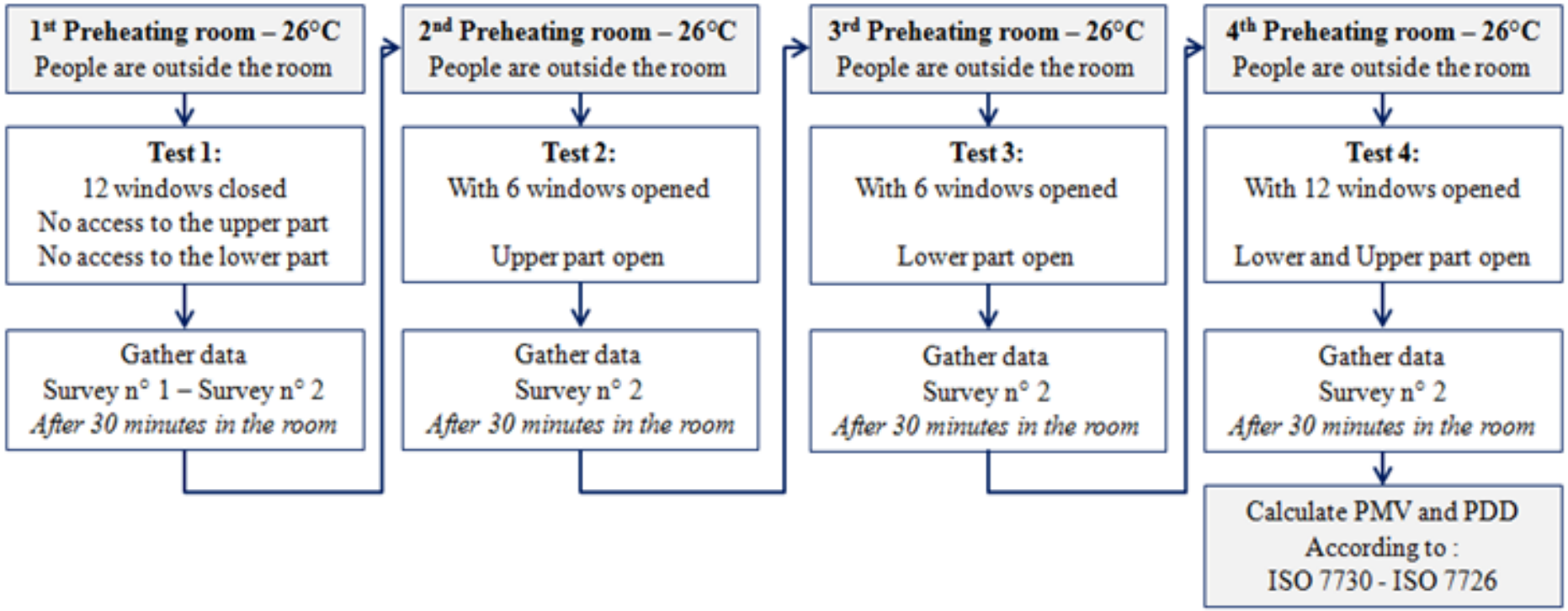




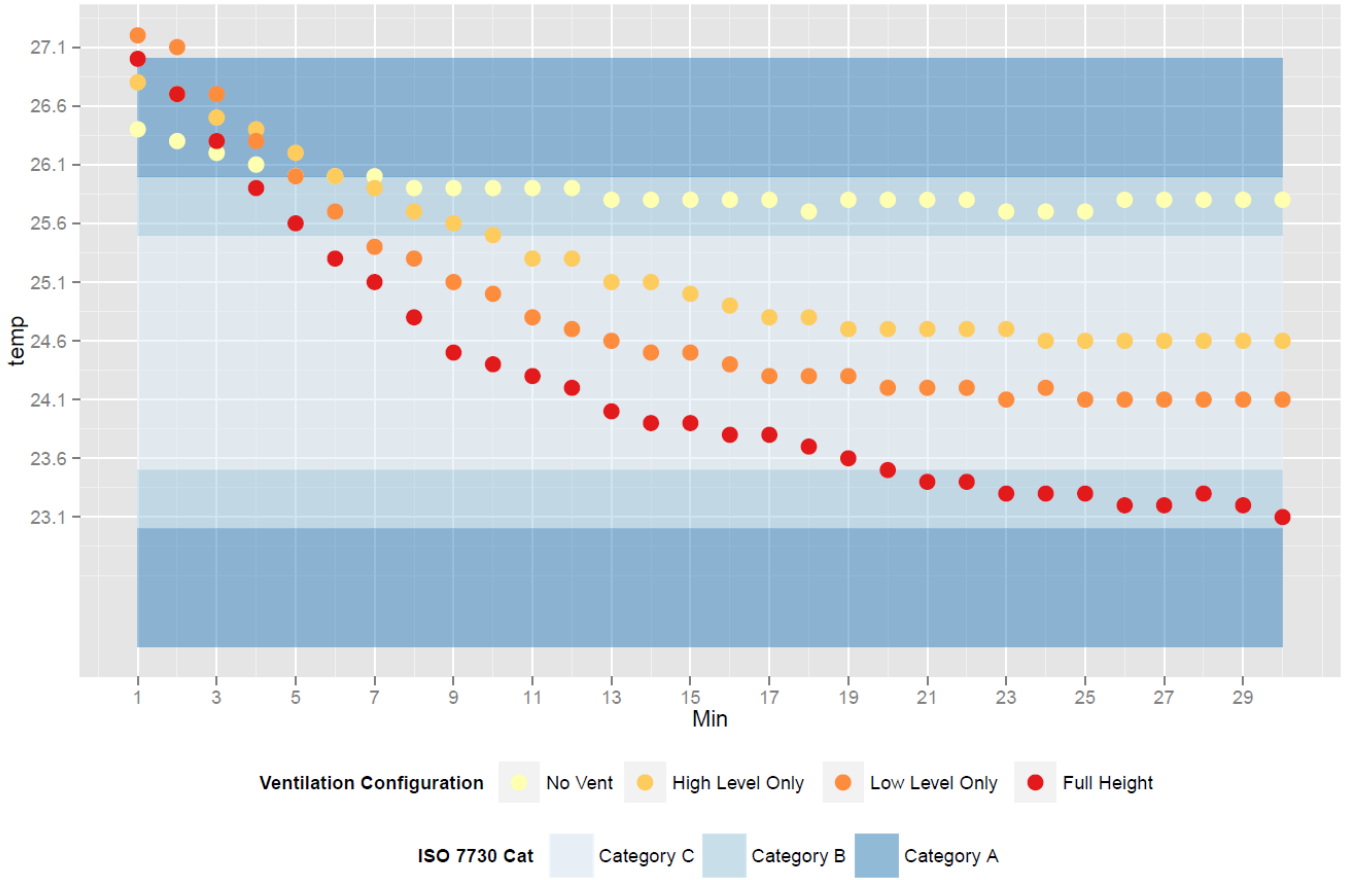
■	2 Bi-directionnal anemometers (on x and y axis)
▲	3 air temperature sensors (0.1m ; 0.6m ; 1.1m)
●	Black globe thermometer
◆	Relative humidity sensor



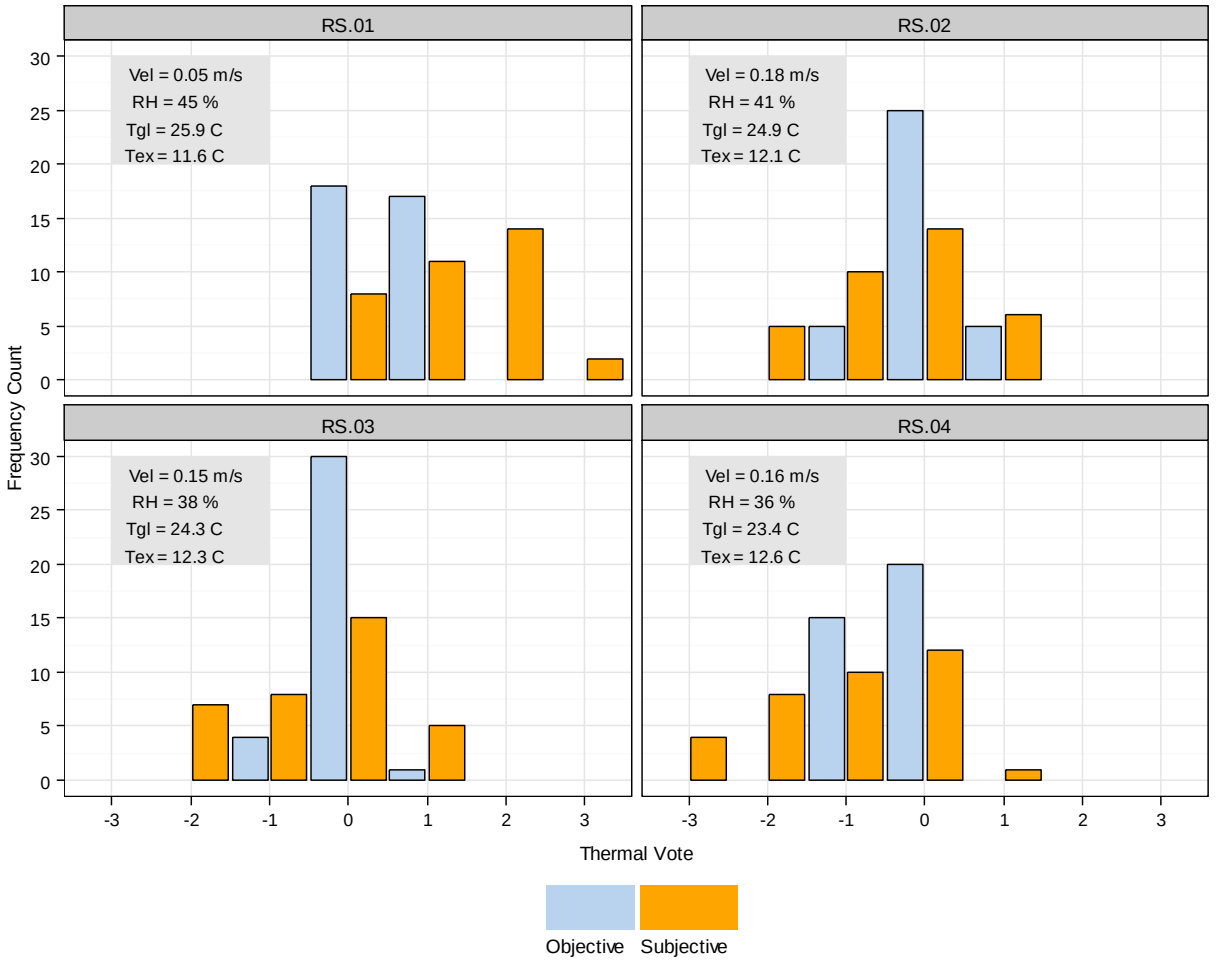
Study set up / methodology


1st Preheating room – 26°C
People are outside the room
Test 1:
12 windows closed
No access to the upper part
No access to the lower part
Gather data
Survey n° 1 – Survey n° 2
After 30 minutes in the room
2nd Preheating room – 26°C
People are outside the room
Test 2:
With 6 windows opened
Upper part open
Gather data
Survey n° 2
After 30 minutes in the room
3rd Preheating room – 26°C
People are outside the room
Test 3:
With 6 windows opened
Lower part open
Gather data
Survey n° 2
After 30 minutes in the room
4th Preheating room – 26°C
People are outside the room
Test 4:
With 12 windows opened
Lower and Upper part open
Gather data
Survey n° 2
After 30 minutes in the room
Calculate PMV and PDD
According to :
ISO 7730 - ISO 7726

Measured indoor air temperature profiles during thermal comfort tests for each ventilation configuration

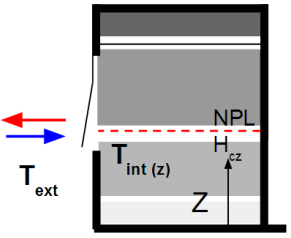


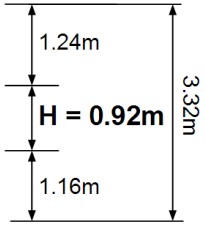
Recorded PMV from subjective survey data along with a comparison to the Fanger PMV model



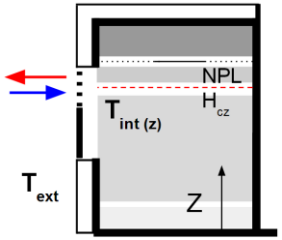
Manual & Automated Ventilation Configurations

CS.01





RS.02



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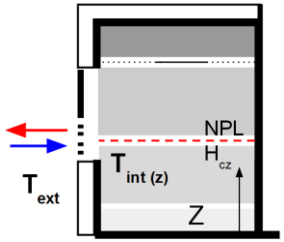

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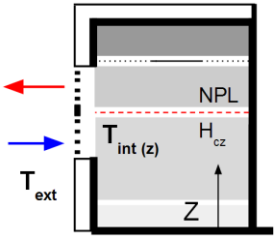
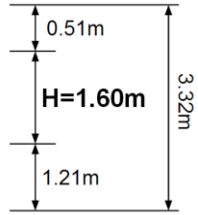




What are we learning?

nZero.2020 / What are we learning

- More data showing people like natural ventilation & openable windows
- PHPP gives realistic predictions for heating energy consumption even within non residential environments
- Surprisingly, so did SBEM for annualised values
- Up to 4 ACH possible with NV SS slot louver systems
- Low energy can mean comfortable but adaptive approach important (free running buildings)
- Overheating still likely even with night cooling
- It is difficult to obtain consistent, accurate measurements over extend periods of time

IEA-EBC Annex 62 Ventilative Cooling

www.venticool.eu

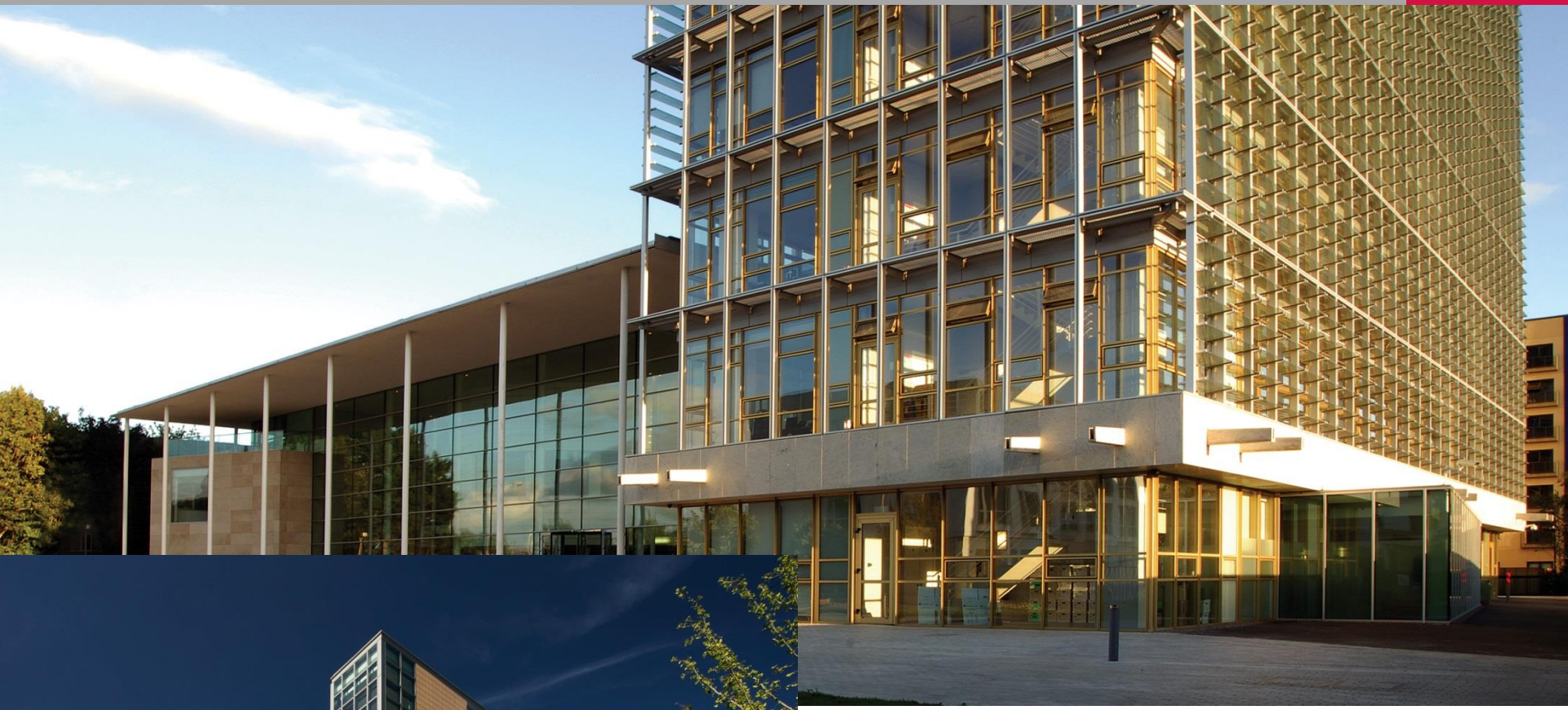
Thermal perception potential of untreated outdoor air for low energy, well insulated, airtight buildings

Improve modelling techniques, guidelines, standards to better account for the contribution to minimising cooling demand

nzero.2020 is a case study

We also are undertaking occupancy evaluation surveys in buildings that utilise ventilative cooling in Cork (and hopefully elsewhere)

nZero.2020 / Annex 62 – Occupancy Evaluations

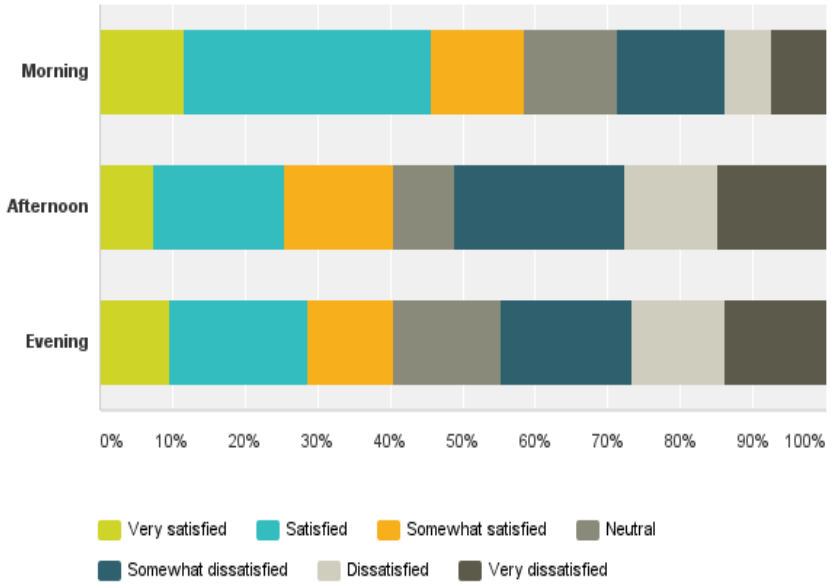


Cork County Hall
- approximately 500 occupants

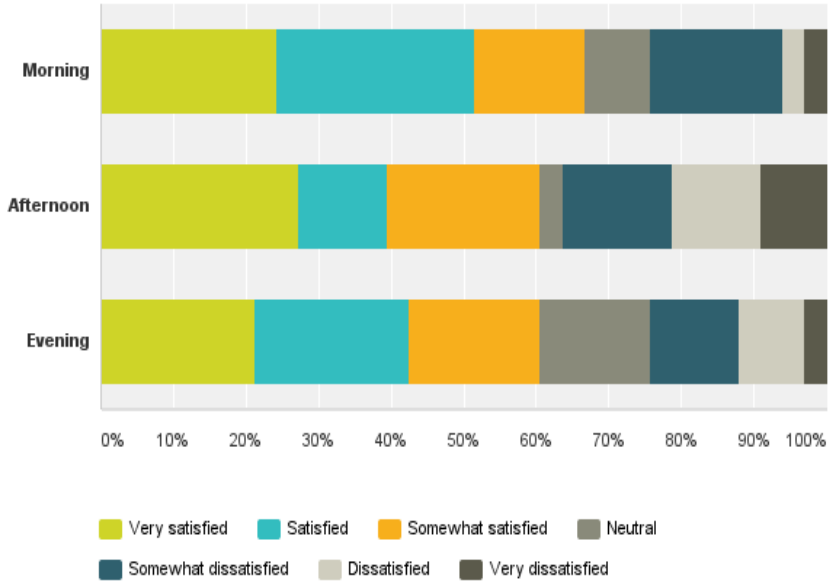
UCC WGB
- approximately 200 occupants

During the warmer months, how satisfied are you with the temperature in your workspace?

Cork County Hall

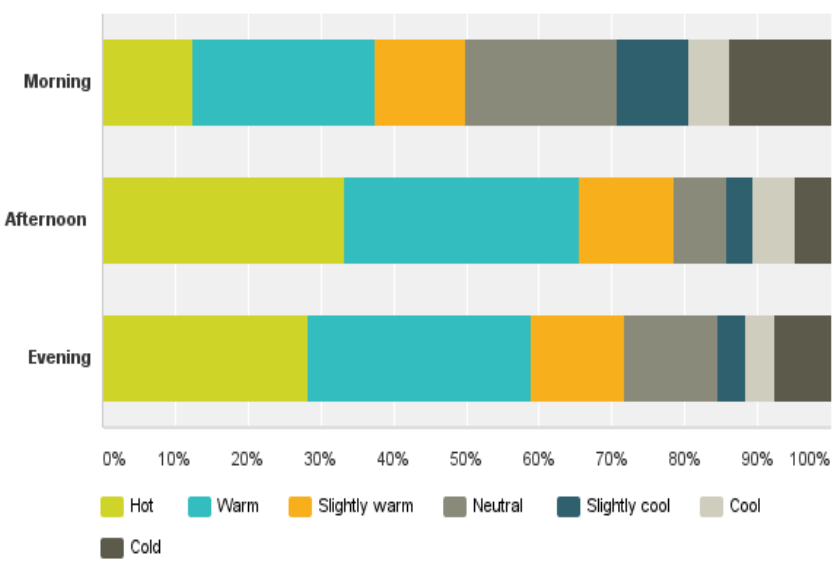


UCC western Gateway

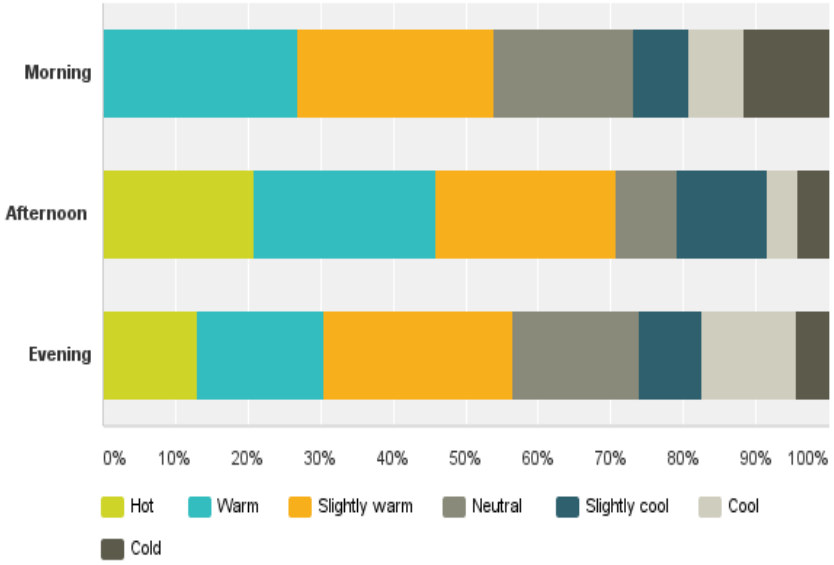


When you are dissatisfied, how would you describe the temperature?

Cork County Hall

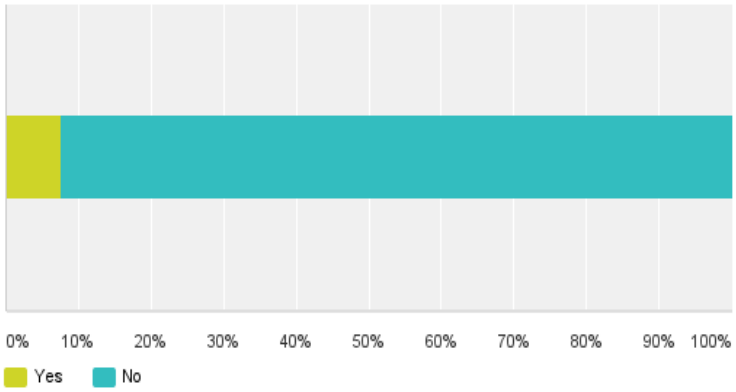


UCC western Gateway

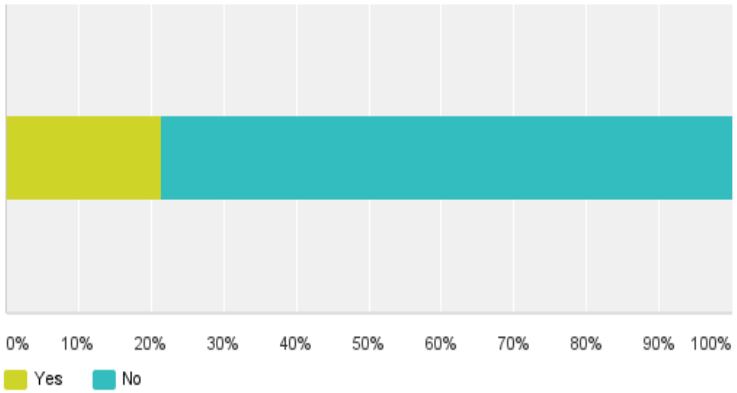


Finally, if you could move to a workspace with air conditioning but no openable windows, would you?

Cork County Hall



UCC western Gateway







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