Overheating risk and ventilative cooling in low energy retrofits: a case study at zero2020

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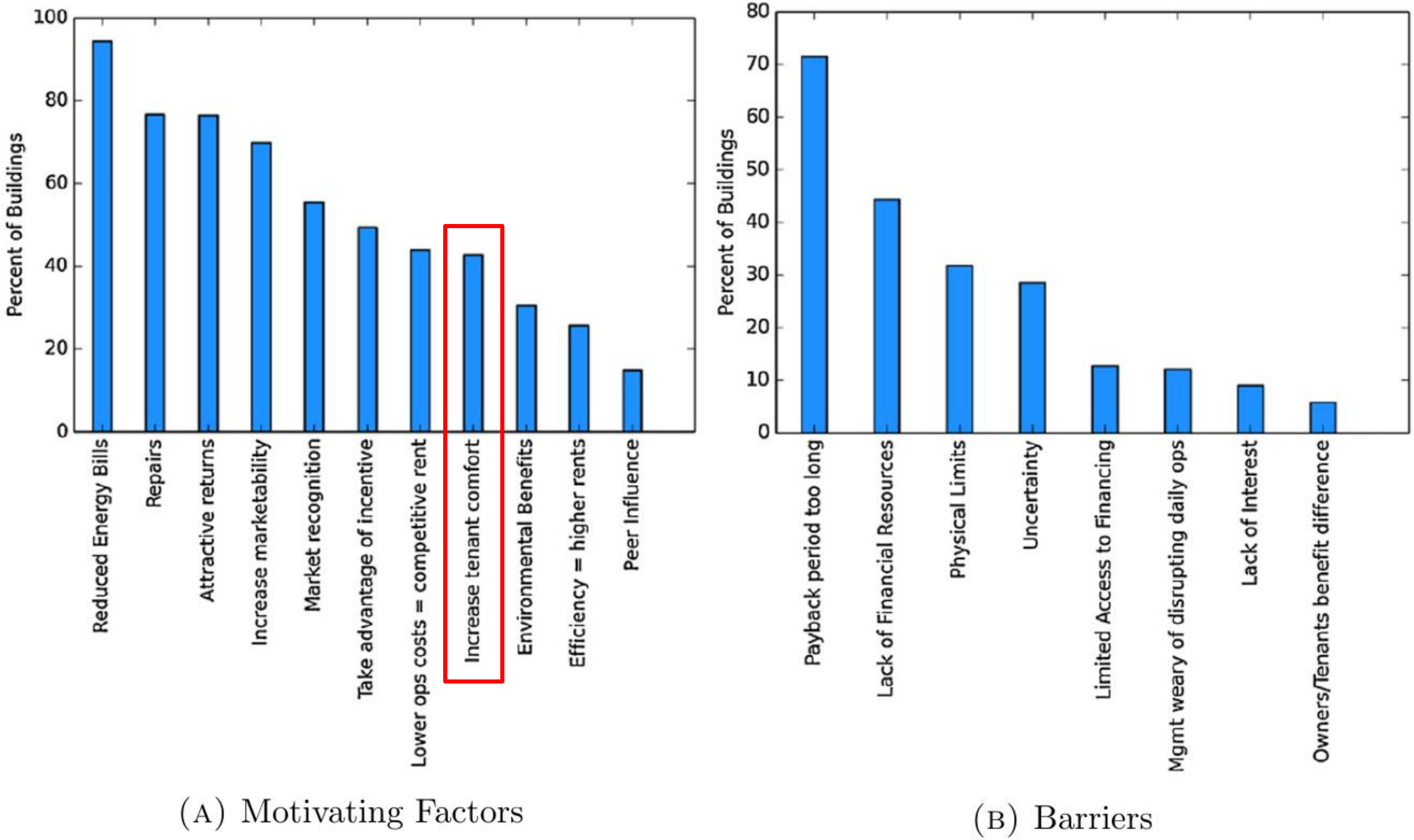
Agenda

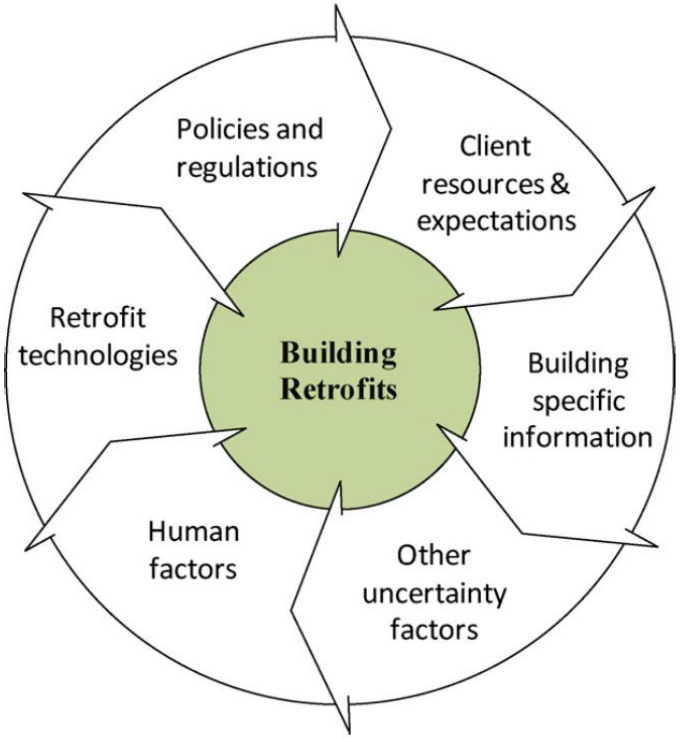
1. zero.2020 energy performance
2. ventilative cooling
3. overheating Risk
4. climate cooling potential at zero2020
5. what are we learning...

What motivates an organisation to undergo a low energy retrofit?

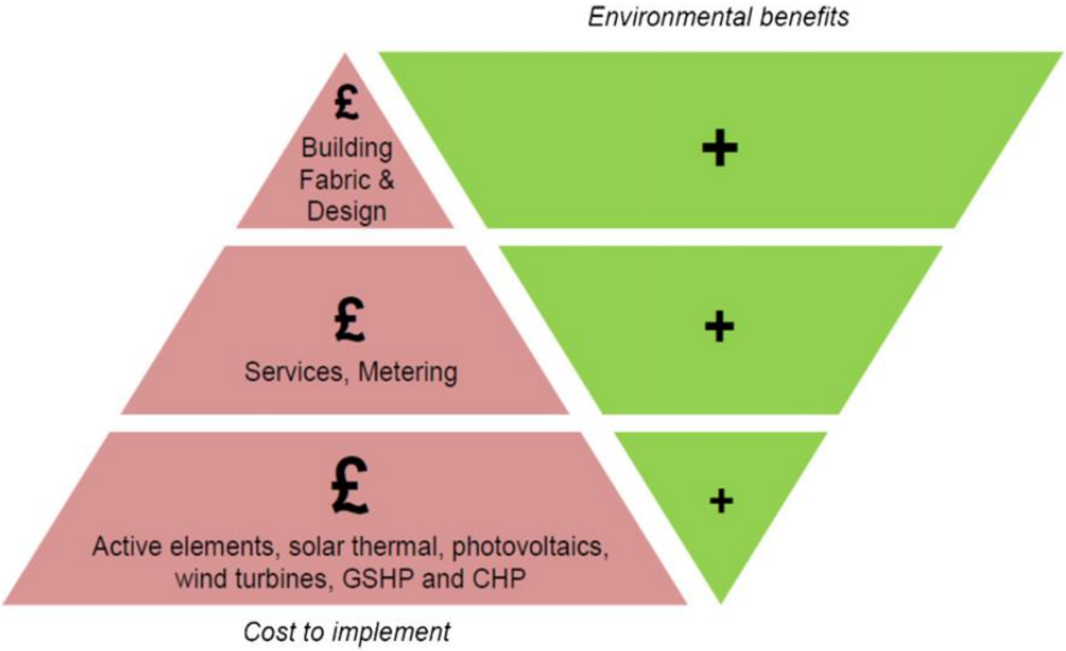


Kontokosta, C. E. (2016). Modeling the energy retrofit decision in commercial office buildings. *Energy and Buildings*, *131*, 1–20.

What defines the scope for a low energy retrofit?



Influencing Factors

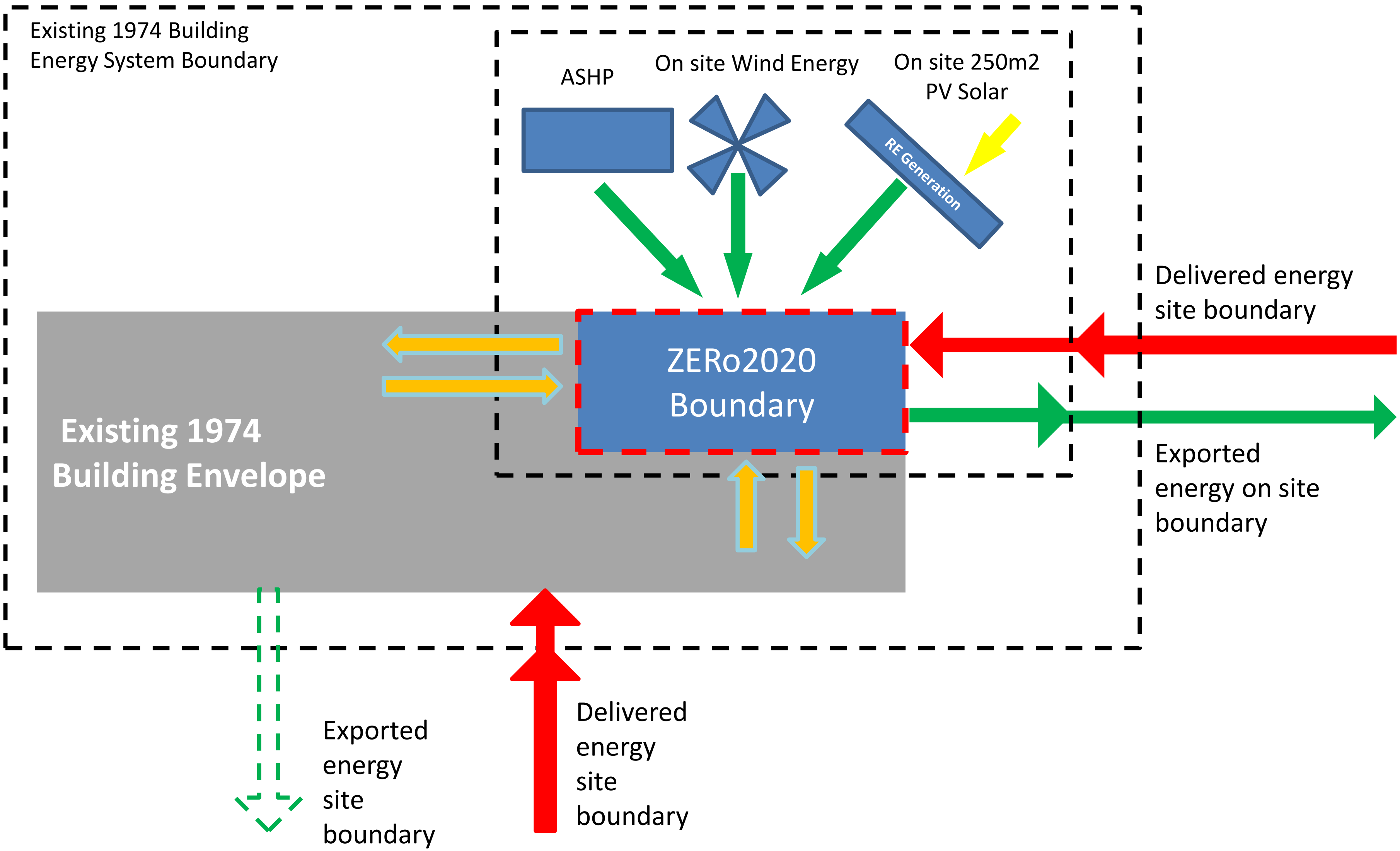


Energy Hierarchy

Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and Buildings*, *55*, 889–902.

nZero.2020 / features

nZero.2020 / Boundary Definition



nZero.2020 / testbed features

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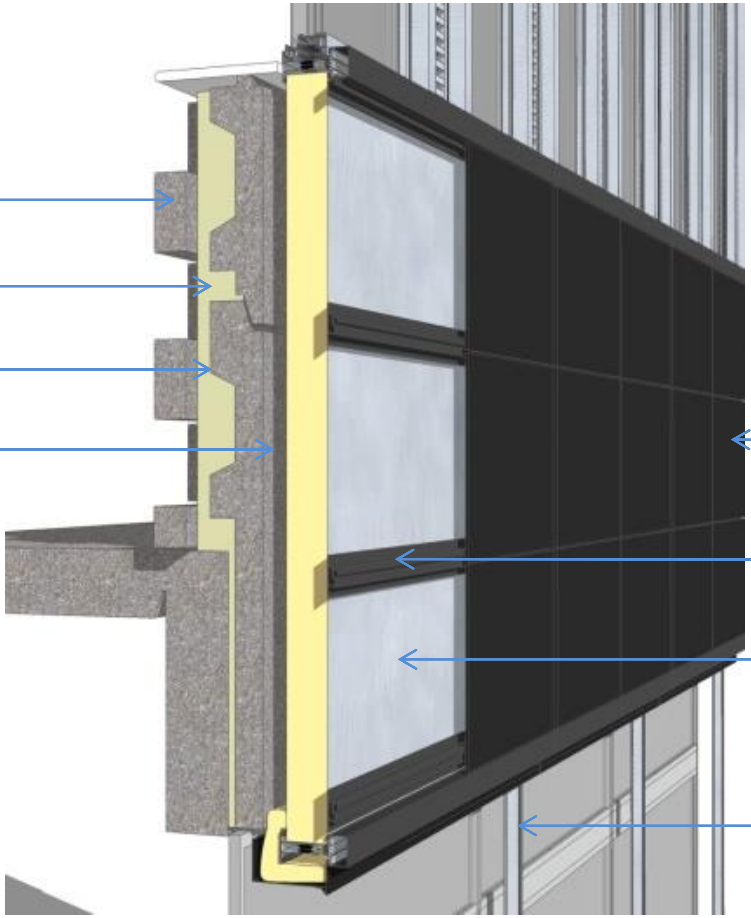


No	Description	Dim (mm)
1	Existing Internal Block	100
2	BASF Wall-tite Spray Foam	86
3	Existing aggregate panel	125
4	Air gap	30
5	Kingspan benchmark ceramic granite panel	12
6	Kingspan support rail	37
7	Kingspan KS 1100 insulated panel	125
8	AMS support mullion	125

Air permeability of 1.76 $(m^3/hr)/m^2$ at 50Pa building pressure.

The existing structure was measured as 14.77 $(m^3/hr)/m^2$

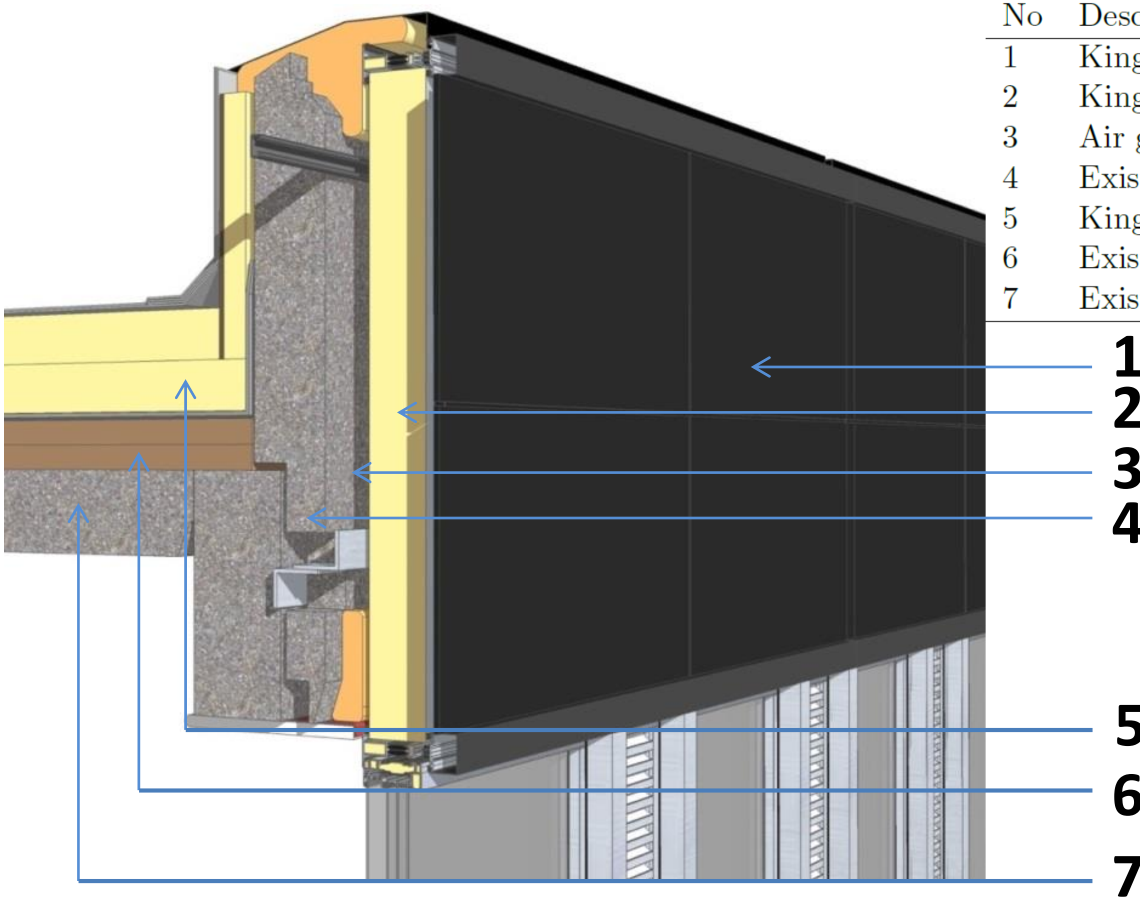
Opaque External Envelope Retrofit

95% reduction in thermal transmittance

O'Sullivan, P., Delaney, F., O'Riain, M., Clancy, T., O'Connell, J., & Fallon, D. (2013). Design and Performance of an External Building Envelope Retrofit Solution For a Grid Optimised Concrete Structure: A Case Study. In *IMC30 Conference Proceedings 2013*.

nZero.2020 / testbed features

No	Description	Dim (mm)
1	Kingspan benchmark ceramic granite panel	12
2	Kingspan KS 1100 insulated panel	125
3	Air gap	30
4	Existing aggregate panel	125
5	Kingspan KS 1100 insulated panel	250
6	Existing Cork Insulation	75
7	Existing Precast Concrete slab	250



External Roof Retrofit

91% reduction in thermal transmittance

O'Sullivan, P., Delaney, F., O'Riain, M., Clancy, T., O'Connell, J., & Fallon, D. (2013). Design and Performance of an External Building Envelope Retrofit Solution For a Grid Optimised Concrete Structure: A Case Study. In *IMC30 Conference Proceedings 2013*.

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

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manual & automated purpose provided
ventilation openings with insulated doors

nZero.2020 / testbed features

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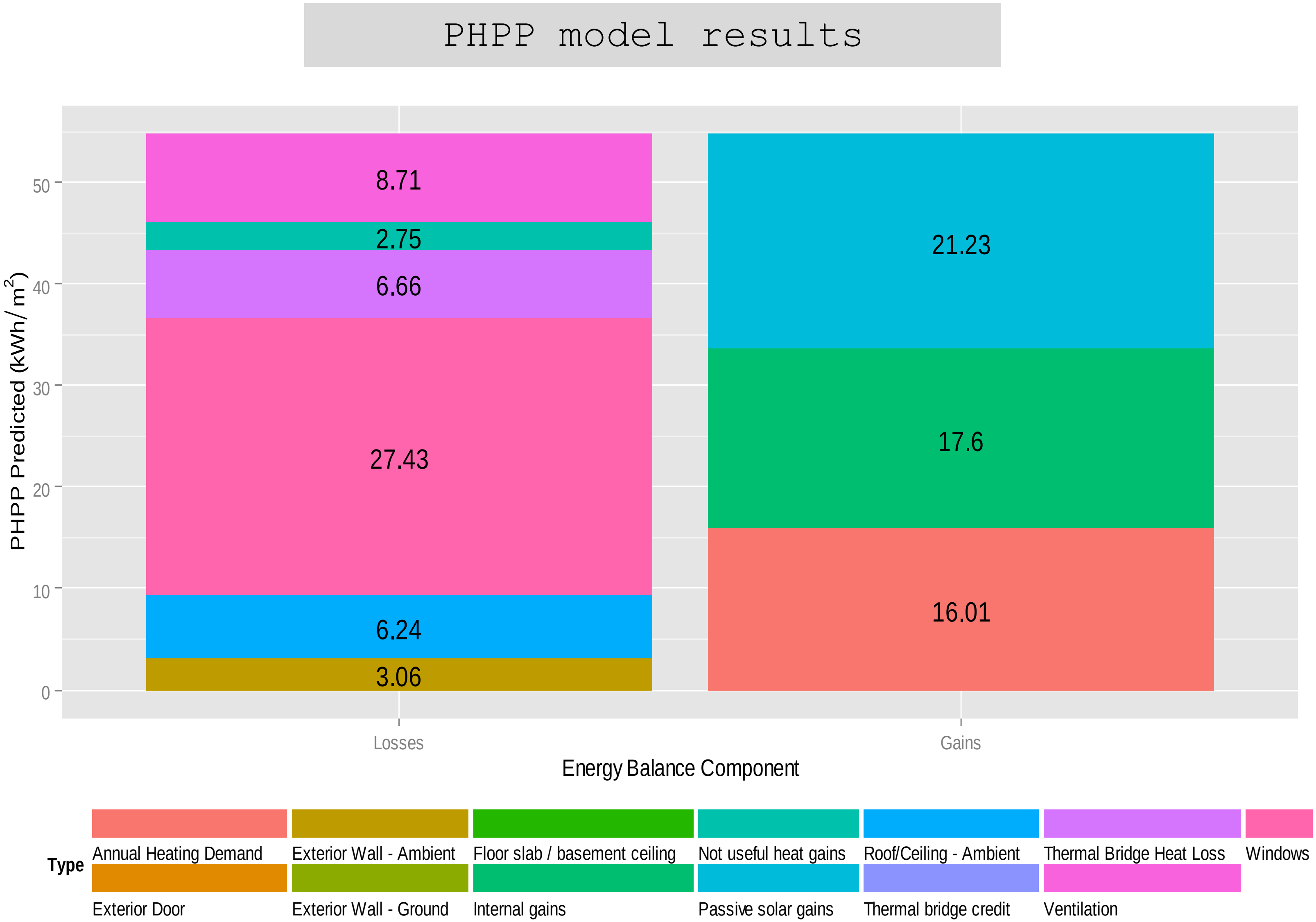
wireless Hanwell radio frequency based data logging system

zero2020 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

96% reduction of heating energy consumption



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

nZero.2020 / Total Energy Consumption

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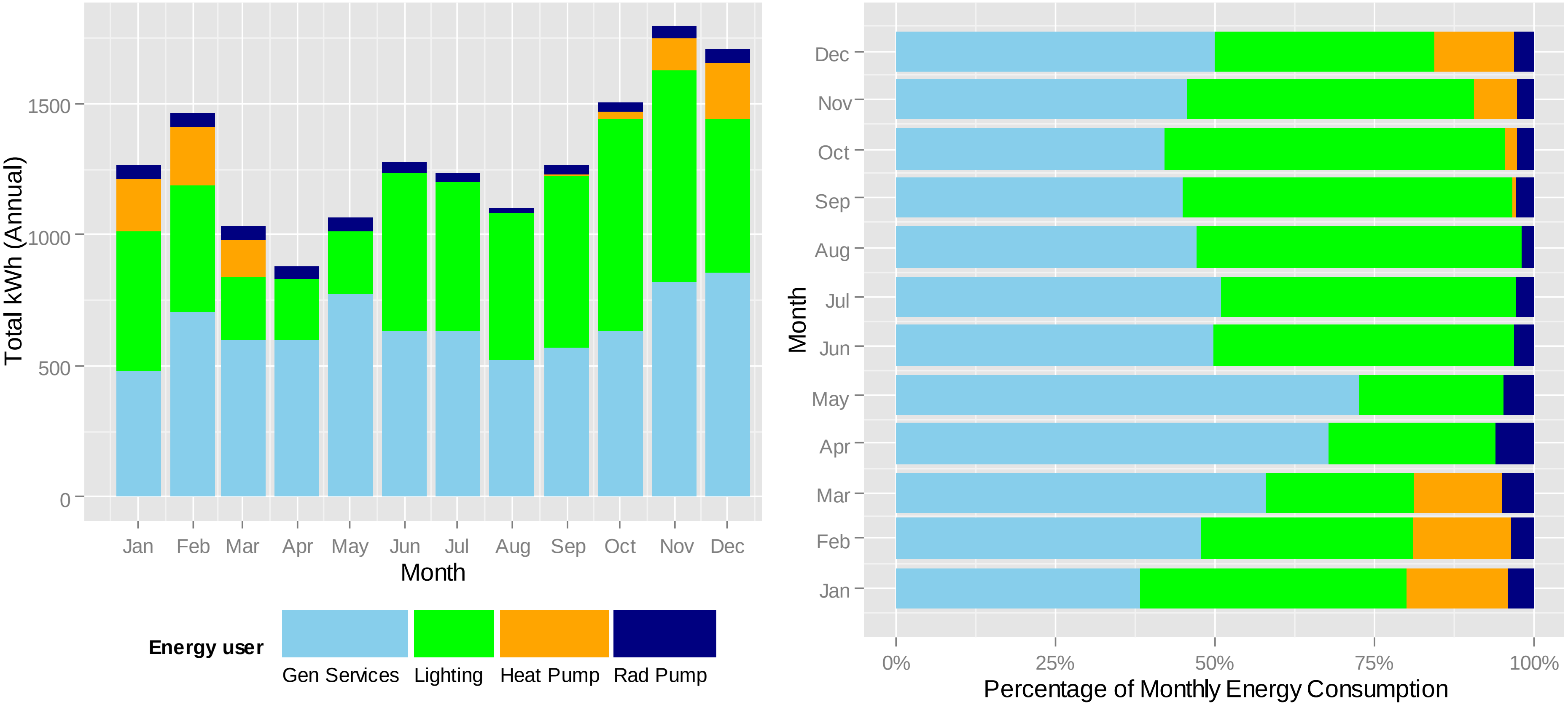
2013 Monthly Totalised Energy Consumption per end use



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

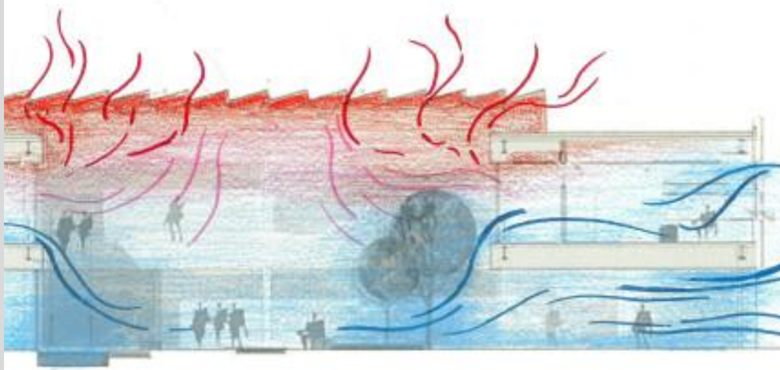
Component	CIT (1974)	TGDL (2008)	TGDL (2017)	Cost Optimal	Zero2020
Wall U-value (W/m^2K):	2	0.6	0.21	0.3	0.09
Roof U-value (W/m^2K):	1.1	0.35	0.20	0.15	0.09
Floor U-value (W/m^2K):	0.8	0.8	0.21	0.10	0.8
Window U-value (W/m^2K):	>5	2.2	1.8	1.8	1

Can ventilative cooling provide a comfortable environment?

Most modern office buildings use mechanical cooling in moments when an optimized natural ventilation (NV) system could work.

Lower energy consumption could be a driver for increased NV use…but **energy costs** are one to two **orders of magnitude less than rent costs.**

NV needs to impose itself by its capability to **improve the work environment and worker productivity** as well as its contribution to climate change mitigation.

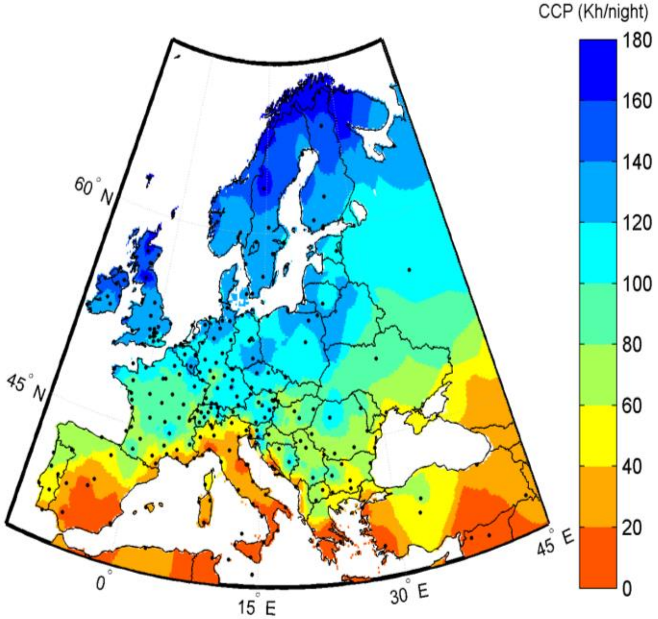


Ventilative Cooling *is the application (distribution in time and space) of ventilation air flow to reduce cooling loads in buildings.*

Nearly-zero energy buildings have lead to **an increased need for cooling** – not only in summer but all year.

Elevated temperature levels are the most reported problem in post occupancy studies - even in the "heating season"

IEA EBC Annex 62 The IEA project on ventilative cooling EBC



Map of mean climatic cooling potential (Kh/night) in July based on Meteonorm data [13].

IEA-EBC Annex 62

Ventilative Cooling

www.venticool.eu

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

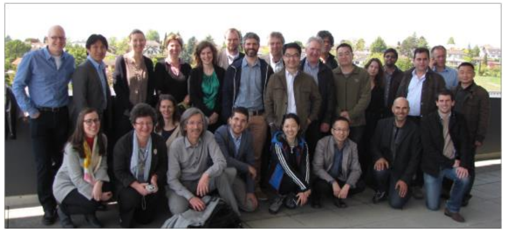
nzero.2020 is a case study

2 new European standards for ventilative cooling planned

Country	Institution
Austria	IBRI
Belgium	BBRI
	Loeven
China	Hunan
Denmark	AAU
	DTU
	VELUX
	WindowMaster
Finland	FIOH
	SAMK
Germany	RWTH Aachen
Greece	NKUA
Ireland	CIT
Italy	EURAC
	POLIMI
Japan	OSAKA
	Ritsumeikan
Netherlands	Tu/e
	BBA Binnenm.
	TUDelft
Norway	NTNU
Sweden	LTH
Switzerland	ESTIA
UK	Brunel
USA	MIT

IEA EBC
Annex 62
The IEA project
on ventilative cooling
EBC





Fully integrated factory assembled module

Quadruple glazed unit c/w sealed triple glazed Argon filled system/ manual interstitial blinds / inner clear float pane

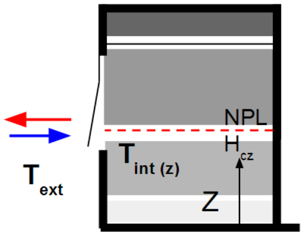
Integrated insulated ventilation doors low level occupancy controlled & high level BMS automated

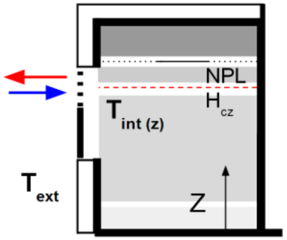
Free-running indoor temperature as no HVAC system is used

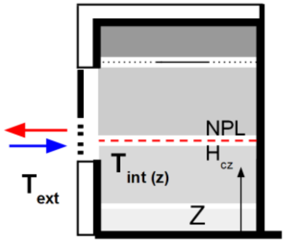
Manual & Automated Ventilation Configurations

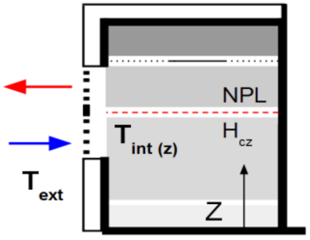
1974	auto	manual	combined









O'Sullivan, P. D., & Kolokotroni, M. (2014). Time-averaged Single Sided Ventilation Rates and Thermal Environment in Cooling Mode for a Low Energy Retrofit Envelope. *International Journal of Ventilation*, *13*(2), 153–168.

Indoor Temperature & Overheating Risk

Traditionally the criteria to assess overheating risk was a static threshold:

% of occupied hours equal to or above a certain threshold value:

- CIBSE: 5% > 25°C
- BRE: 1% > 28°C

Nicol, F., & Spires, B. (2013). CIBSE TM52: The Limits of Thermal Comfort. CIBSE. London.

nZero.2020 / Overheating risk – summer 2013

nZero.2020 / Overheating risk – summer 2013

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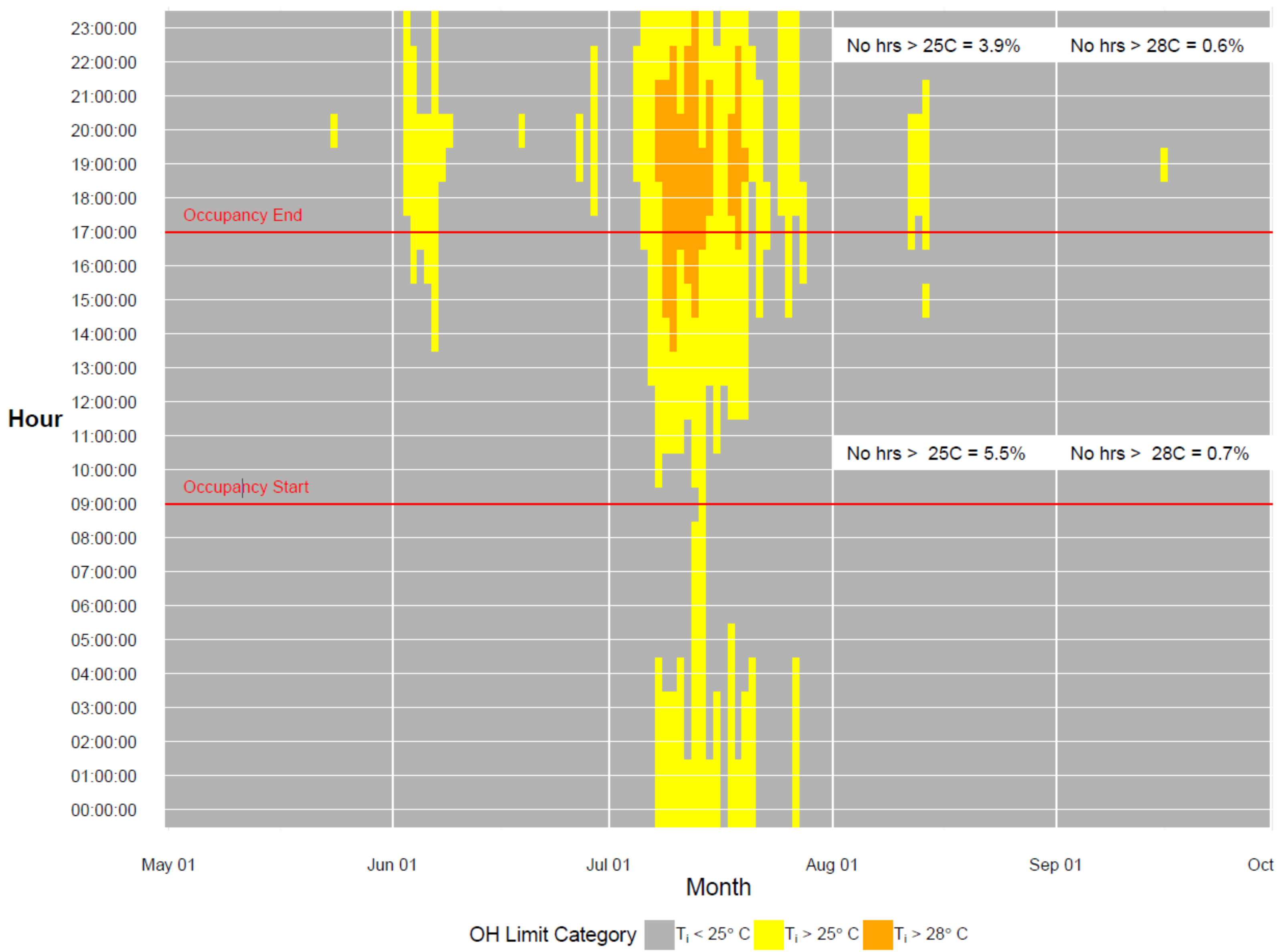
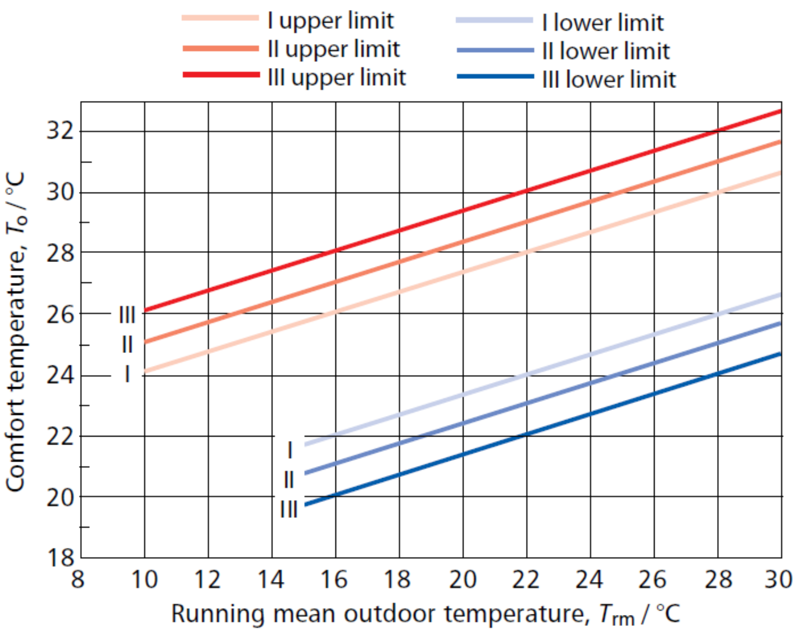


Adaptive approach to thermal comfort *in free running buildings – moving target for comfort*

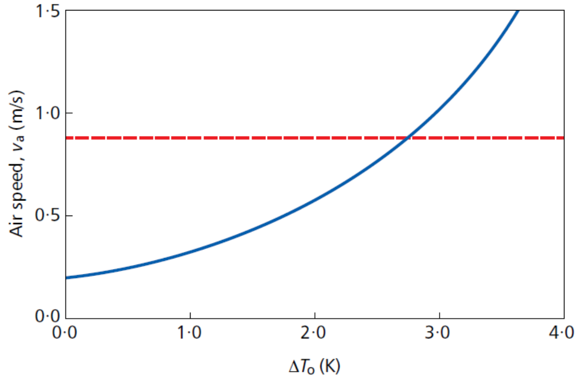
Local air movement are major factor in extending the thermal comfort range

CIBSE Propose 3 new criterion. Not just static % hours exceedance



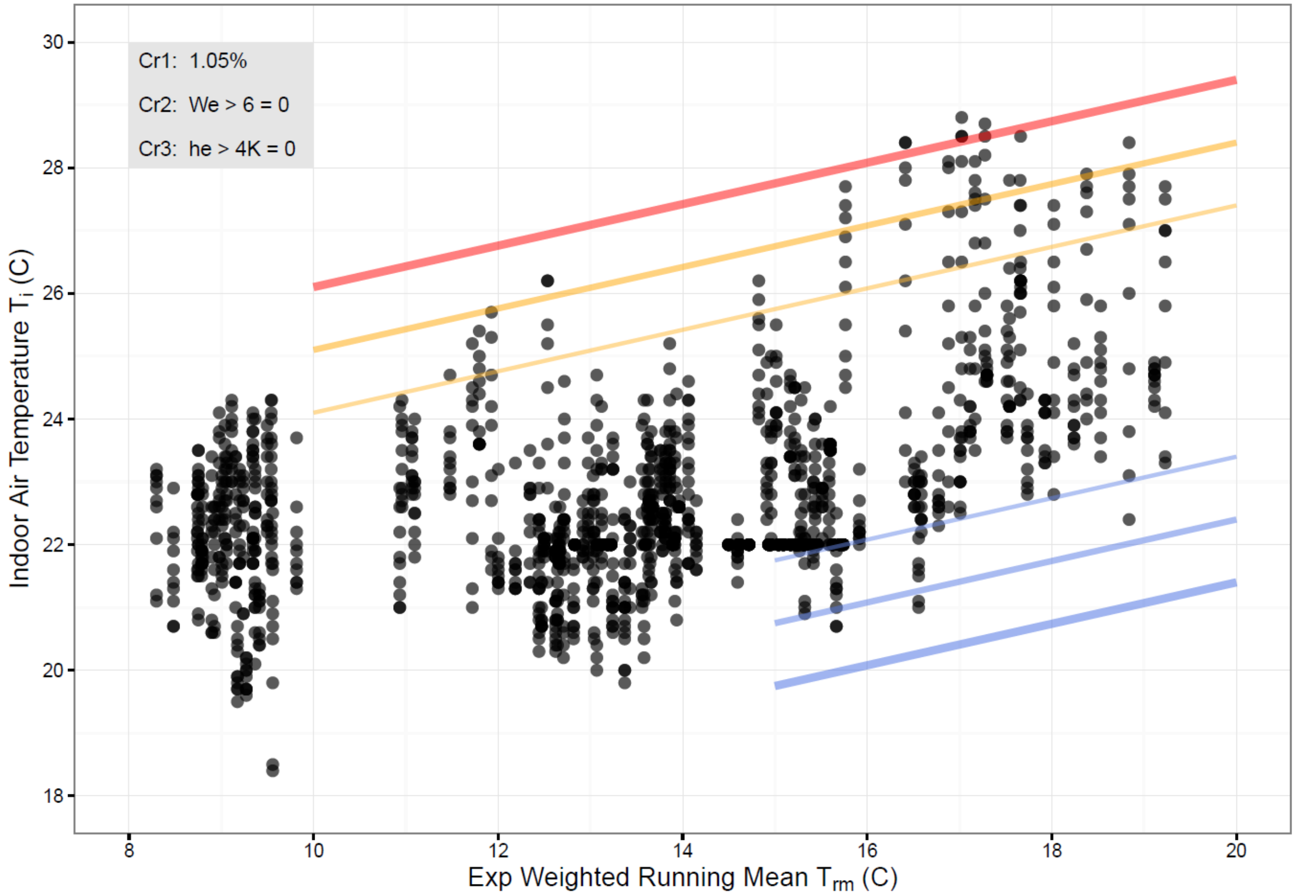
Criterion 1:

The Number of Hours that the operative temperature can exceed the threshold comfort temperature by 1K or more during occupied hours of a typical non heating season shall not be more than 3% of occupied hours.



NSAI. (2007). *ISEN 15251:2007 -Indoor Environmental Input Parameters for design and Assessment of Energy performance of Buildings addressing Indoor Air.*

Nicol, F., & Spires, B. (2013). CIBSE TM52: The Limits of Thermal Comfort. CIBSE. London.



Open Plan Office 2013

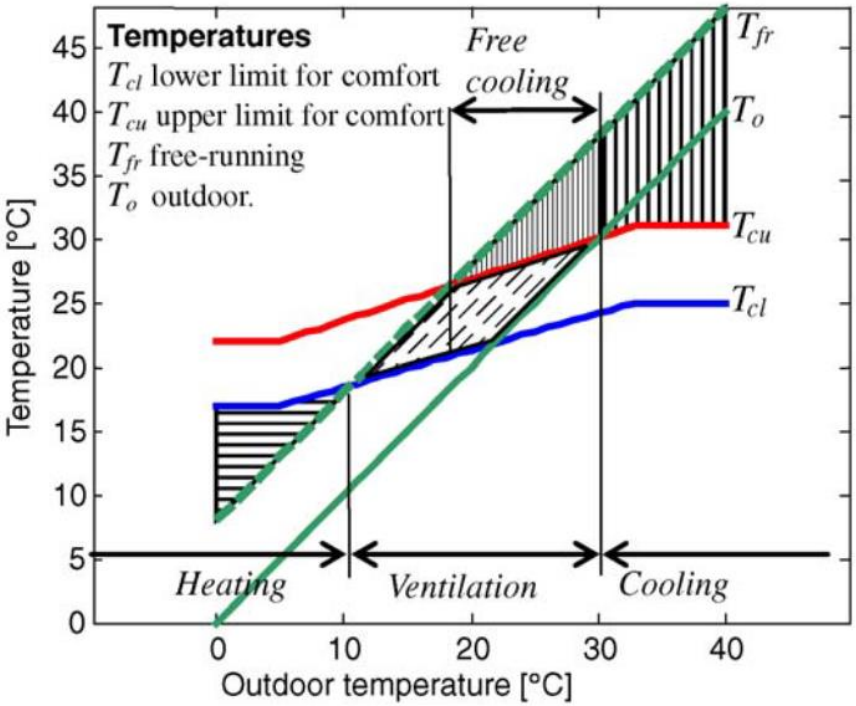
(not fully occupied!)

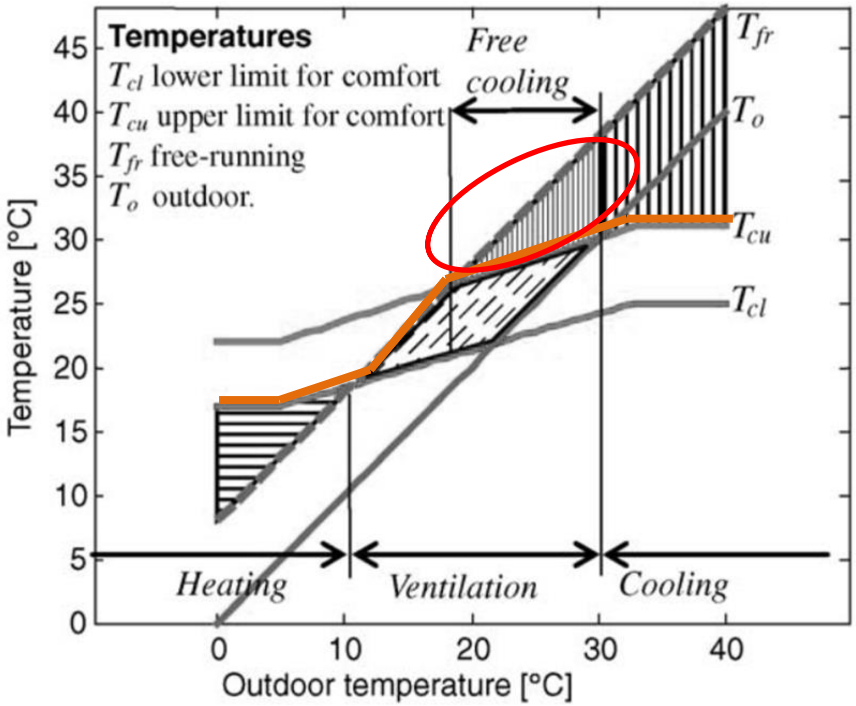
Room	Name	CR1	CR2	CR3	h^*
B287	CAMMS Seminar Room	0	0	0	0.0000
B289	Conference Room	0.6	0	0	0.0050
B290	CAMMS Secretary Office	0.2	1	2	0.0020
B291	CAMMS Managers Office	0	0	0	0.0006
B294	MeSSO Open Plan Office	1.05	0	0	0.9800

How do we quantify climate cooling potential?

Need to consider the relationship between:
- Free running building temperature
- Outdoor temperature
- Comfort limits

Free cooling available – especially in mild climates





Ghiaus, C., & Allard, F. (2006). Potential for free-cooling by ventilation. *Solar Energy*, *80*(4), 402–413.

- How often is this cooling potential available?
- When is Ventilative Cooling needed?
- What is the required flowrate?

Mode	**Description**	**Vent Rate**	**Code**
0	Outdoor temperature is below the balance point temperature – heating mode	Min IAQ	Red
1	When outdoor temperature exceeds balance point temperature – cooling mode; minimum required IAQ rate can provide cooling requirements	Min IAQ	Amber
2	Cooling mode; Enhanced ventilation is needed to satisfy the comfort temperature requirements	Enhanced VC	Blue

Climate cooling potential – todays climate

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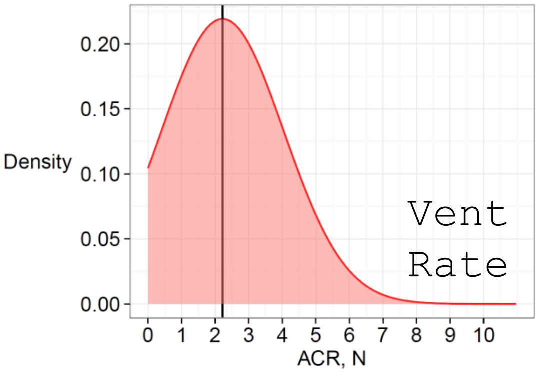
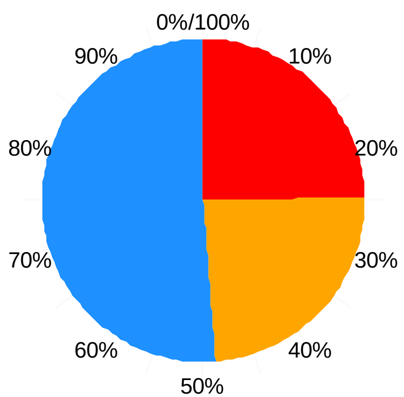
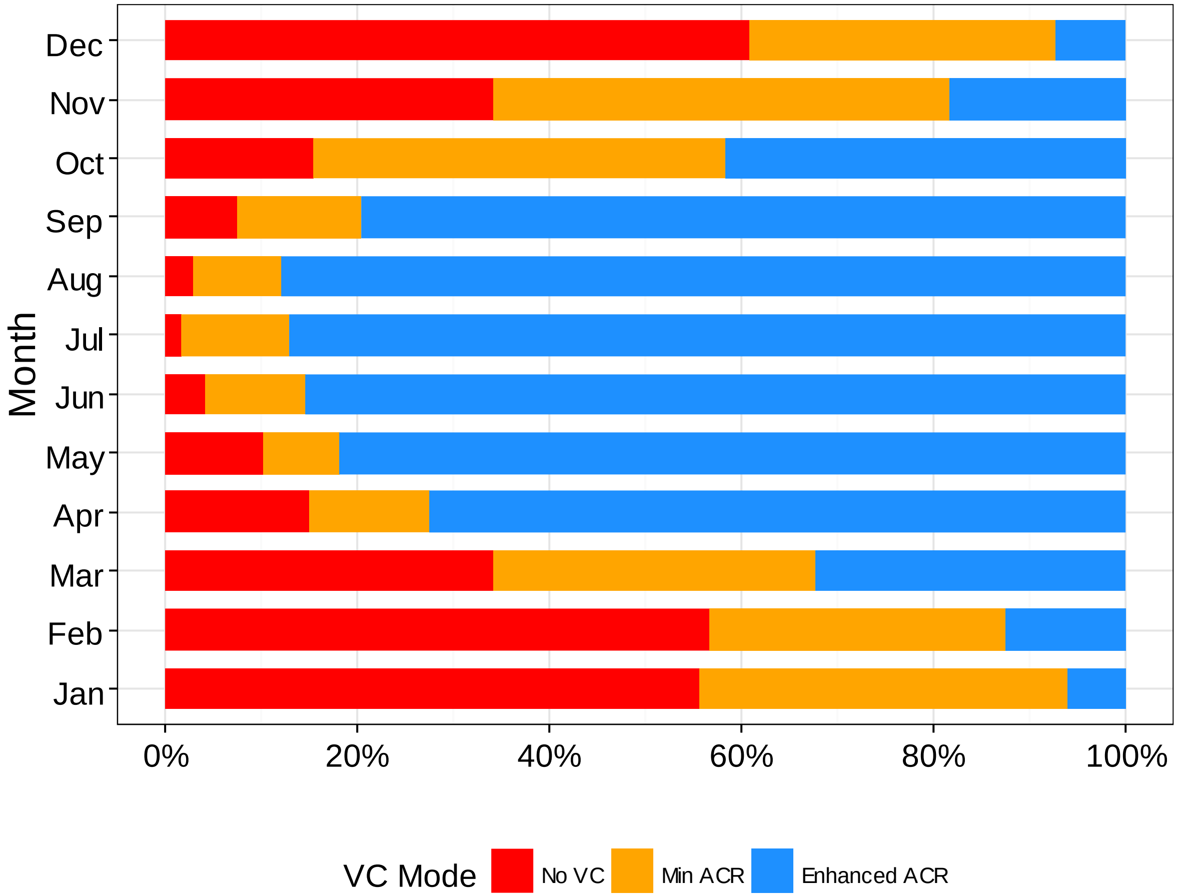
CCP – Part L 2008

Parameter	Value	Units
U – wall / U-roof	0.6 / 0.35	W/m²K
U – glazing	2.2	W/m²K
G – glazing	0.8	-
Shading control setpoint	50	W/m²
Min vent rate	12	l/sp
Lighting power	11	W/m²
Equip power	10.2	W/m²
Occupancy	10	m²p





Annual hrs

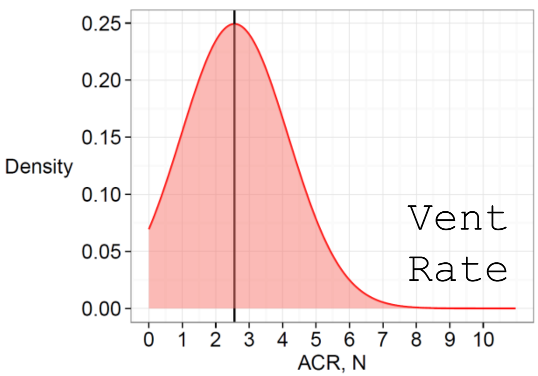


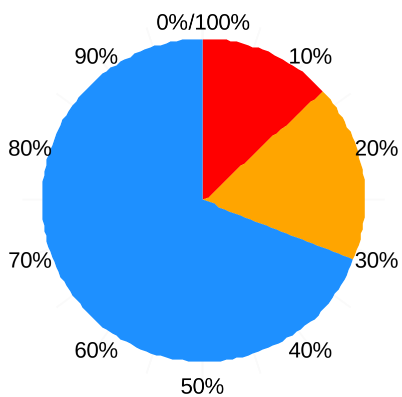
Cooling hrs – 51%
Mean Vent Rate – 2.2 ACH
SD Vent Rate – 1.8 ACH

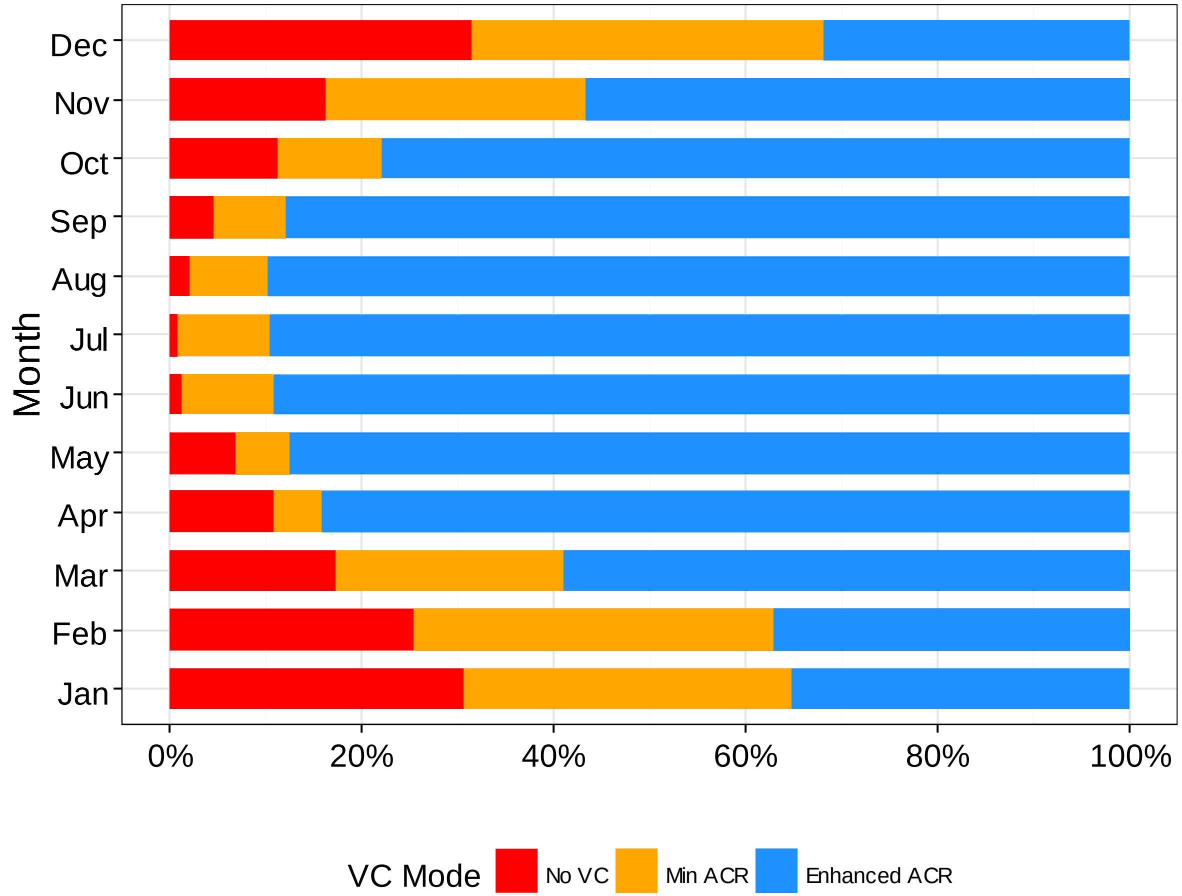
Climate cooling potential – todays climate

CCP – Part L 2017

Parameter	Value	Units
U – wall / U – roof	**0.21 / 0.20**	W/m²K
U – glazing	**1.8**	W/m²K
G – glazing	**0.65**	-
Shading control setpoint	50	W/m²
Min vent rate	12	l/sp
Lighting power	11	W/m²
Equip power	10.2	W/m²
Occupancy	10	m²p



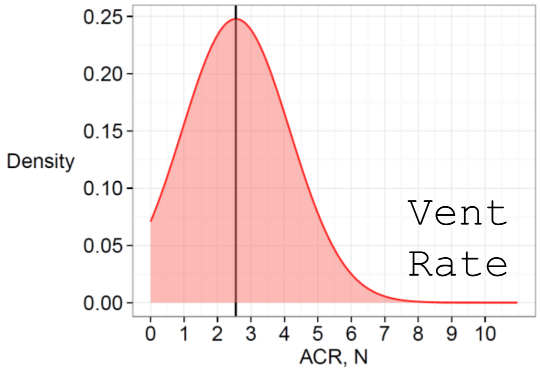


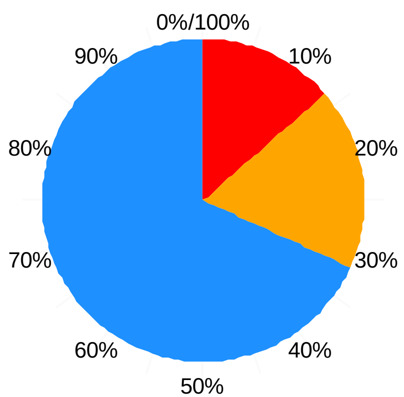


Cooling hrs – 69%
Mean Vent Rate – 2.5 ACH
SD Vent Rate – 1.6 ACH

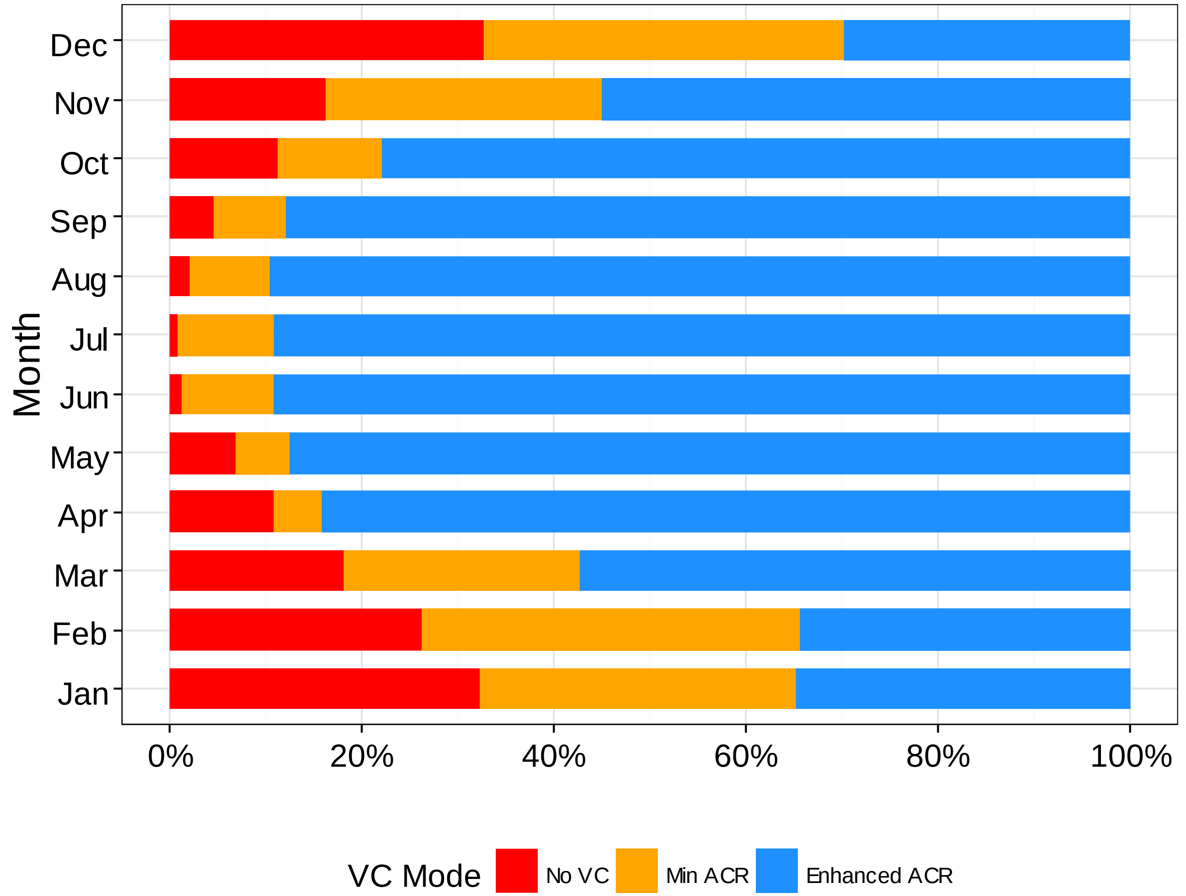
CCP – Proposed Cost Optimal

Parameter	Value	Units
U – wall / U – roof	0.3 / 0.15	W/m²K
U – glazing	1.8	W/m²K
G – glazing	0.65	-
Shading control setpoint	50	W/m²
Min vent rate	12	l/sp
Lighting power	11	W/m²
Equip power	10.2	W/m²
Occupancy	10	m²p





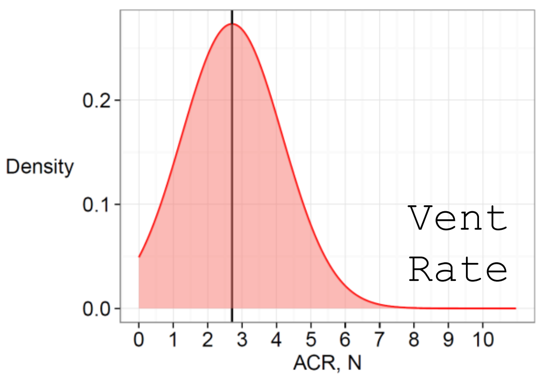
Annual hrs

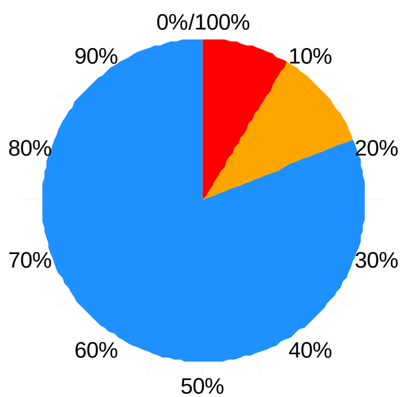


Cooling hrs – 68%
Mean Vent Rate – 2.5 ACH
SD Vent Rate – 1.6 ACH

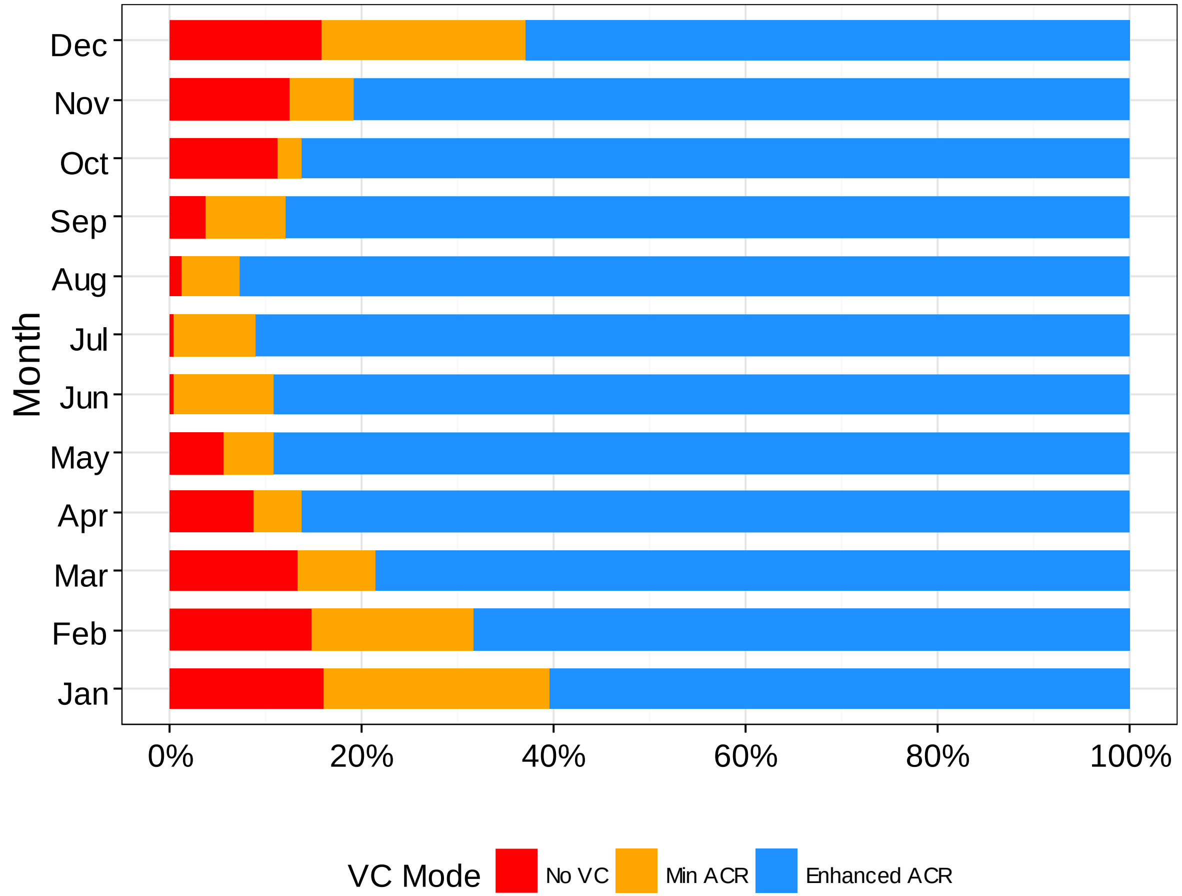
CCP – zero2020

Parameter	Value	Units
U – opaque	**0.10**	W/m²K
U – glazing	**1.09**	W/m²K
G – glazing	**0.517**	-
Shading control setpoint	50	W/m²
Min vent rate	12	l/sp
Lighting power	11	W/m²
Equip power	10.2	W/m²
Occupancy	10	m²p





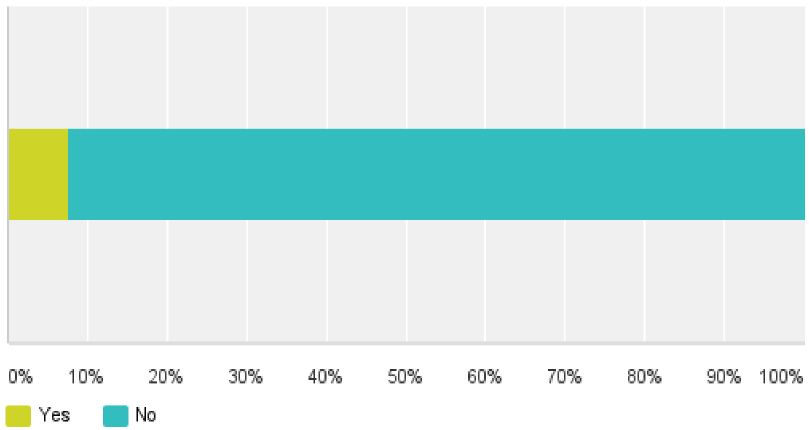
Annual hrs



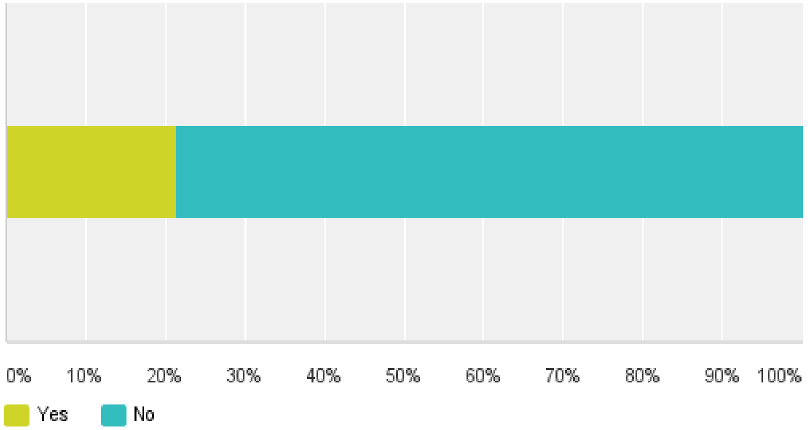
Cooling hrs – 82%
Mean Vent Rate – 2.7 ACH
SD Vent Rate – 1.5 ACH

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

Cork County Hall thermal comfort occupant survey 2014 – 110 respondents



UCC WGB thermal comfort occupant survey 2014 – 40 respondents



What are we learning?

- More data showing people like natural ventilation & openable windows
- Low-energy can mean comfortable but adaptive approach important (free running buildings)
- Overheating will be an issue in low energy retrofits depending on level of upgrade even with night cooling
- Cooling needs are increasing with new and refurbished buildings and cooling season is extending
- Good climate cooling potential exists in Ireland and can offset cooling energy loads (100% in some cases)
- Good component design needed to ensure required ventilation rates are achieved

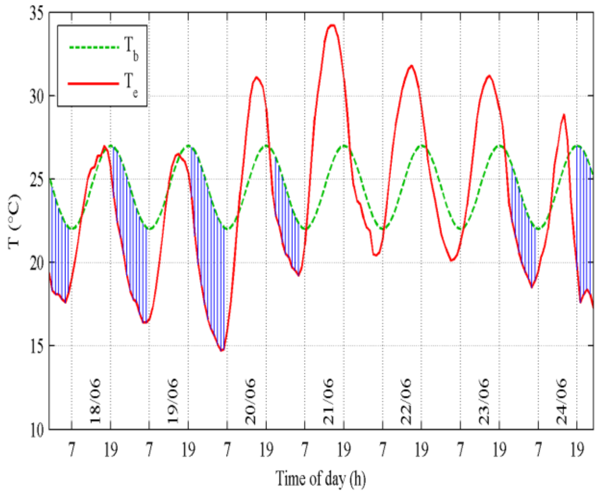
Thank you for listening.

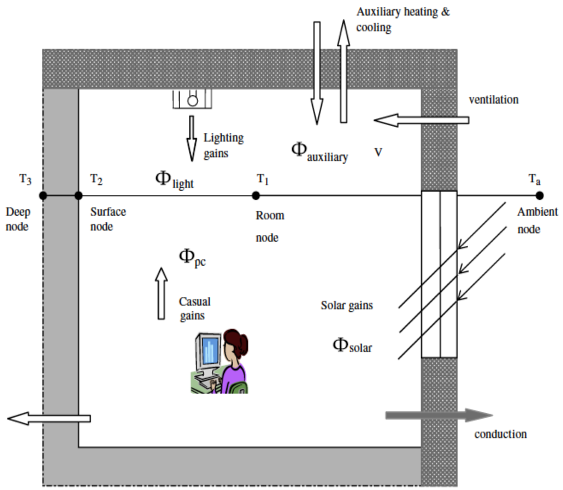
http://messo.cit.ie/nbert

www.zero2020energy.com

Availability of energy for cooling from untreated outdoor air is dependant on:

- the threshold comfort temperature (standards)
- the outdoor temperature (climate)
- Solar irradiation (climate)
- Ventilation rate (openings)
- Building thermophysical properties (u-values etc)
- Building usage patterns (people, pc's, etc)





Thermal Comfort Study 05.2015 / 35 participants / 4 configurations

Config.	MTSV	PD_{per}	PD_{pref}	PD_f	ISO 7730	EN 15251	ASHRAE 55
RS-01	1.3	46%	46%	40%	–	IV	Unacceptable
RS-02	−0.5	20%	6%	10%	C	III	Acceptable
RS-03	−0.4	14%	3%	8%	B	II	Acceptable
RS-04	−1.1	34%	17%	29%	–	IV	Unacceptable