

Thermal comfort – recent challenges

Quality and compliance - Thermal comfort and indoor air quality

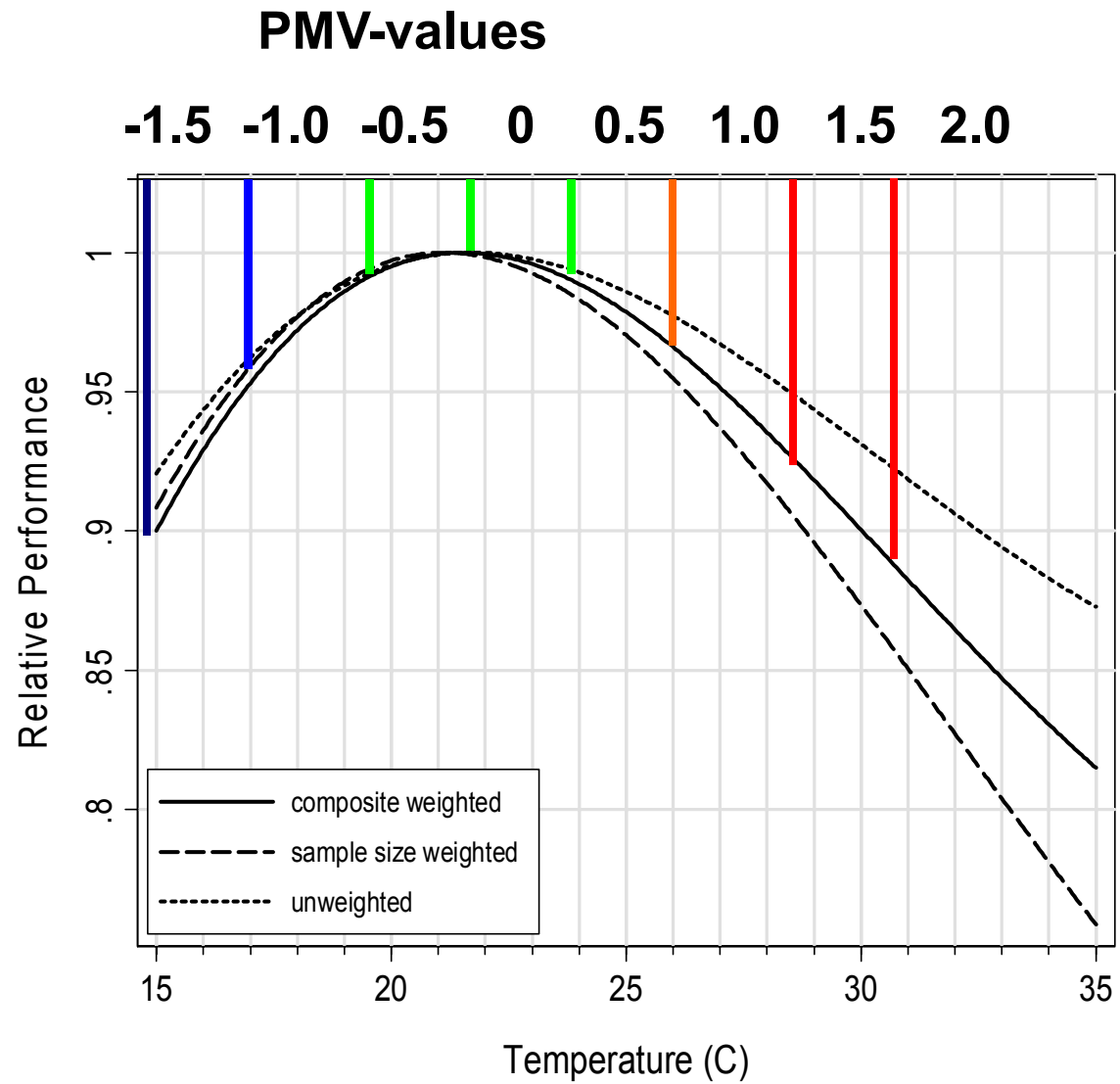
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Thermal comfort – recent challenges

- Over heating in nZEB
- Global warming
- Adaptive comfort
- Ventilative cooling
- Personalized environment
- Cool Cool Bizz
- Combined influence



COMFORT-PRODUCTIVITY

Building costs

People	100
Maintenance	10
Financing	10
Energy	1



Achieving Excellence in Indoor Environmental Quality

- Physical factors
 - Thermal Comfort
 - Air quality (ventilation)
 - Noise-Acoustic
 - Illumination
- Personal factors
 - Activity
 - Clothing
 - Adaptation
 - Expectation
 - Exposure time

Temperature ranges for three categories of indoor environment

Type of building/ space	Category	Operative Temperature for Energy Calculations °C	
		Heating (winter season), ~ 1,0 clo	Cooling (summer season), ~ 0,5 clo
Offices and spaces with similar activity (single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms, Sedentary activity ~1,2 met	I	21,0 – 23,0	23,5 - 25,5
	II	20,0 – 24,0	23,0 - 26,0
	III	19,0 – 25,0	22,0 - 27,0

- *Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics*
- *Up for 5 year review at CEN TC156/TC371*
- *Together with JWG ISO TC163/205*

Recommended categories for design of mechanical heated and cooled buildings

Category	Thermal state of the body as a whole		<i>Local thermal discomfort</i>			
	PPD %	Predicted Mean Vote	<i>Draught Rate, DR %</i>	<i>Vertical air temperature difference %</i>	<i>Warm or cool floor %</i>	<i>Radiant Temperature Asymmetry %</i>
I	< 6	-0.2 < PMV < + 0.2	<10	< 3	< 10	< 5
II	< 10	-0.5 < PMV < + 0.5	<20	< 5	< 10	< 5
III	< 15	-0.7 < PMV < + 0.7	<30	< 10	< 15	< 10
IV	> 15	PMV<-0.7; or 0,7<PMV	>30			



LOCAL THERMAL DISCOMFORT

influence design and dimensioning

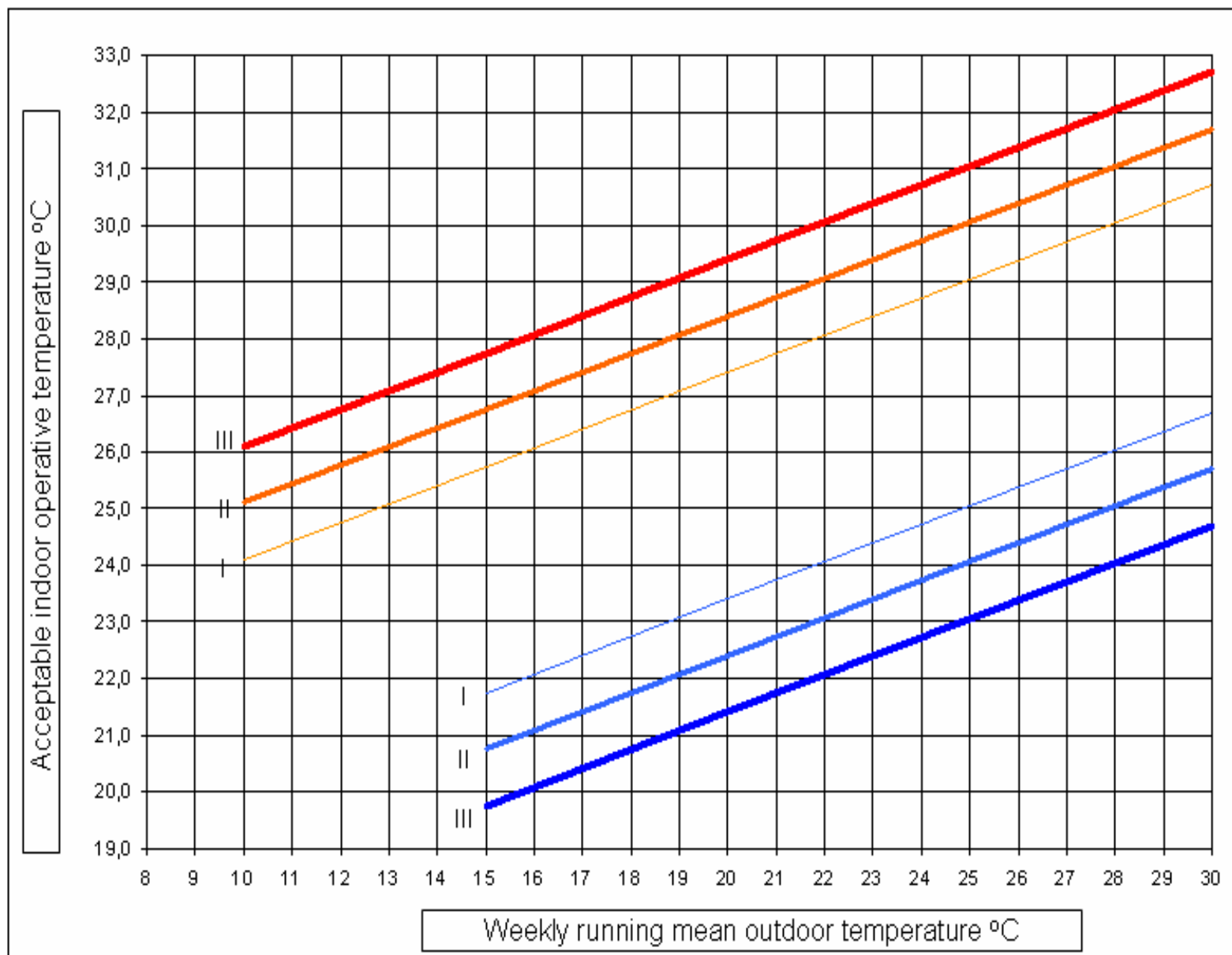
- FLOOR SURFACE TEMPERATURE
- VERTICAL AIR TEMPERATURE DIFFERENCE
- DRAUGHT
- RADIANT TEMPERATUR ASYMMETRI

Included in ISO EN 7730 and ASHRAE
55



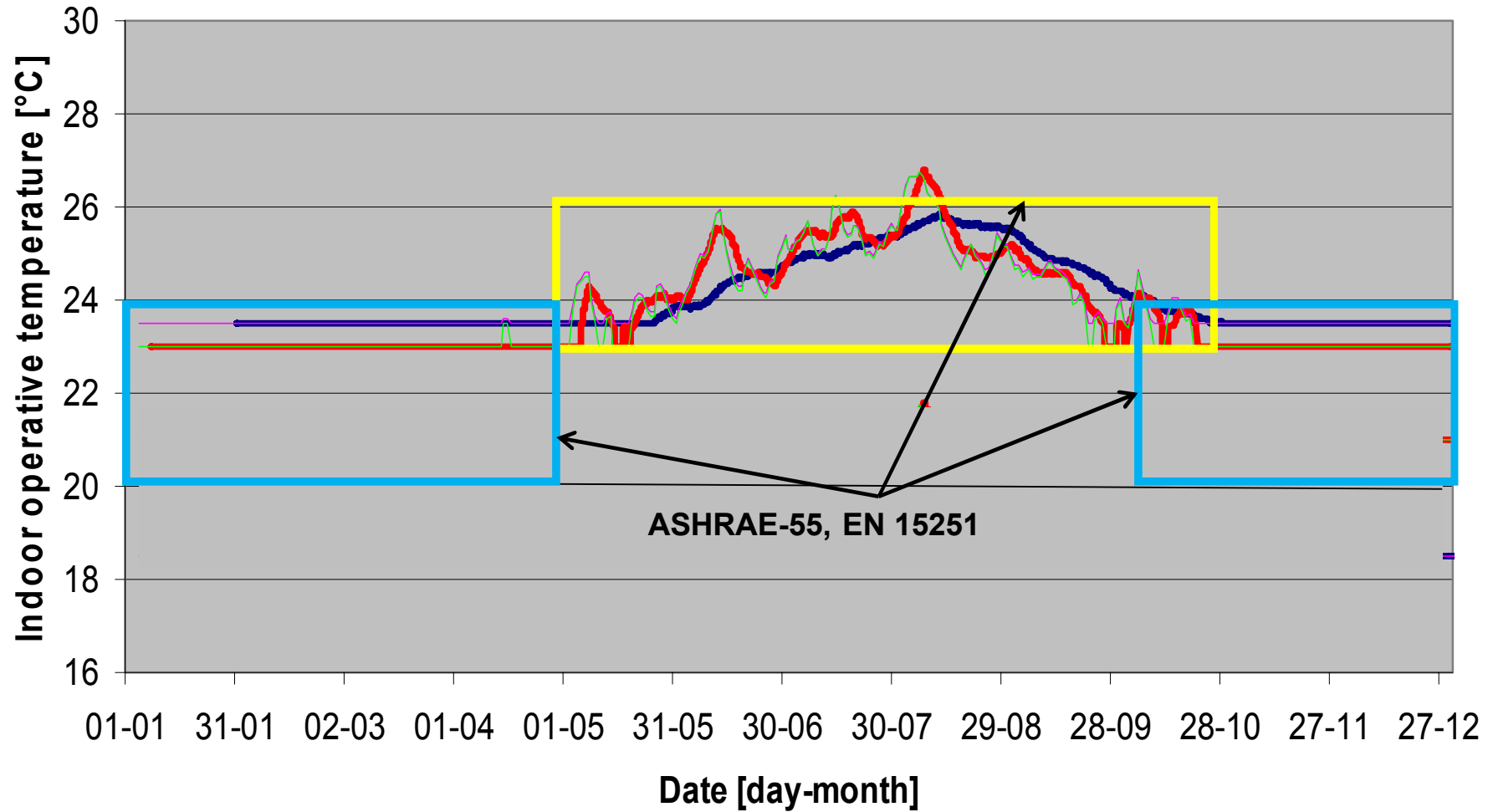
ADAPTATION IN NATURAL VENTILATED BUILDINGS ?

- Behavioural
 - Clothing, activity, posture
- Psychological
 - Expectations





Copenhagen



ASHRAE 15251 ASHRAE weighted average 15251 Weighted average



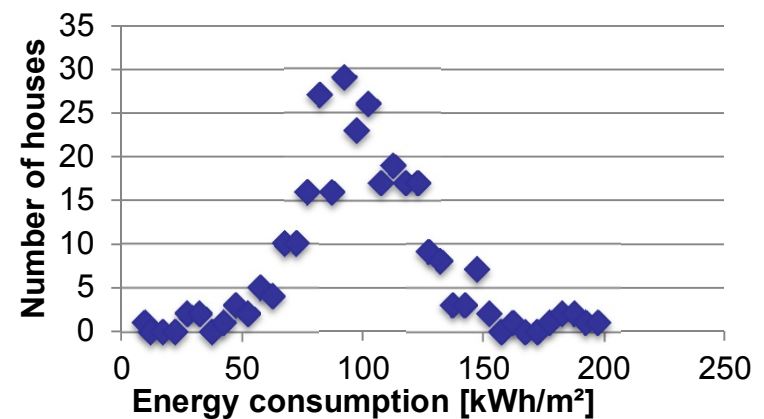
Summer Comfort Danish requirements

- Maximum 100 hours above 26 °C during time of occupancy
- Maximum 25 hours above 27 °C



Investigation of heat consumption in 290 identical houses

- Highest consumption up to 20 times higher than lowest
- Savings
 - 90 % if all use same as lowest consumer
 - 45 % if all use same as the 10 % lowest
 - 30 % if all use same as the 25 % lowest





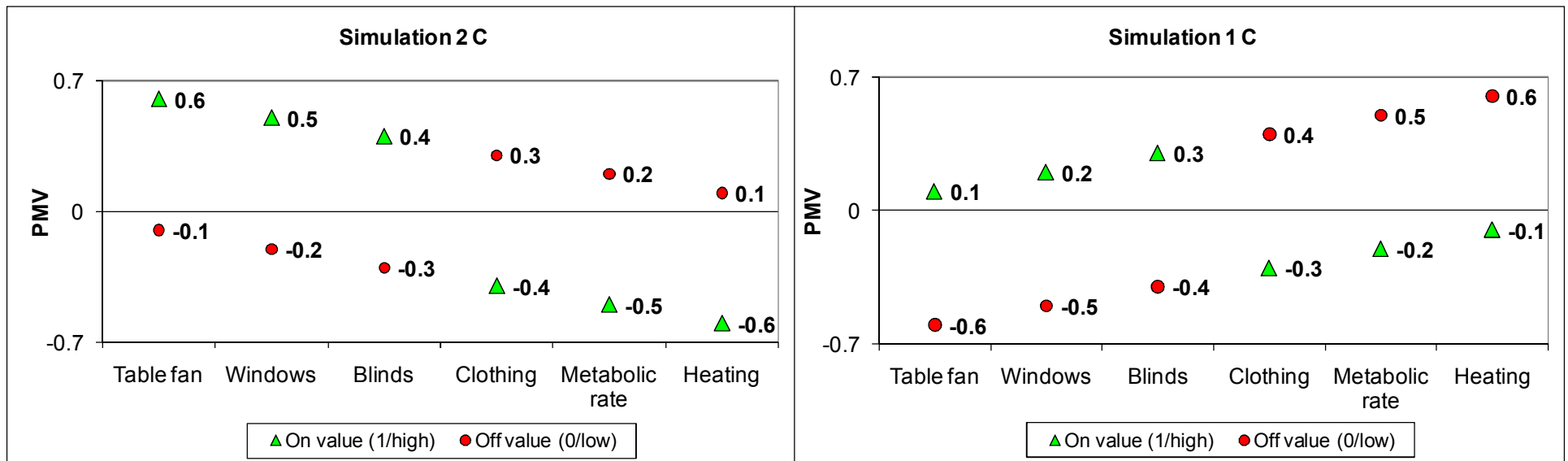
Simulation of the effects of occupant behaviour on indoor climate and energy consumption

- The simulated occupant could manipulate four different environmental controls
 - table fan
 - window opening
 - Blinds
 - Heating
- two personal controls
 - clothing insulation
 - metabolic rate
- All control actions were carried out with the aim of keeping the PMV value within predefined limits

Simulations – Behaviour patterns and criteria

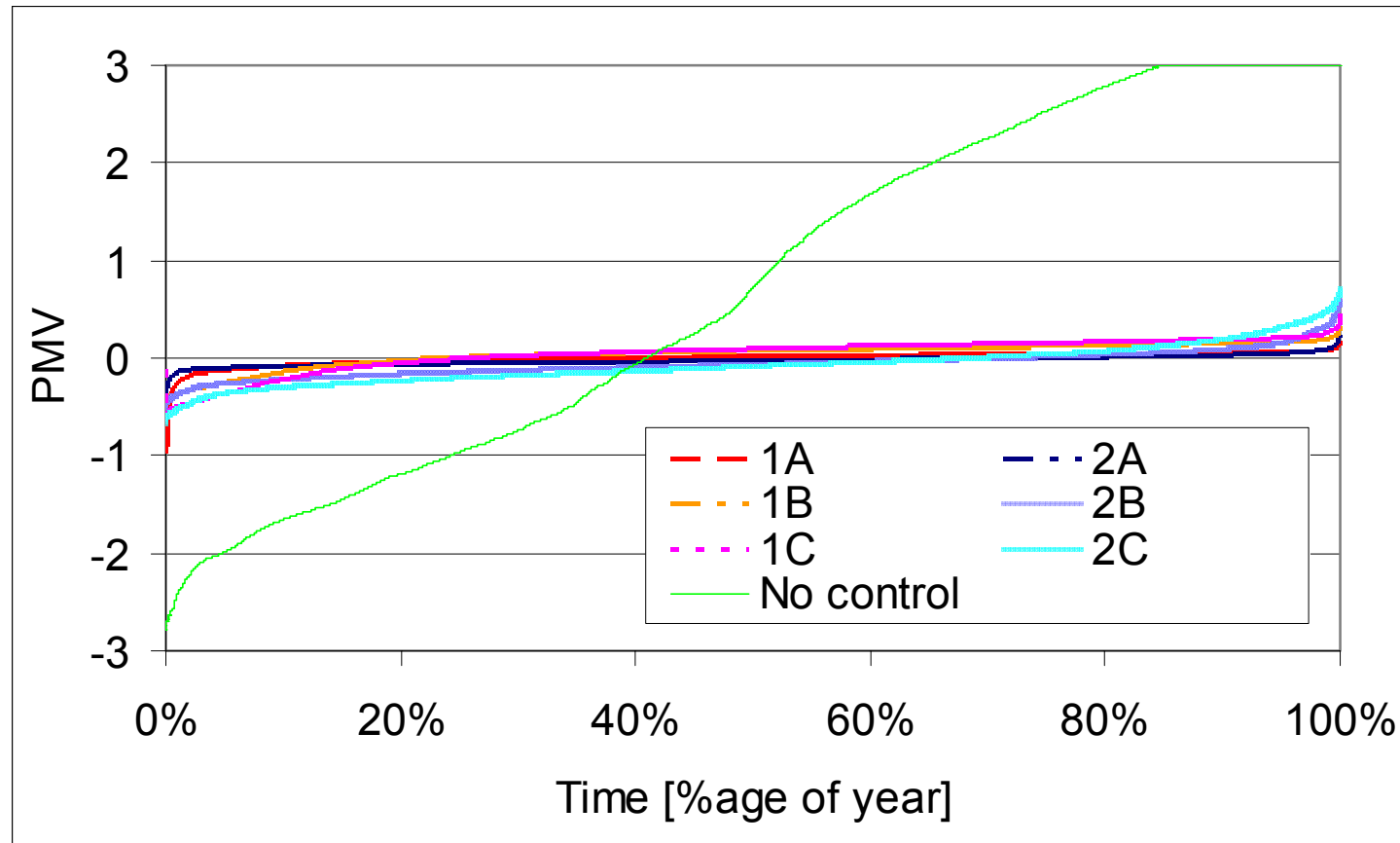
Criterion	Behaviour pattern 1	Behaviour pattern 2
A (-0.2 < PMV < 0.2)	Simulation 1A	Simulation 2A
B (-0.5 < PMV < 0.5)	Simulation 1B	Simulation 2B
C (-0.7 < PMV < 0.7)	Simulation 1C	Simulation 2C

- Behaviour pattern 1:
Energy expensive
- Behaviour pattern 2:
Energy efficient





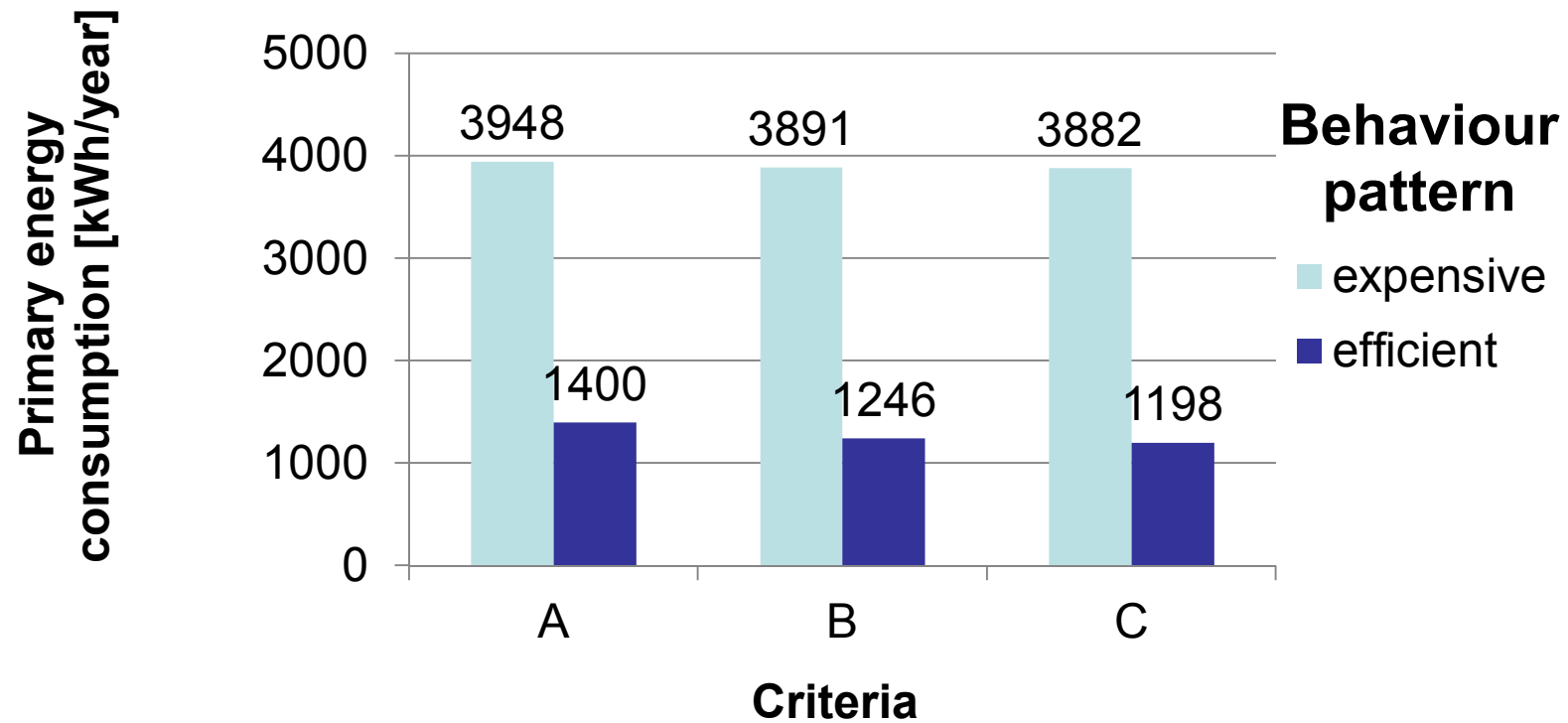
Simulation of the effects of occupant behaviour on indoor climate and energy consumption



Duration curves for the PMV index in the 6 simulations and for the reference simulation. The figure shows how long time (in percentage of a year) the PMV index was below a certain value.



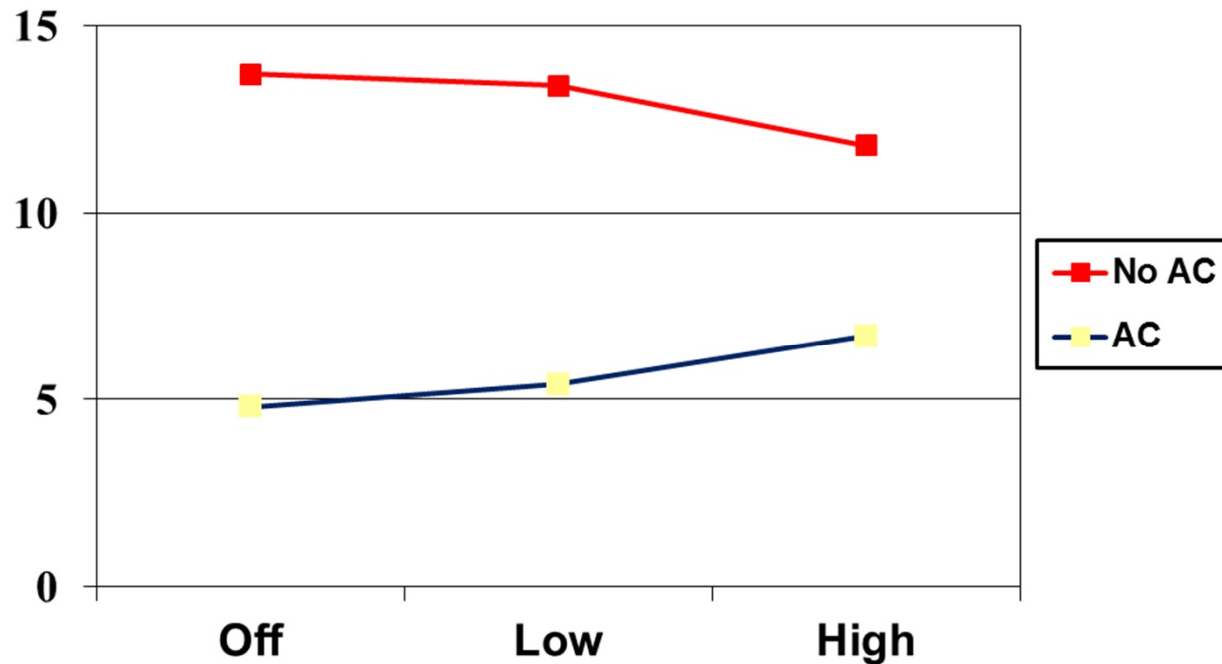
Results - Energy



- Simulated behaviour patterns – realistic?
- Drivers behind behaviour?

Hours/week with windows open

(NB: Different classes with natural/mechanical ventilation)

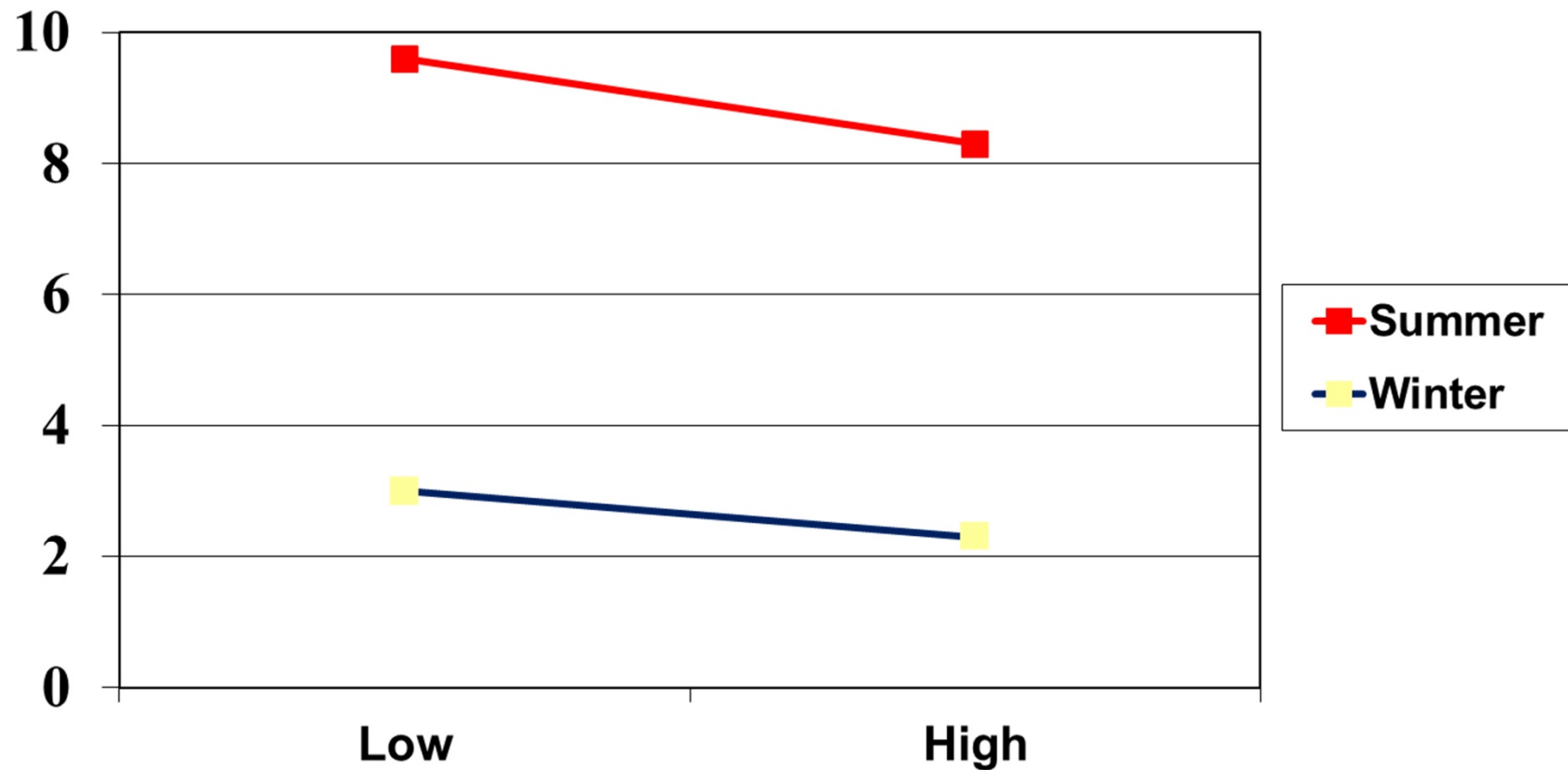


Mechanical ventilation



Hours/week with windows open

(NB: different classes in winter & summer)



Ventilation (with no cooling)

Current project - Behaviour changes as a tool of energy conservation?

- Is it possible to achieve energy savings by facilitation of behaviour changes?
- Can direct and current information about consequences of actions facilitate behaviour changes?
- Will information about actual price of heating and advice about behaviour facilitate changes in habits?





Indoor Air Quality and Thermal Comfort in Zero Energy Buildings

If an energy efficient measure also improve the indoor environment it will

- Lower Health Risk
- Increase Comfort
- Increase Productivity
- Always be cost efficient.