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Thermal comfort – recent challenges

Quality and compliance - Thermal comfort and indoor air quality

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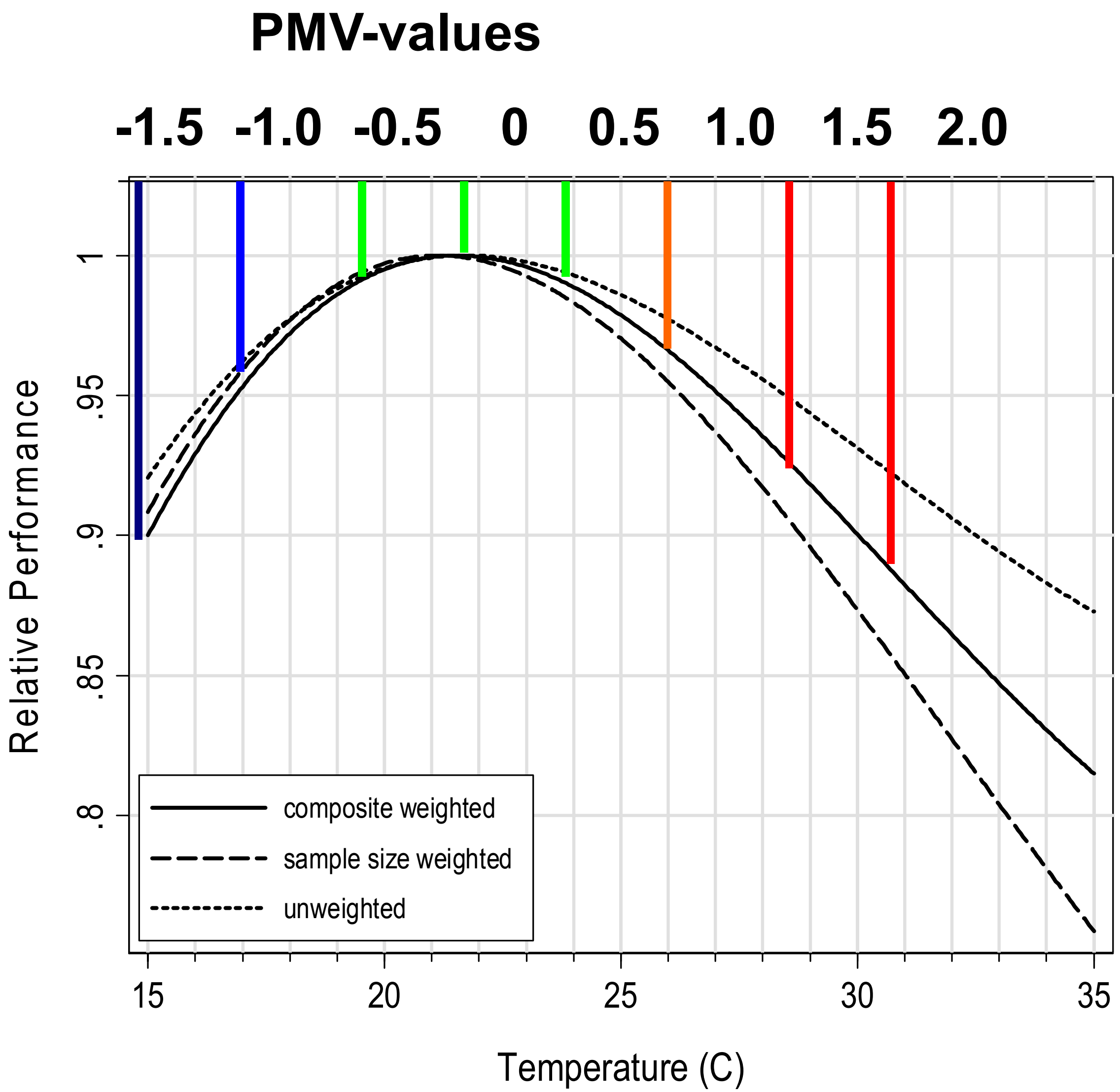
Thermal comfort – recent challenges

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



from Seppänen and Fisk 2005a

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COMFORT-PRODUCTIVITY
Building costs

People	100
Maintenance	10
Financing	10
Energy	1

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Achieving Excellence in Indoor Environmental Quality

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

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Temperature ranges for three categories of indoor environment

Type of building/ space	Category	Operative Temperature for Energy Calculations °C	
Offices and spaces with similar activity (single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms, Sedentary activity ~1,2 met		Heating (winter season), ~ 1,0 clo	Cooling (summer season), ~ 0,5 clo
	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

EN15251

- *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*

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Recommended categories for design of mechanical heated and cooled buildings

Category	Thermal state of the body as a whole		*Local thermal discomfort*			
	PPD %	Predicted Mean Vote	*Draught Rate, DR %*	*Vertical air tempe-rature difference %*	*Warm or cool floor %*	*Radiant Tempe-rature Asym-metry %*
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

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ADAPTATION IN NATURAL VENTILATED BUILDINGS ?

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

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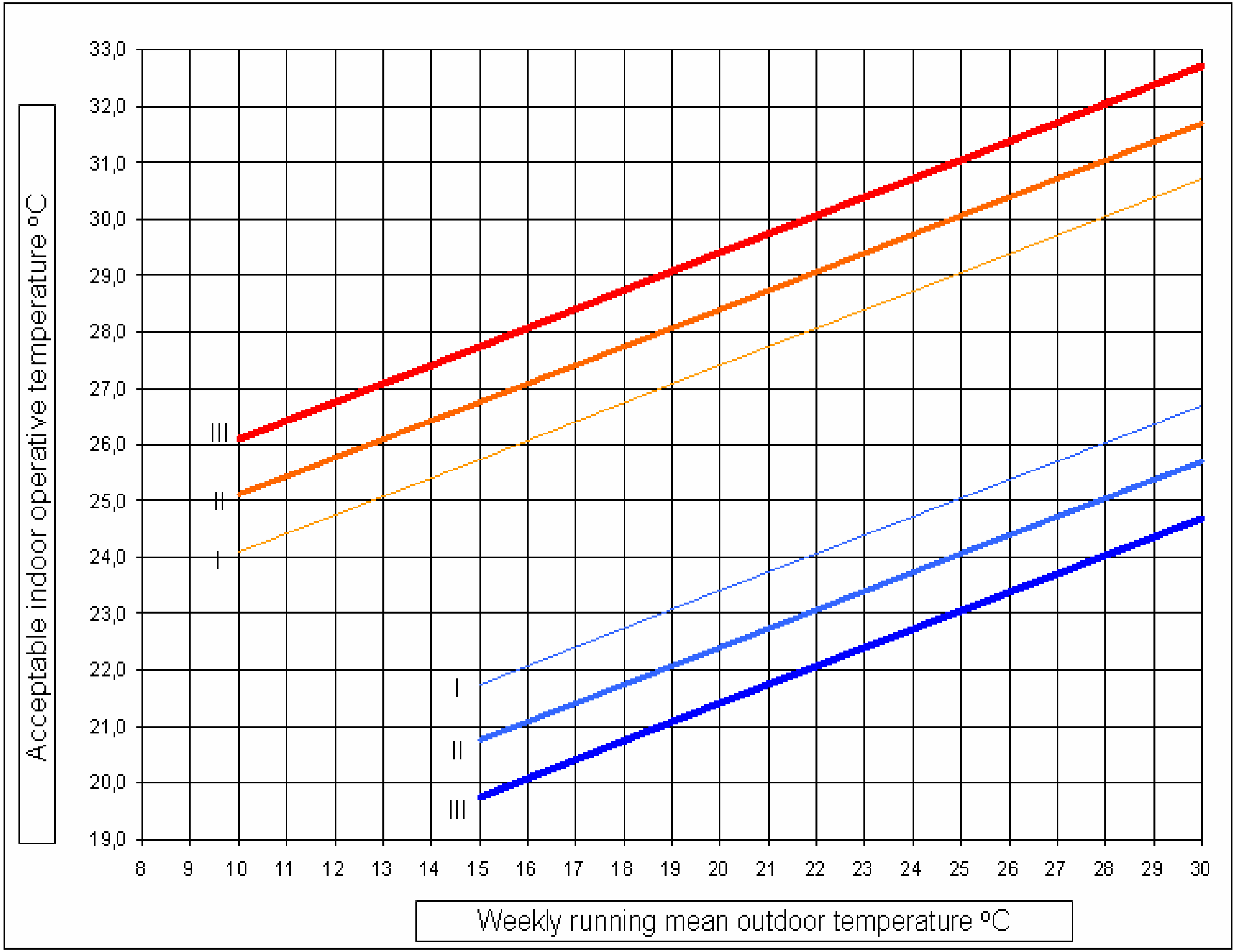

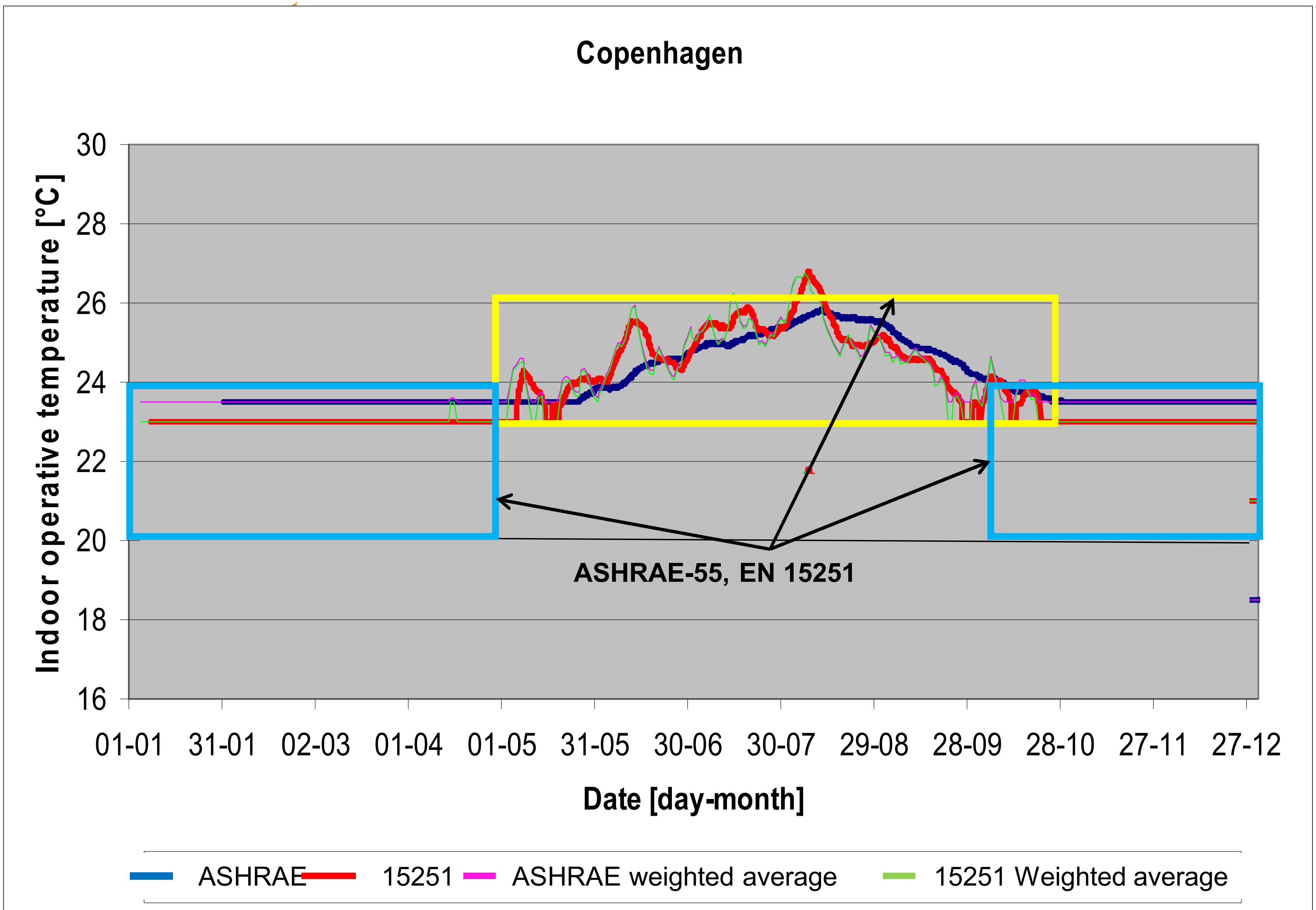
Copenhagen
30
28
26
24
22
20
18
16
Indoor operative temperature [°C]
ASHRAE-55, EN 15251
01-01
31-01
02-03
01-04
01-05
31-05
30-06
30-07
29-08
28-09
28-10
27-11
27-12
Date [day-month]
ASHRAE
15251
ASHRAE weighted average
15251 Weighted average

Summer Comfort
Danish requirements

- Maximum 100 hours above 26 ^{o}C during time of occupancy
- Maximum 25 hours above 27 ^{o}C

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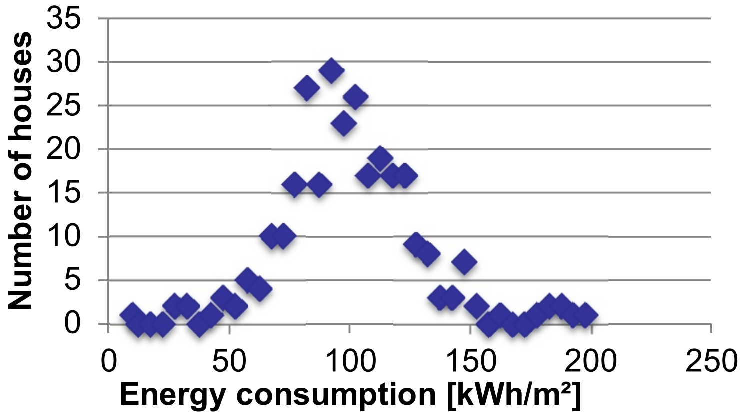
Investigation of heat consumption in 290 identical houses

- 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



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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

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Simulations – Behaviour patterns and criteria

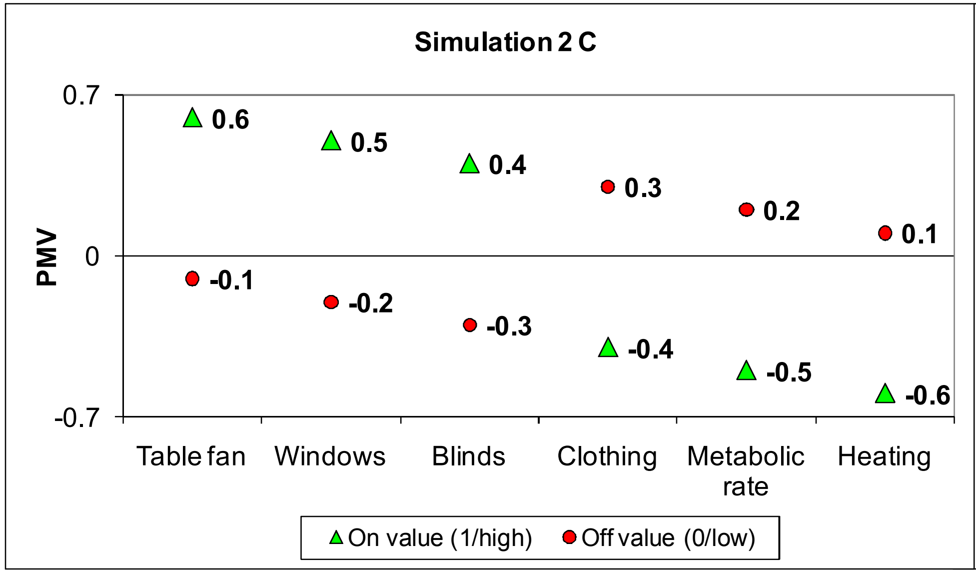
Criterion	Behaviour pattern 1	Behaviour pattern 2
A (-0.2<PMV<0.2)	Simulation 1A	Simulation 2A
B (-0.5<PMV<0.5)	Simulation 1B	Simulation 2B
C (-0.7<PMV<0.7)	Simulation 1C	Simulation 2C

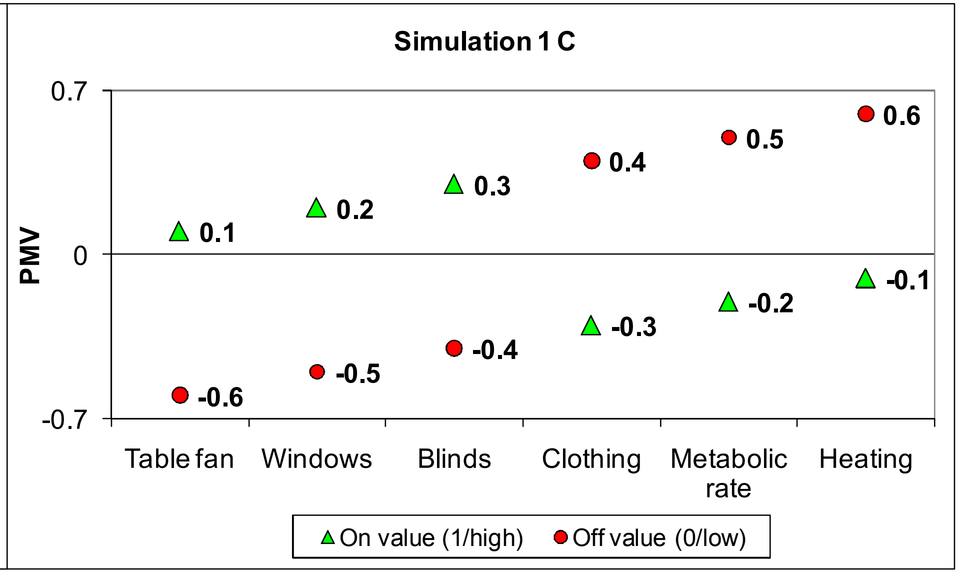
- **Behaviour pattern 1:**

  Energy expensive

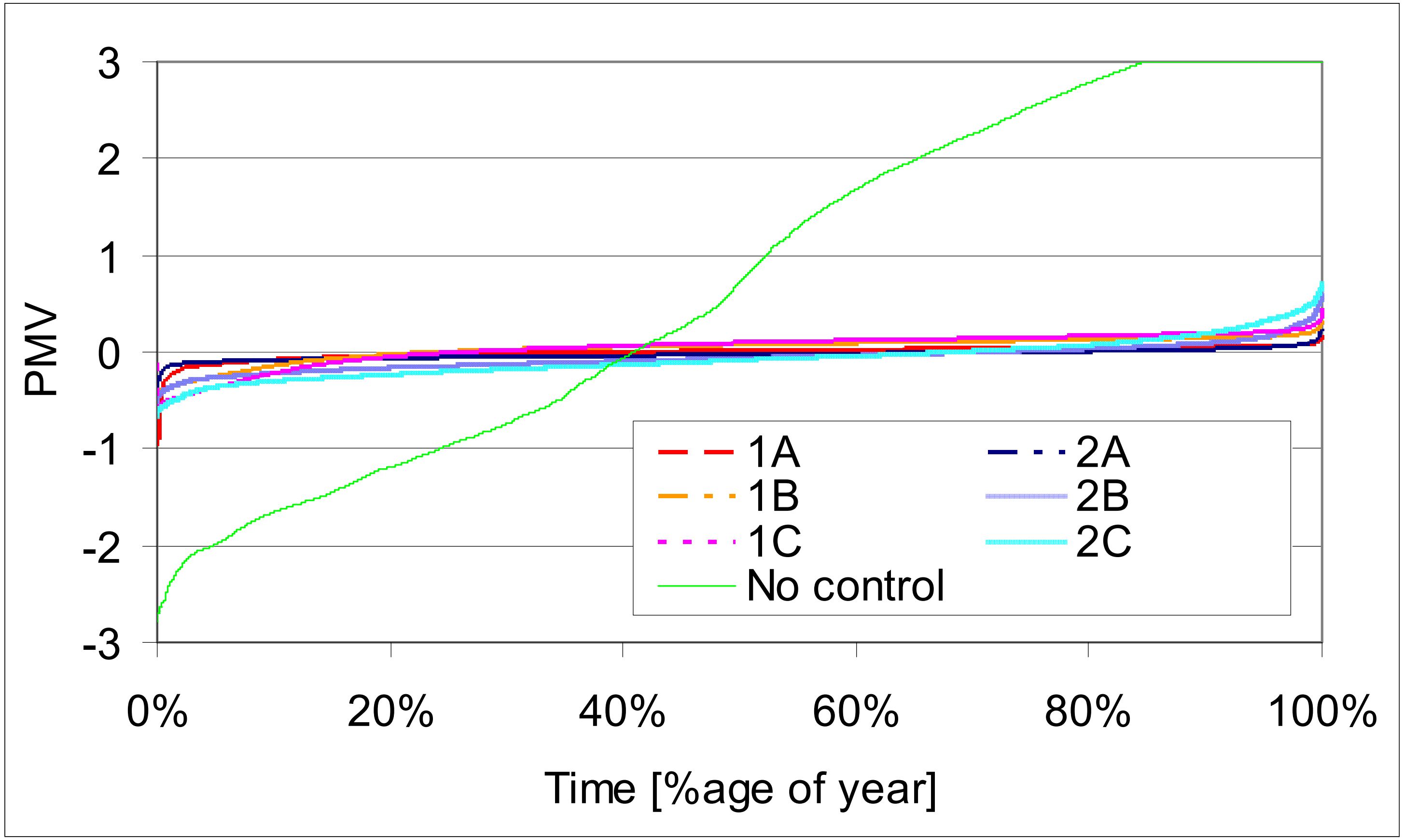
Behaviour pattern 2:

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.

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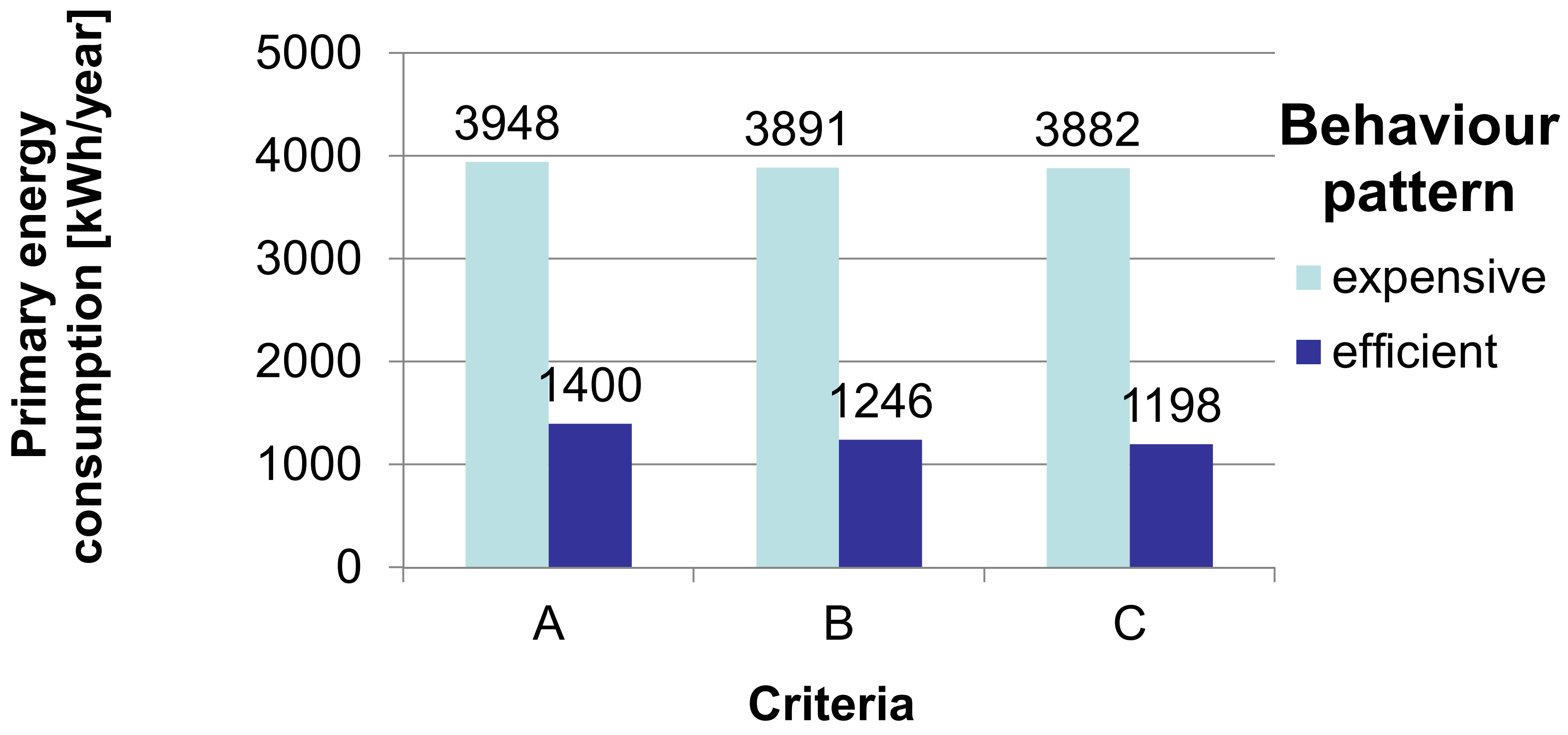
Results - Energy



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

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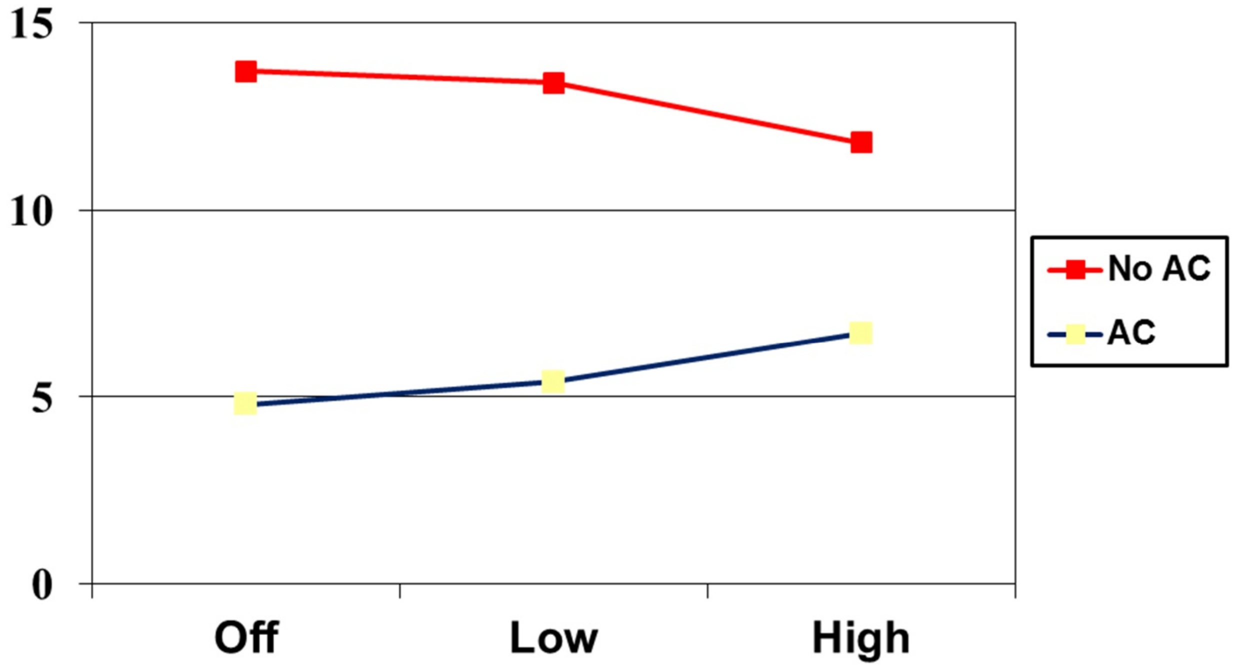
Hours/week with windows open

(NB: Different classes with natural/mechanical ventilation)



Mechanical ventilation

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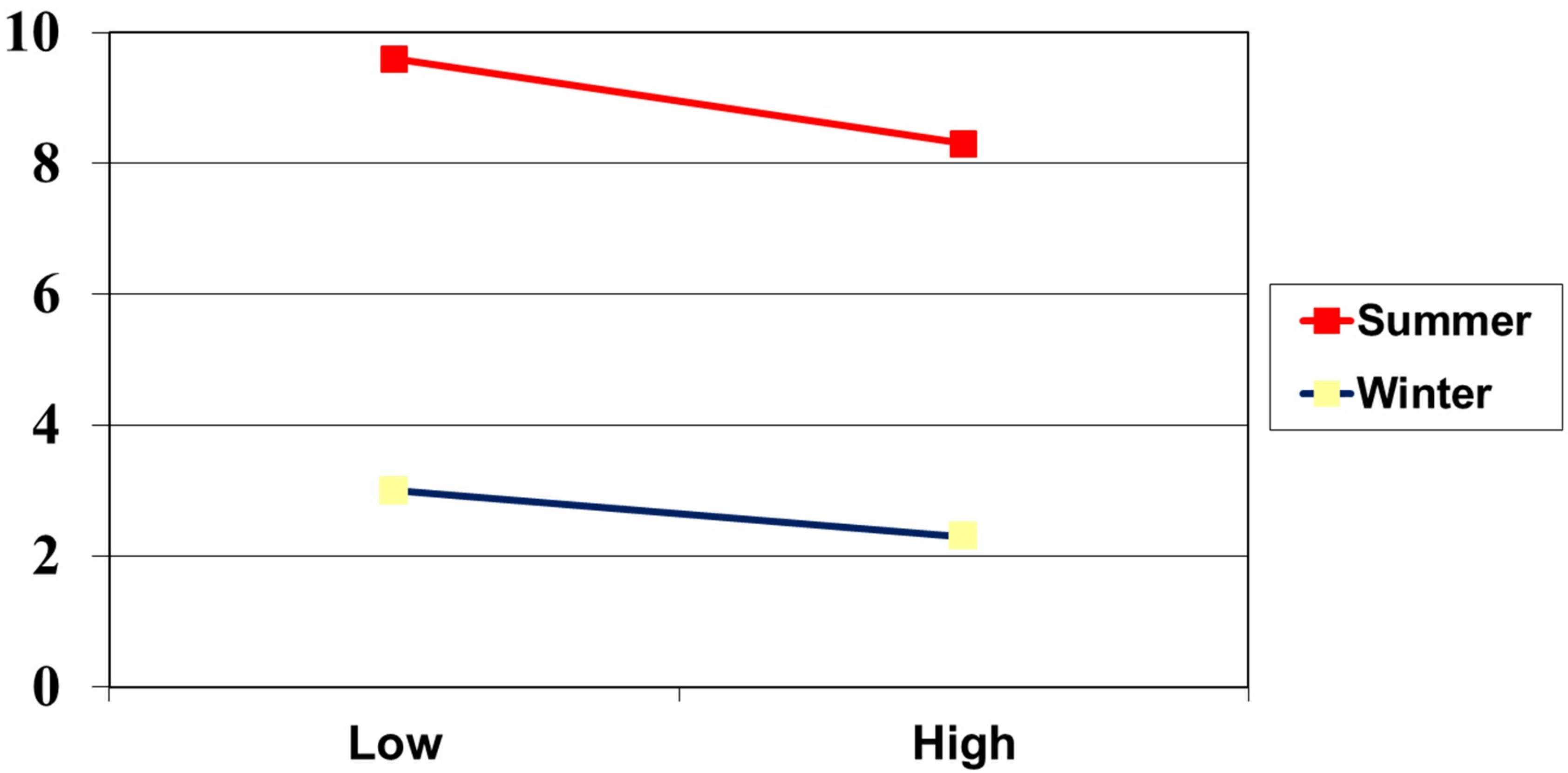
Hours/week with windows open

(NB: different classes in winter & summer)



Ventilation (with no cooling)

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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?

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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.