The Energy Costs of Comfort and Compatibility with EPBD

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Comfort Monitoring for CEN Standard EN 15251 linked to EPBD

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The COMMONCENSE Project

Comfort Monitoring for CEN Standard EN 15251 linked to EPBD

- **Partners**
  - **Sonnergy, UK, (Coordinator)**
  - **Politechnico di Milano (eERG), Italy**
  - **University of Athens (NKUA), Greece**
  - **Universidade di Porto (FEUP), Portugal**
  - **London Metropolitan University (LMU), UK**
  - **Bartenbach LichtLabor (BBL), Austria**
- **Action**
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  - **Commenced 1 December 2007, ends 31 May 2010**
  - **Kick-Off Meeting, London, 24-25 January 2008**

Energy Use in Buildings

- **>40% of all delivered energy in the EU is used in buildings**
- **In the UK 66% of building energy use is for space heating**
- **20% domestic building energy use is for water heating**
- **20% commercial building energy use is for lighting**
- **Similar patterns of energy use in Member States with cooling dominated climates**
- **Use of mechanical ventilation and air conditioning is increasing**
- **Security of supply, environmental impacts, sustainable development, ambitious energy and carbon reduction targets, energy efficiency, renewable energy generation, opportunities for wealth and job creation**

What is Thermal Comfort?

"that state of mind which expresses satisfaction with the thermal environment" (ASHRAE)

How do you feel ?

+3 Hot

+2 Warm

+1 Slightly warm

0 Neutral

-1 Slightly cool

-2 Cool

-3 Cold

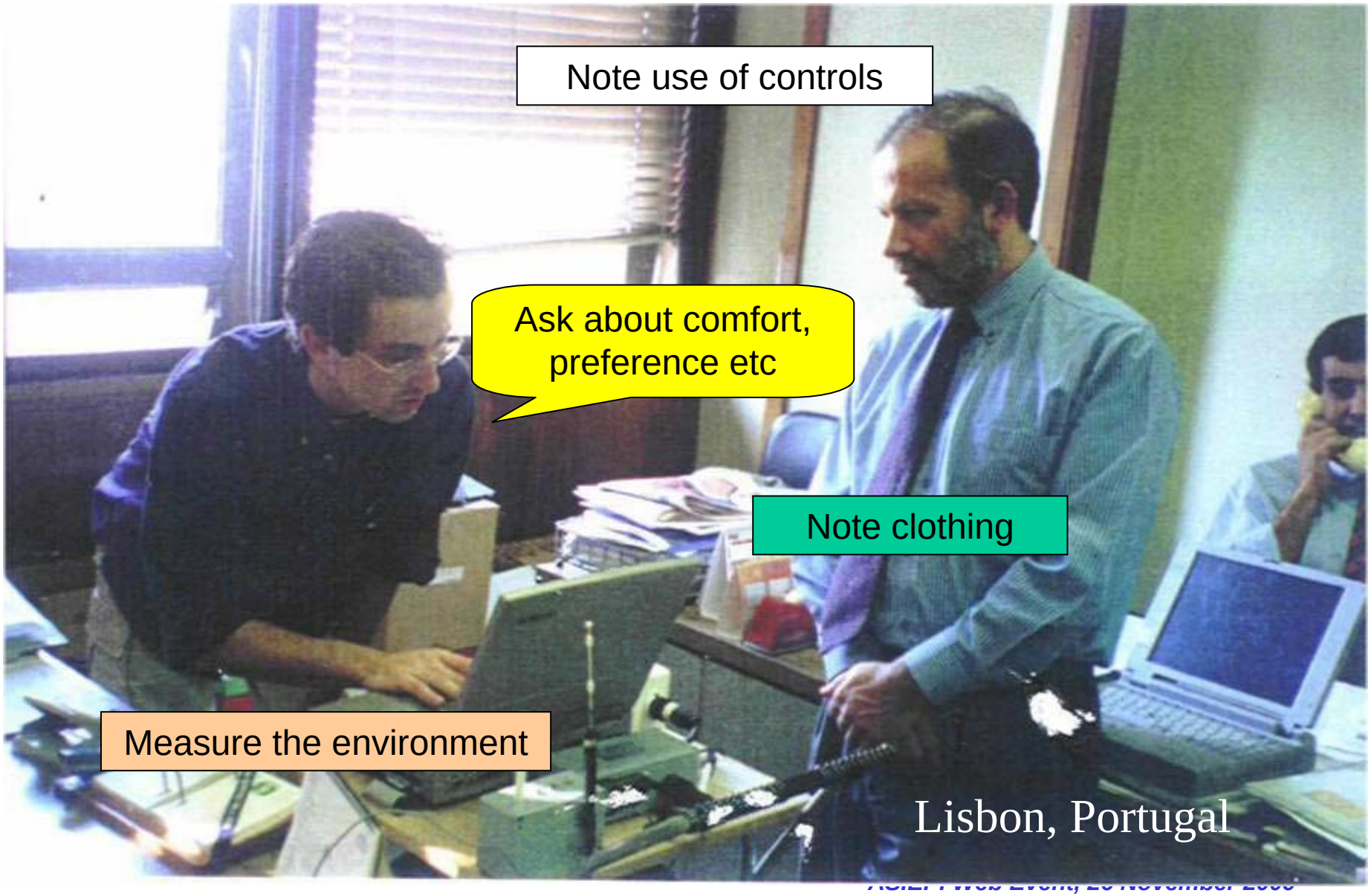
"Comfort"

Predicting comfortable temperatures

Thermal comfort is investigated in two ways:

1. **Undertaking laboratory studies in closely controlled conditions to build a model based on heat balance based on physics and physiology (e.g. PMV)**
2. **Studying peoples reaction to conditions in their normal everyday environment using user surveys and statistics to produce an empirical model**

The survey


Note use of controls
Ask about comfort, preference etc
Note clothing
Measure the environment
Lisbon, Portugal

Heat balance model

The basic equation for heat balance is:

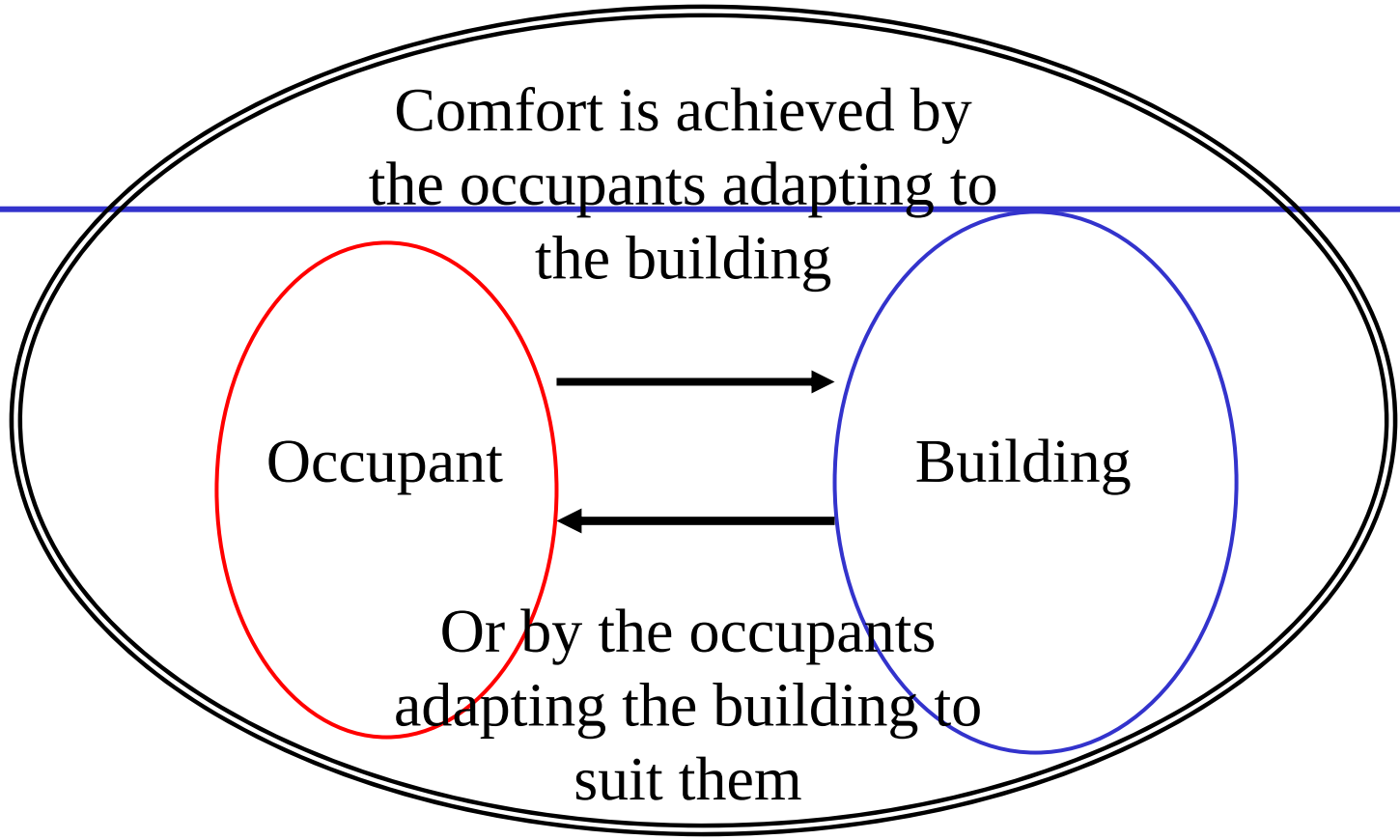
M-W = Ev + Ra + K + Co + Re + S

- **Where *M* = rate of metabolic heat production**
- ***W* = energy used in doing mechanical work**
- ***Ev* = heat loss by evaporation from the skin**
- ***Ra* = Heat loss through radiation**
- ***K* = Heat loss by conduction (generally negligible)**
- ***Co* = Heat loss by convection**
- ***Re* = Heat loss by respiration (convective + evaporative)**
- ***S* = Heat stored in the body (= 0 over time)**

Heat balance model

Psychophysics

- **Comfort is a psychological phenomenon and solely not one of physics and physiology**
- **This means that an index based on these will never give an exact prediction of comfort**
- **Comfort can only be measured by asking the subject population**



This has to be done within the existing climatic, social, economic, **architectural** and cultural context. **Buildings should be designed to provide acceptable conditions**

Adaptive Approach - Inclusion in Standards

This 'adaptive' approach is now included in some standards and guides for comfort in particular for buildings which are not heated or cooled:

- ASHRAE Standard 55-2004
- Dutch adaptive Guideline (2005)
- CIBSE Guide Section A1 2006
- CEN Standard EN15251:2007

EN15251

Title:

Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics

CEN/TC 156WG12 - EN15251 - 2007 drafted in support of implementation of the EPBD

Scoping the problem

- **The provision of comfort is a key concern for building designers.**
- **EN15251 defines acceptable indoor temperatures, light levels and other environmental parameters as the basis for energy calculation.**
- **Mechanical cooling is expensive in energy.**
- **Naturally ventilated (NV) buildings with fewer energy costs cannot control indoor conditions as closely.**
- **Formally standards have used comfort models which favour close environmental control so NV buildings have been looked on as second-rate. EN15251 allows NV buildings more freedom for environmental variation in line with the findings of adaptive comfort theory.**

EN15251 Strong points

- **Brings together limits for all environmental dimensions**
- **Includes allowance for NV buildings in free-running mode in temperature limits**
- **Wide range of methods for assessing compliance – particularly in the thermal environment**
- **Allows for cooling effect of user-controlled fans**
- **Includes a new approach to categorisation**
- **Buildings can be categorised using either the PMV or the adaptive approach**

Commoncense Aims

- **Commoncense seeks to use existing information from field surveys to test the limits set by EN15251 for temperature and lighting and to validate its recommendations using existing data and building simulations.**
- **Identify the energy cost of complying with the comfort categories defined by EN 15251**
- **Demonstrate achievement of effective and significant reduction in the energy consumption in buildings without compromising occupant comfort**
- **Where necessary make recommendations to CEN to alter or improve the standard**

The Work of CommonCense

- **Commoncense tests whether EN15251 ‘works’ and sensible implementation results in energy savings**
- **Do the categories express real satisfaction with the environment?**
- **Improve understanding for implementation and provide advice on how to revise the standard if it gives difficulties or problems**
- **Provide information about the energy implications of the Standard and in particular whether the Standard, by using a system of categories, is encouraging high energy buildings in the case of new buildings and major rehabilitations.**
- **Provide quantitative information about the energy cost of achieving the different comfort categories using a range of different cooling/heating techniques and building forms.**
- **Give information about how to enable low energy buildings to comply more readily.**
- **Identify problems and difficulties and produce solutions for building designers and engineers**

EN15251 Comfort Categories

- **New categories**
- **Category II is assumed to be the 'norm'**

Category	Explanation
I	High level of expectation and is recommended for spaces occupied by very sensitive and fragile persons with special requirements like handicapped, sick, very young children and elderly persons
II	Normal level of expectation and should be used for new buildings and renovations
III	An acceptable, moderate level of expectation and may be used for existing buildings
IV	Values outside the criteria for the above categories. This category should only be accepted for a limited part of the year

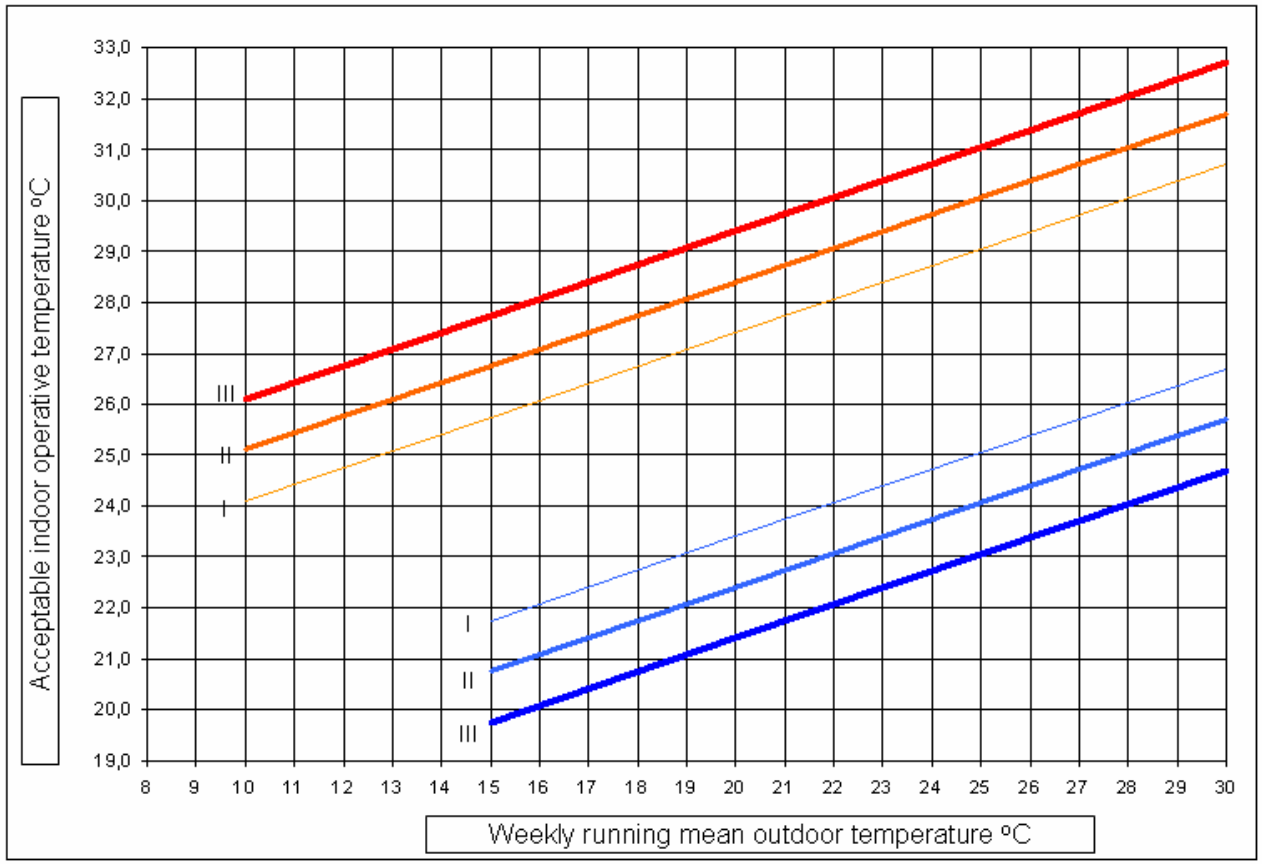
Categories in EN15251
Mechanically cooled buildings

Category	Applicability/level of expectancy	PMV range
I	High: Buildings with high expectancy for sensitive occupants	± 0.2
II	Normal: New buildings and renovations	± 0.5
III	Acceptable: Existing buildings	± 0.7
IV	Low expectancy only for short periods	± >0.7

Categories in EN15251
Free running buildings

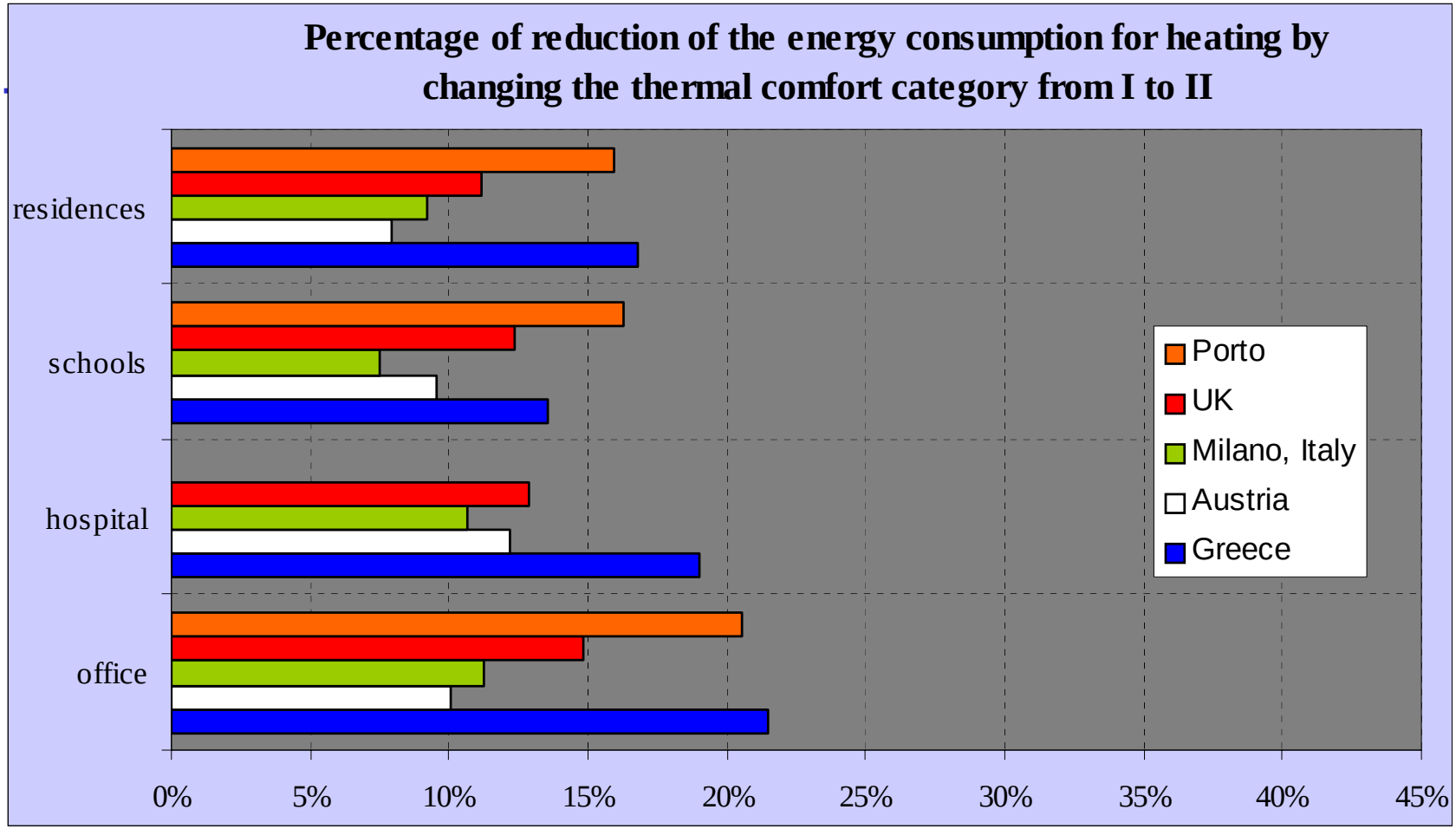
Category	Applicability/level of expectancy	FR Temp range
I	High: Buildings with high expectancy for sensitive occupants	± 2K
II	Normal: New buildings and renovations	± 3K
III	Acceptable: Existing buildings	± 4K
IV	Low expectancy only for short periods	± >4K

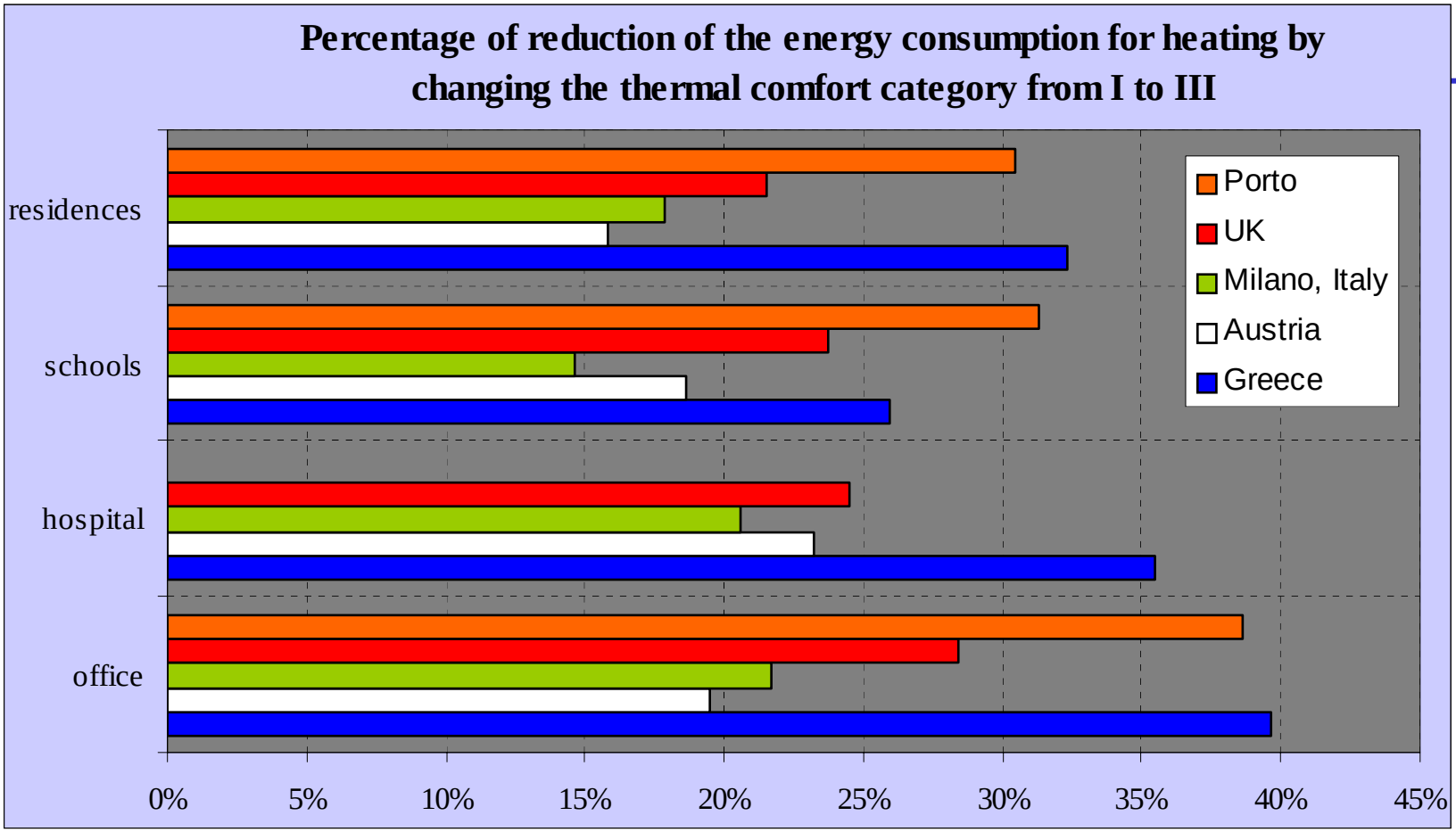
Free Running Comfort Limits EN15251



Expected energy consumption of all major types of buildings and European climates based on the application of the EN 15251

- **Collected necessary information to allow the simulation for twenty eight (28) typical buildings in Europe and to determine the energy needed to place them in the comfort categories I, II, III and IV of EN 15251**
- **Office buildings (7) -** Greece(1), Austria(1), Italy(3), UK(1), Portugal(1)
- **Hospitals (6) -** Greece(1), Austria(1), Italy(3), UK(1)
- **Schools (7) -** Greece(1), Austria(1), Italy(3), UK(1), Portugal(1)
- **Residences (7) -** Greece(1), Austria(1), Italy(3), UK(1), Portugal(1)
- **Cafeterias-Restaurants (1) -** Portugal(1)
- **The thermal simulations are performed with the simulation tool TRNSYS.**
- **The calculations are done for a whole year period, using the climatic data of the greater region for both heating and cooling.**


Percentage of reduction of the energy consumption for heating by changing the thermal comfort category from I to II
residences
schools
hospital
office
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
Porto
UK
Milano, Italy
Austria
Greece


Percentage of reduction of the energy consumption for heating by changing the thermal comfort category from I to III
residences
schools
hospital
office
Porto
UK
Milano, Italy
Austria
Greece
0%
5%
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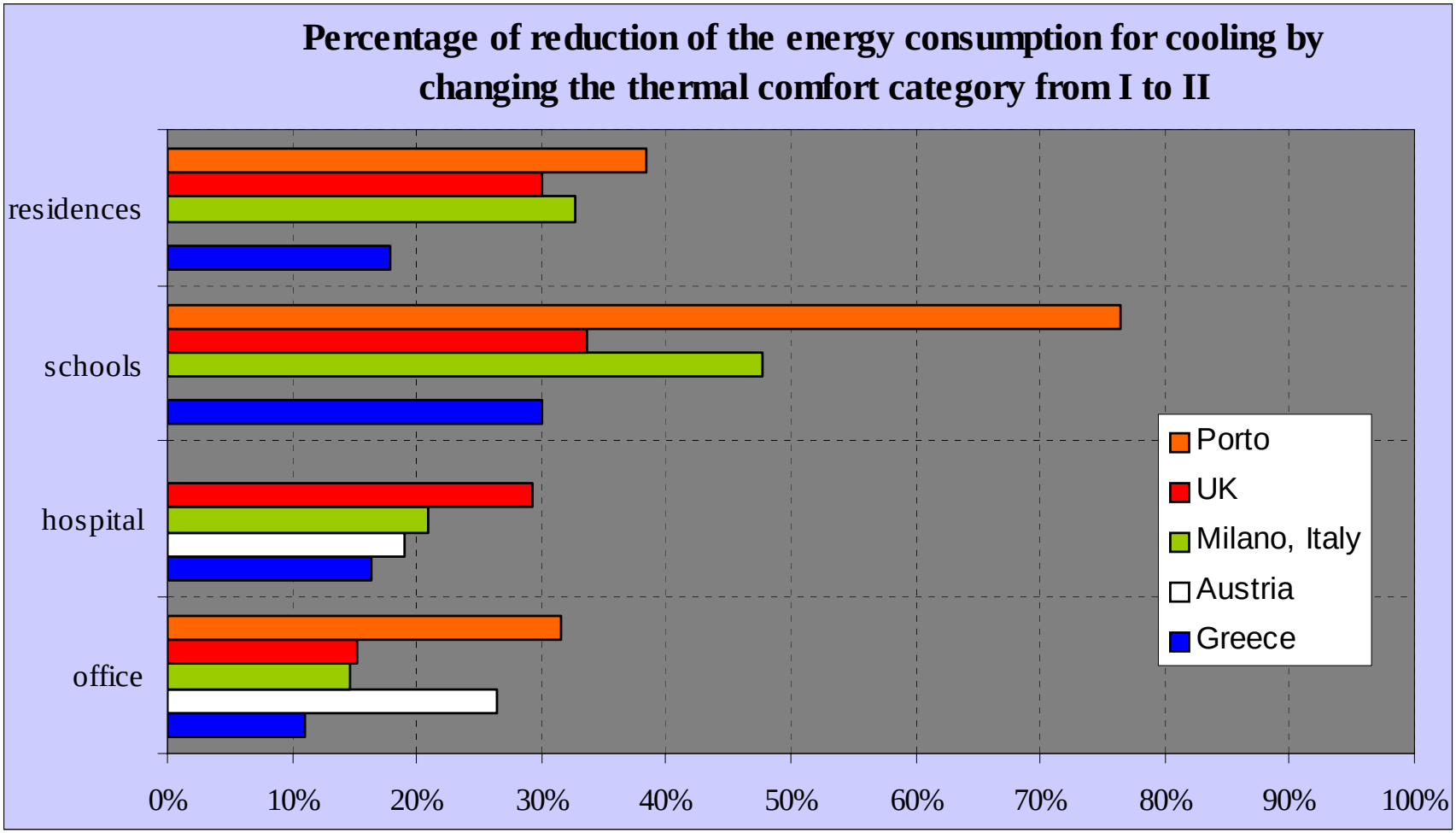
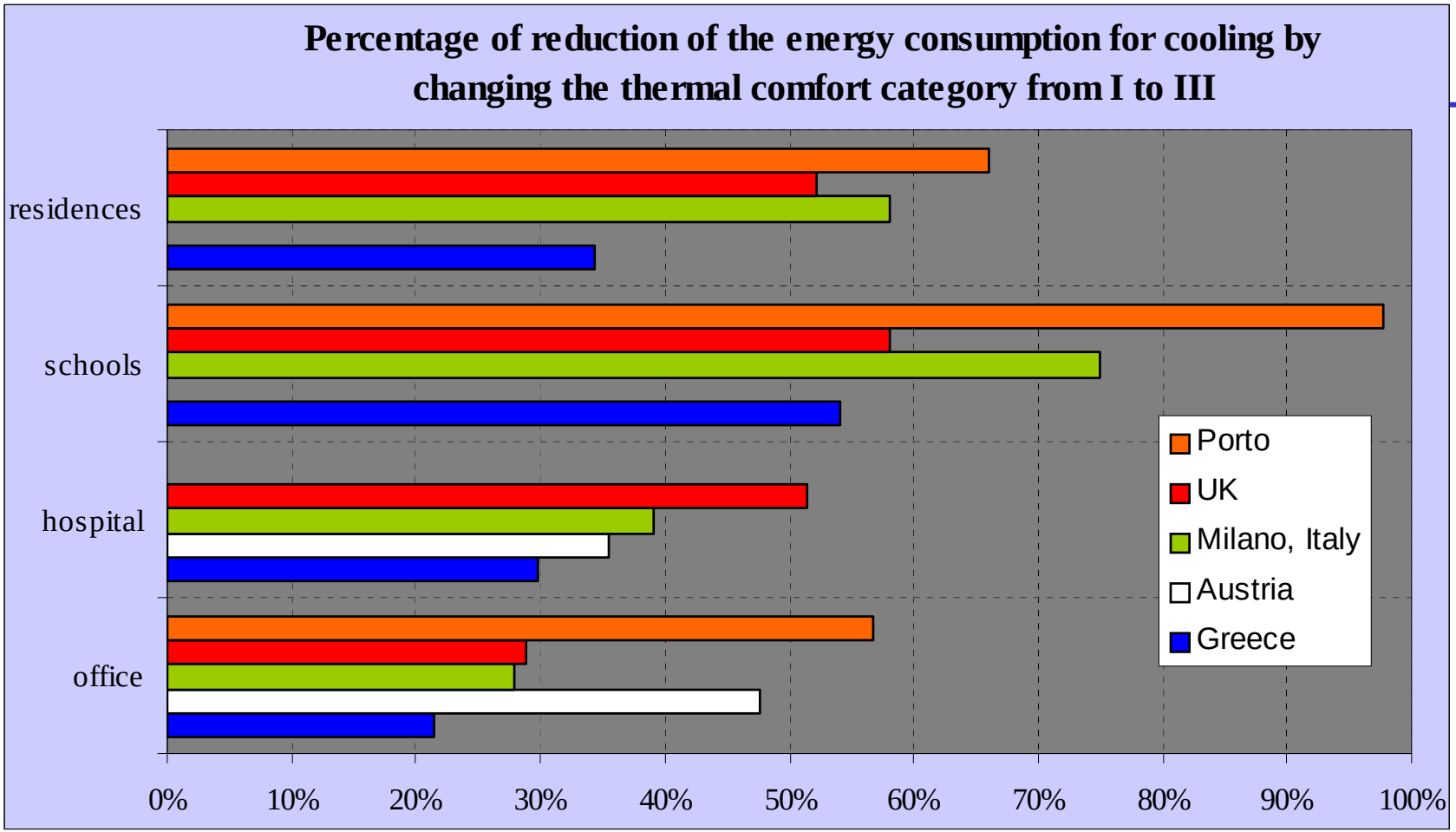
40%
45%


Percentage of reduction of the energy consumption for cooling by changing the thermal comfort category from I to II
residences
schools
hospital
office
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Porto
UK
Milano, Italy
Austria
Greece


Percentage of reduction of the energy consumption for cooling by changing the thermal comfort category from I to III
residences
schools
hospital
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Porto
UK
Milano, Italy
Austria
Greece
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Comparison of the calculated energy consumption with the existing national benchmarks in Greece

	Schools											
	Max and Min values of Energy Consumption [(kWh/(m²*έτος)]											
	Climatic Zone											
		A			B			Γ			Δ	
A+		ΕΚ <	15		ΕΚ <	20		ΕΚ <	25		ΕΚ <	35
A	15	≤ ΕΚ <	25	20	≤ ΕΚ <	30	25	≤ ΕΚ <	35	35	≤ ΕΚ <	55
B+	25	≤ ΕΚ <	40	30	≤ ΕΚ <	40	35	≤ ΕΚ <	50	55	≤ ΕΚ <	80
B	40	≤ ΕΚ <	50	40	≤ ΕΚ <	50	50	≤ ΕΚ <	70	80	≤ ΕΚ <	105
Γ	50	≤ ΕΚ <	60	50	≤ ΕΚ <	60	70	≤ ΕΚ <	80	105	≤ ΕΚ <	120
Δ	60	≤ ΕΚ <	65	60	≤ ΕΚ <	70	80	≤ ΕΚ <	90	120	≤ ΕΚ <	140
E	65	≤ ΕΚ <	85	70	≤ ΕΚ <	90	90	≤ ΕΚ <	115	140	≤ ΕΚ <	170
Z	85	≤ ΕΚ <	100	90	≤ ΕΚ <	105	115	≤ ΕΚ <	135	170	≤ ΕΚ <	205
H	100	≤ ΕΚ		105	≤ ΕΚ		135	≤ ΕΚ		205	≤ ΕΚ	

	Residence											
	Max and Min values of Energy Consumption [(kWh/(m²*έτος)]											
	Climatic Zone											
		A			B			Γ			Δ	
A+		ΕΚ <	60		ΕΚ <	60		ΕΚ <	65		ΕΚ <	75
A	60	≤ ΕΚ <	80	60	≤ ΕΚ <	80	65	≤ ΕΚ <	90	75	≤ ΕΚ <	100
B+	80	≤ ΕΚ <	110	80	≤ ΕΚ <	115	90	≤ ΕΚ <	125	100	≤ ΕΚ <	140
B	110	≤ ΕΚ <	140	115	≤ ΕΚ <	145	125	≤ ΕΚ <	160	140	≤ ΕΚ <	180
Γ	140	≤ ΕΚ <	155	145	≤ ΕΚ <	165	160	≤ ΕΚ <	180	180	≤ ΕΚ <	205
Δ	155	≤ ΕΚ <	175	165	≤ ΕΚ <	185	180	≤ ΕΚ <	205	205	≤ ΕΚ <	230
E	175	≤ ΕΚ <	215	185	≤ ΕΚ <	225	205	≤ ΕΚ <	250	230	≤ ΕΚ <	285
Z	215	≤ ΕΚ <	255	225	≤ ΕΚ <	265	250	≤ ΕΚ <	300	285	≤ ΕΚ <	335
H	255	≤ ΕΚ		265	≤ ΕΚ		300	≤ ΕΚ		335	≤ ΕΚ	

EN 15251 : Scope (on measurement)

- **The standard specifies methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements.**
- **The standard specifies criteria for measurements which can be used if required to measure compliance by inspection.**
- **The standard identifies parameters to be used by monitoring and displaying the indoor environment in existing buildings.**

- **The evaluation of the indoor environment includes (1) thermal criteria for winter, (2) thermal criteria for summer, (3) air quality and ventilation criteria, (4) lighting criteria, (5) acoustic criteria.**
- **Classification of indoor environment can be based on showing the design criteria for each parameter, calculations or measurements over a time period (week, month, year) of relevant parameters like room temperature, ventilation rates, humidity, and CO2 concentrations.**

Assessment of comfort categories of existing buildings

- Identify an operative procedure for determining how the indoor - time and space - average operative temperature should be monitored and how many measurements in time should be performed in order to assign a building to a certain category
- The standard asks that during no more than 3% of occupied hours, in 95% of occupied space temperature is within the range which defines a certain category, hence it is necessary to determine a practical procedure to decide how many points are representative of thermal zones.
- Identify methodology for lighting measurements which will include the necessary physical parameters and suggest subjective inputs.
- Measurement in 11 buildings in 4 countries

Building	A: Efficient Tertiary	B: New Standard Tertiary	C: New naturally Ventilated Tertiary	D: Residential PassivHas
Destination	Office and social housing	University: Office and Laboratory	School Office	Residential
Area	600 m^2	3000 m^2	>3000 m^2	200 m^2
N° Occupants	25	250	500 students 50 workers	4

Building A

BUILDINGS MONITORING: EXAMPLE CHARACTERISTICS

Envelope

High insulation levels (U=0,16 W/m^{2}K)
Medium-low thermal inertia

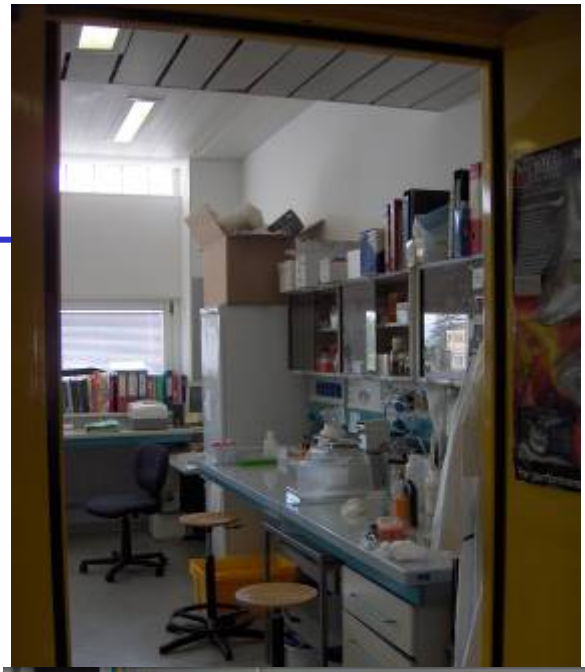
Heating

Boiler and Fan coils

Cooling system

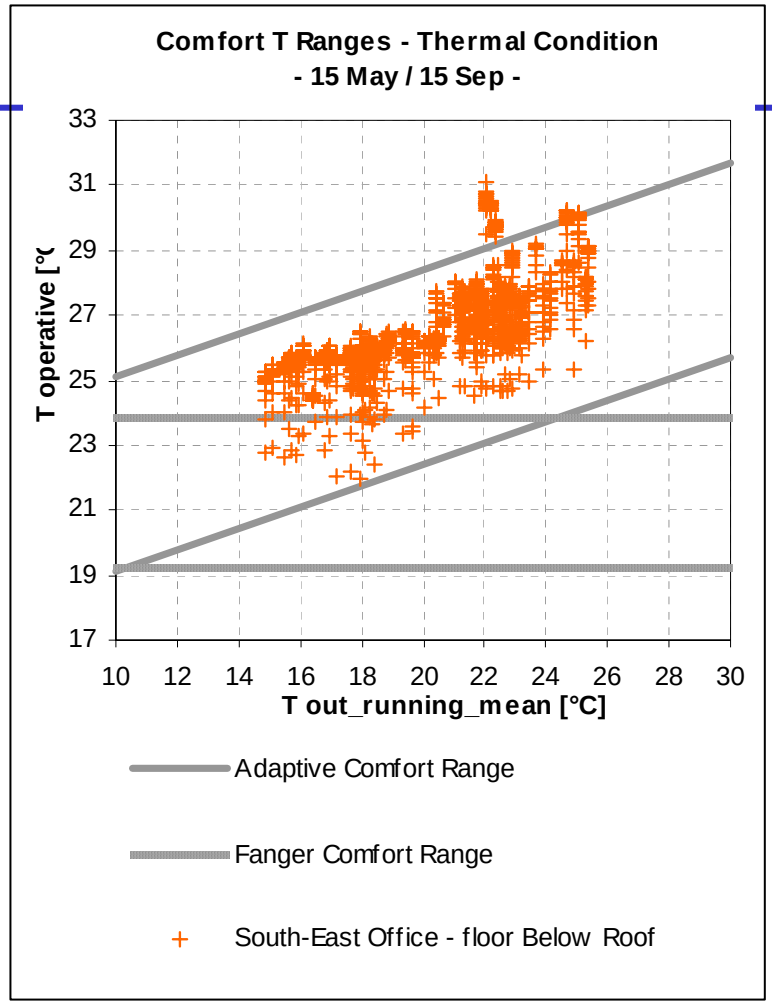
Natural ventilation
Chiller and Fan coils

Building B

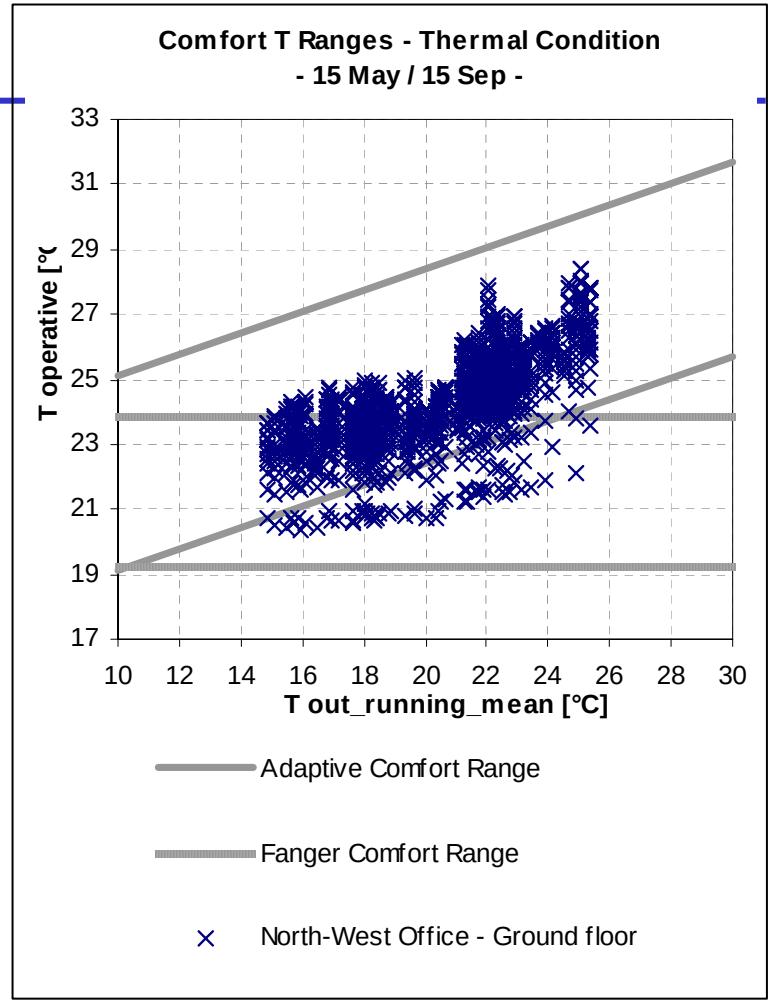


Thermal condition variability in space

- **Warmest office.**



- **Coldest office.**



Redefining comfort standards

- **Until now comfort standards have been concerned with accurate measurement and definition of indoor conditions on the basis that this equates with accurate measurement of 'comfort'**
- **In the process it has become accepted that tightly controlled conditions equate with better comfort**

Redefining comfort standards

- **Analysis of field surveys and adaptive comfort theory have made it clear that whilst close control is one way of achieving comfort it is not the only way**
- **At the same time close control is an expensive strategy in terms of energy**
- **New standards are needed which reflect the need for low-carbon futures**

Energy-based comfort standards

- **We want to define a standard which encourages** NOT **high energy buildings but** LOW **energy buildings**
- **They must be** comfortable **or they are not sustainable**
- **How could such a standard be framed?**

Redefinition ?
Low energy categories

Category	Possible description
A	**Buildings which are comfortable with no use of energy**
B	**Buildings which are comfortable but only use energy part of the year**
C	**Buildings which are comfortable but use energy all year**

CommonCense Dissemination Actions

- **Cooperation with identified National Target Groups and establishing effective links with professional bodies and organisations**
- **Now running a series of workshops, conferences and related dissemination events**
- **Supporting guidance materials,teaching aids and tools downloadable from the COMMONCENSE web-site:**
  www.learn.londonmet.ac.uk/commoncense

Workshops, conference and dissemination events

- **Events are being held in**
  - UK
  - Italy
  - Greece
  - Portugal
  - Austria

INTERNATIONAL CONFERENCE

ADAPTING TO CHANGE: NEW THINKING ON COMFORT

9-11th April 2010

Cumberland Lodge, Windsor Great Park, UK

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