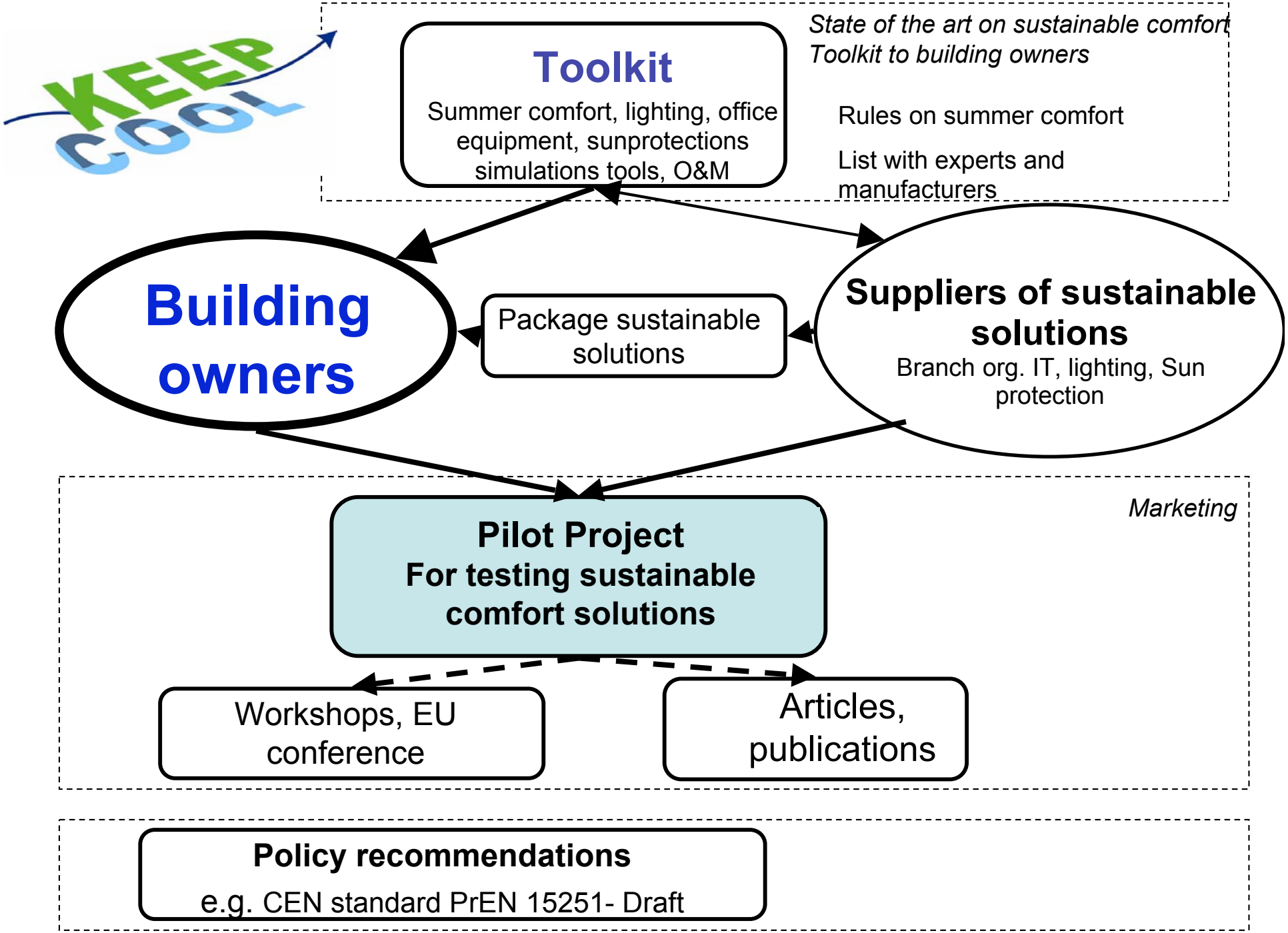
Principles and standards for Sustainable Summer Comfort

Transform market from COOLING to COMFORT

Carlos Lopes, J. Fergus Nicol, Lorenzo Pagliano, Marton Varga

Intelligent Energy Europe


KEEP COOL
Toolkit
Summer comfort, lighting, office equipment, sunprotections simulations tools, O&M
State of the art on sustainable comfort
Toolkit to building owners
Rules on summer comfort
List with experts and manufacturers
Building owners
Package sustainable solutions
Suppliers of sustainable solutions
Branch org. IT, lighting, Sun protection
Marketing
Pilot Project
For testing sustainable comfort solutions
Workshops, EU conference
Articles, publications
Policy recommendations
e.g. CEN standard PrEN 15251- Draft

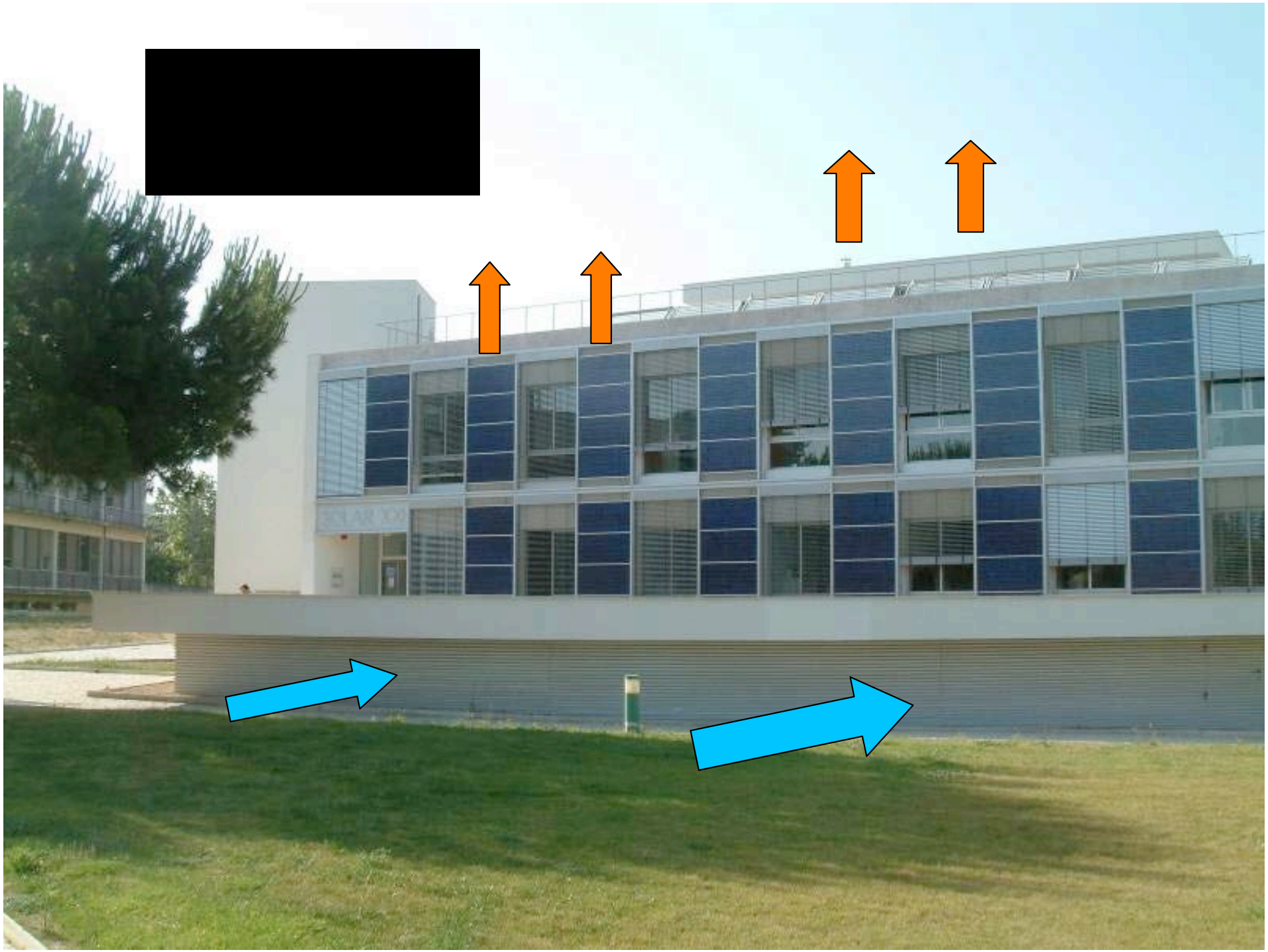
Sustainable summer COMFORT (rather than COOLING)

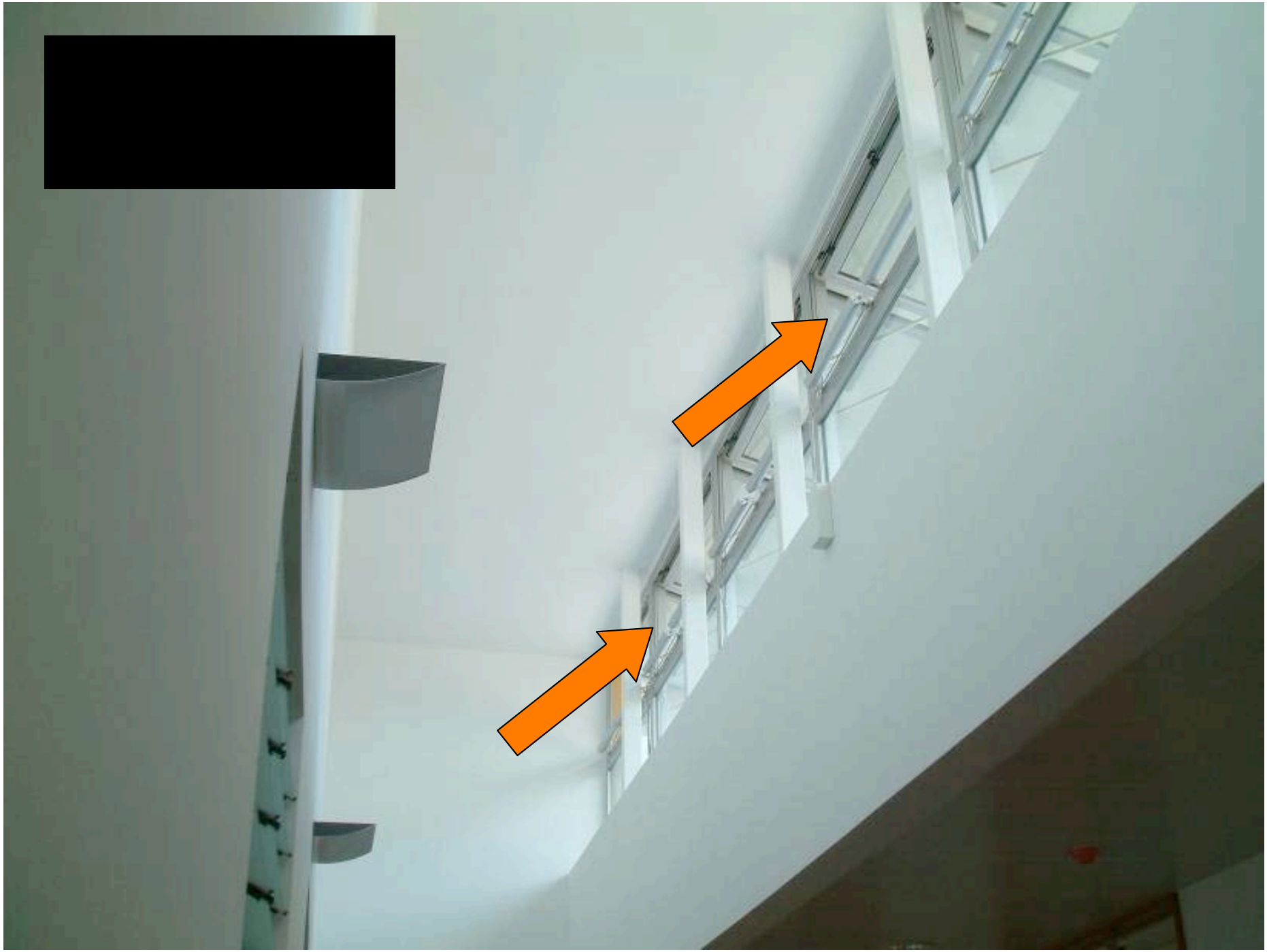
Sustainable summer comfort can be defined as:

- Achieving summer comfort conditions (explicitly defined, see next slides)
- with minimal use of “resource energy” (CEN Overall energy use, primary energy and CO2 emissions)
- and with environmentally non-harmful materials

Ten steps to achieve sustainable summer comfort

1. Comfort objectives explicitly defined
2. Site layout
3. Reduce heat gains at the envelope boundary
4. Control heat transfer through the structure
5. Reduce internal heat gains
6. Allow for local and individual adaptation
7. Passive cooling (e.g. night ventilation, ground cooling)
8. Solar cooling
9. Efficient conventional active cooling
10. Operation, maintenance and monitoring



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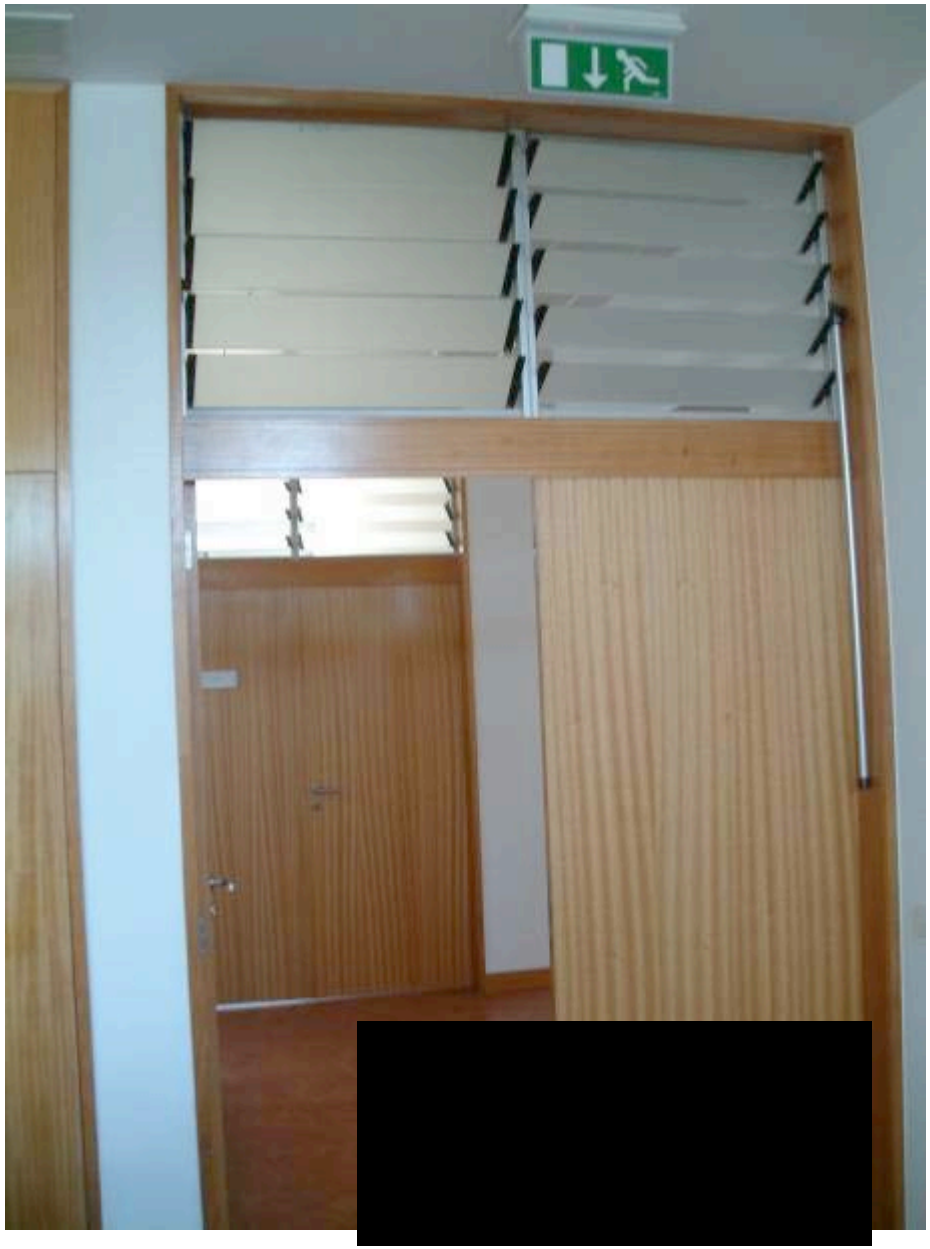

Allow for local and individual adaptation

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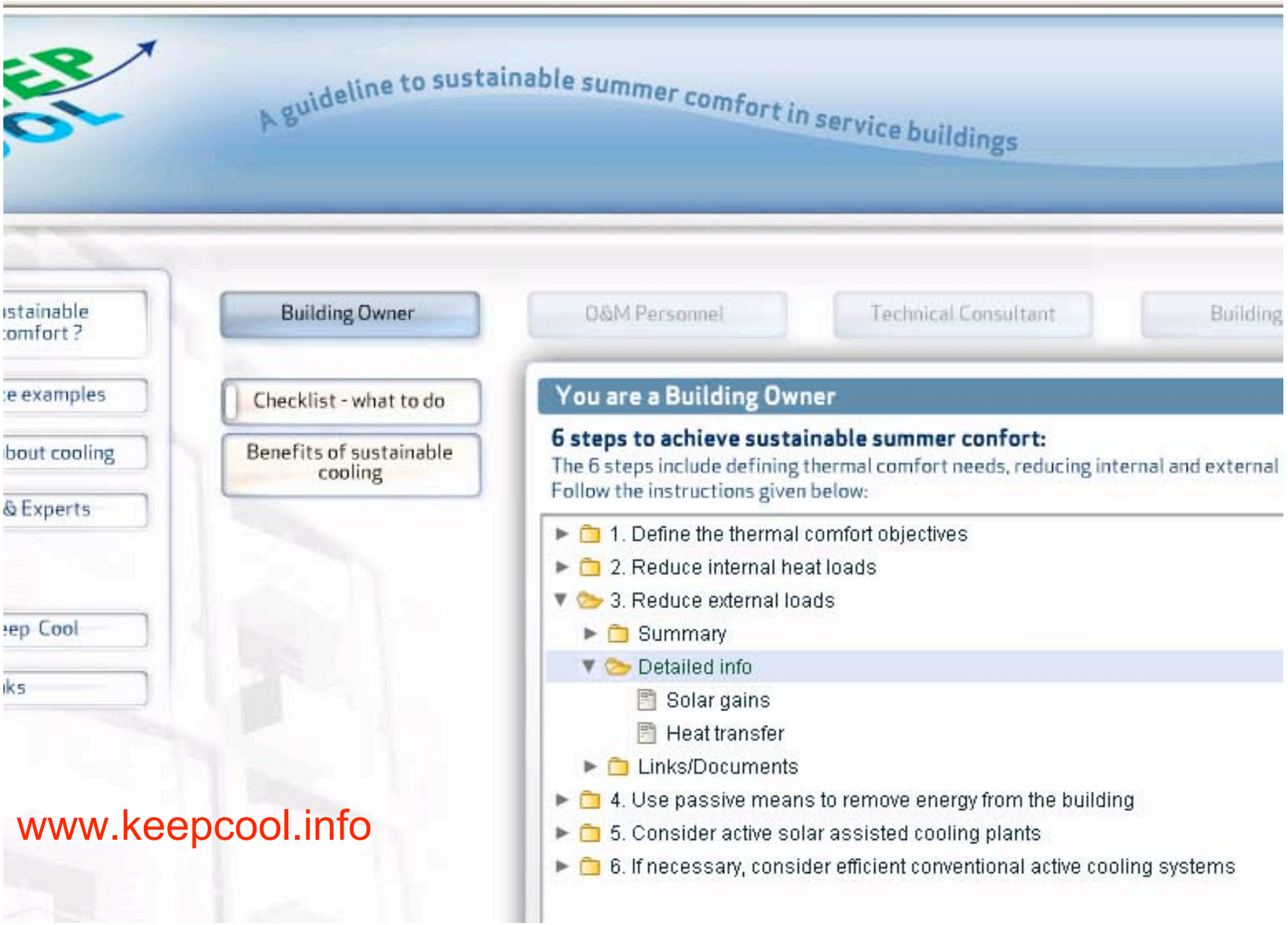
KEEP COOL


A guideline to sustainable summer comfort in service buildings
Building Owner
O&M Personnel
Technical Consultant
Checklist - what to do
Benefits of sustainable cooling
You are a Building Owner
6 steps to achieve sustainable summer confort:
The 6 steps include defining thermal comfort needs, reducing internal and external
Follow the instructions given below:
1. Define the thermal comfort objectives
2. Reduce internal heat loads
3. Reduce external loads
Summary
Detailed info
Solar gains
Heat transfer
Links/Documents
4. Use passive means to remove energy from the building
5. Consider active solar assisted cooling plants
6. If necessary, consider efficient conventional active cooling systems
www.keepcool.info

la Repubblica
MILANO
SABATO 25 GIUGNO 2005

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L'ozono oltre i limiti di guardia, allarme della Protezione civile. Nel centro della città continuano i black

Caldo senza tregua, paura per gli anzian

L'INTERVENTO

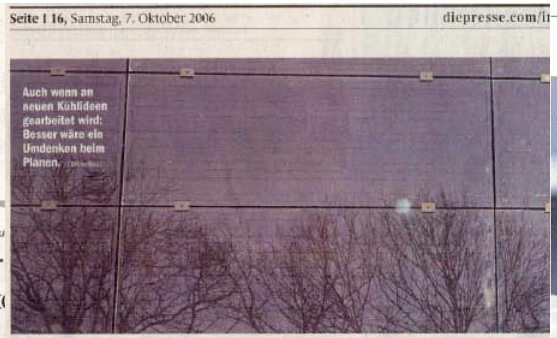
Andiamo in ufficio con i pantaloni corti

PAOLO HUTTER

Per meglio sopportare il caldo, ma soprattutto per ridurre il sovraconsumo elettrico dei condizionatori, ai dipendenti pubblici giapponesi - persino ai dirigenti - è stato vietato dall'inizio di giugno l'uso di giacca e cravatta. Solo una camicia leggera, lanciata in tv dal primo ministro in persona. In una città italiana, dove già vestiamo più informalmente che in Giappone, dovremmo andare oltre

Un'altra giornata molto calda con tanti che

Non si fermano all'a
Grave uno dei bandit



Auch wenn an neuen Kühlideen gearbeitet wird: Besser wäre ein Umdenken beim Planen.

Kühlideen mit Wasse

VON MARTIN FISCHER

KLIMAANLAGEN ADE? *Neue Technolog von umweltschädigenden und te*

Kaum hat der Sommer dieser Tage endgültig abgedankt, wird er schon heftig betrau-

maanlagen sorgen für enormen mverbrauch und helfen dank weltbelastender Kältemittel n CO_2-Anstieg kräftig mit. Und Betriebskosten leiden mit der welt ...

chitektonische K „Kühl-Investitionen" mieden werden. So Reiter von der AEE- kunft „die Finger vo zu lassen" und di Technik von Wohn auf Bürogebäude

ordenken statt nachhinken

Vid Bosch biltestanläg testas under extrema k krav på VVS-installatio

FOTO: BOSCH

Keep C

Vor dem Hintergrund des massiv steigenden Kühlener Dienstleistungsgebäuden gewinnen passive Kühlsyster auf der Basis erneuerbarer Energien immer mehr an B

Den vorhandenen Ansätzen in diesem Bereich zum Durchbruch zu verhelfen, ist das Ziel von Keep Cool, eines internationalen Projektes im Rahmen des klimaaktiv-Programms ecofacility. Neben der Wissensvermittlung, die den Schwerpunkt des Projektes bildet, wird KeepCool ein Entscheidungshilfetool für Gebäudeeigentümer entwickeln. Als drittes Ziel will das Projekt auf die politischen Rahmenbedingungen Einfluss nehmen, damit diese der Energieeffizienz beim Kühlen von Gebäuden vermehrt Rechnung tragen.

Die zunehmende elektrische Ausstattung von Dienstleistungsgebäuden und ihre im architektonischen Trend liegende großzügige Verglasung haben Kühlung in den letzten Jahrzehnten auch in Ländern mit gemäßigtem Klima zu einem Thema gemacht. Die Studien Energy Efficiency of Room Air-Conditioners (EERAC) und Energy Efficiency and Certification of Central Air Conditioners (EECCAC) sagen eine Vervierfachung des Kühlenergiebedarfs in Europa zwischen 1990 und 2020 voraus. Die Internationale Energieagentur bezeichnet „Kühlung und Klimatisierung" sogar als eines der am schnellsten wachsenden Felder neuen Energiebedarfs. Denn die Abwärme der Geräte und die erhöhte Sonneneinstrahlung bringen eine Wärmemenge ins Haus, die in den meisten Gebäuden

Das Proj
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2. Maßna

ERNEUERBARE ENERGIE
2005-2
Zeitschrift für eine nachhaltige Energiezukunft

KEEP COOL

ett sätt att undvika kyla

Keep Cool är ett EU-projekt som vill undvika användning av artificiell komfortkyla och luftkonditionering och i stället satsa på "hållbar kyla". Inte ens i Sydeuropas varma klimat är det självklart att använda kyla i alla lägen och därför finns det ingen anledning att slentrianmässigt installera kyla i fastigheter i Sverige.

Carlos Lopes, Energimyndigheten, arbetar med projektet Keep Cool.

Carlos Lopes på Energimyndigheten har arbetat med projektet sedan det startade i januari 2005. Han konstaterar att industribranschen för traditionell kyla är mycket väl organiserad. Beställaren hittar lätt de uppgifter han behöver och konsulterna säljer gärna luftkonditionering trots att luftkonditioneringssystem är dyrbara investeringar och inte alltid fungerar som de ska. Dessutom är många omedvetna om hur mycket energi kylning kräver.

Att man inte istället väljer hållbar kyla beror på att det finns för lite kunskap och för många aktörer som inte är organiserade.

Men det ska projektet Keep Cool ändra på. Målgruppen är i första hand fastighetsägare.

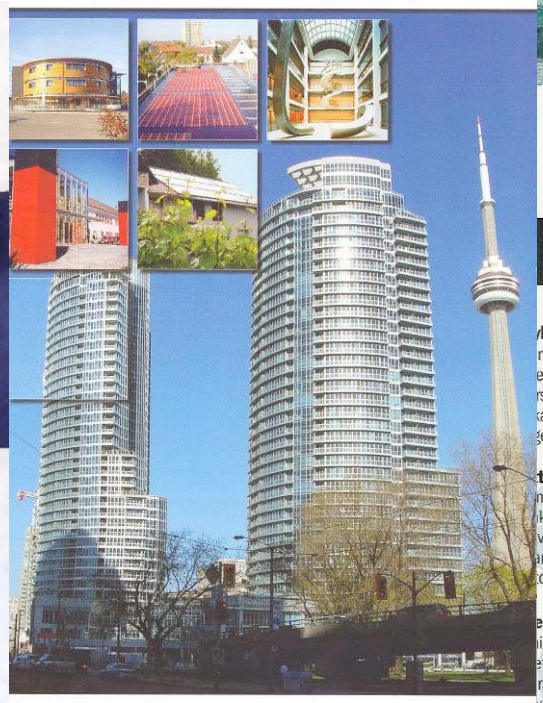
Paketlösning

– Vi har utvecklat ett koncept där vi erbjuder en paketlösning och förser fastighetsägaren med en "verktygslåda", da solskydd. Det går att reducera värmen från både belysning, datorer och andra maskiner. Därför har man bildat en referensgrupp som samarbetar i projektet med både IT-, belysnings- och solskyddsbranschen samt konsult- och energitjänstföretag.

– Komforttemperatur inomhus är beroende av utetemperaturen. Kroppen vänjer sig vid en temperatur och man klär sig därefter. Därför känner man sig komfortabel med en högre temperatur inomhus när det är varmt ute. Då behövs inte kylning och därför föredrar jag att prata om hållbar lösning på komfortkyla, eller sommarkomfort. Tyvärr finns det mycket okunskap och det är alltid lättare att göra det på "business as usual"-sätt, konstaterar Carlos Lopes.

Europeisk konferens

Vissa delar av EU-projektet är gemensamma för hela



Energieeffiziente Klimatisierung

VVS-tidningen
energi&milj

32 Keep cool för att undvika kyla

24 Vågor eller 44 Vind?

Dissemination activities 2 : Direct advice

- Concrete advice to building owners
  - all countries
- Pilot projects
  - Austria, Portugal, Scotland, Spain, Sweden
- Architecture competitions
  - Austria, Germany, Spain
- Reference Group of suppliers
  - Scotland, Sweden

Sustainable summer comfort in regulations and energy policies

- Limits for cooling demand in the Austrian building code
- Sustainable summer comfort in subsidy schemes
  - Austria
  - Germany
  - Italy
  - Spain
- Influence on the European standard EN 15251 defining thermal, lighting... comfort

Aiming at a correct definition of comfort, “avoiding unnecessary energy consumption”

Main changes achieved in the new standard EN15251

F.Nicol, L.Pagliano
+European Environmental Citizens' Organisation for Standardisation (ECOS)

Subjective Comfort Survey (ASHRAE scale)

Used for interviews and base for both the Famger nad Adaptive Comfort models

How do you feel?

+3 Hot

+2 Warm

+1 Slightly warm

0 Neutral

-1 Slightly cool

-2 Cool

-3 old

FANGER Comfort Model

- interviews in controlled chambers after 3 hours stay in stationary conditions. and simultaneous measurements of :
  - air temperature,
  - mean radiant temperature,
  - relative air velocity,
  - relative humidity,
  - activity (metabolic rate),
  - clothing (thermal resistance).
- Used to produce a correlation
- which allows to calculate from values of air temperature etc in a given situation the Predicted Mean Vote (on the ASHRAE scale -3 to +3) or PMV
- **The Predicted Mean Vote** can also be reformulated as **Predicted Percentage of Dissatisfied** PPD
- Remember Validity conditions!!!!

Recommended categories for design of mechanical heated and cooled buildings in ISO 7730 (proposed for prEN13251)

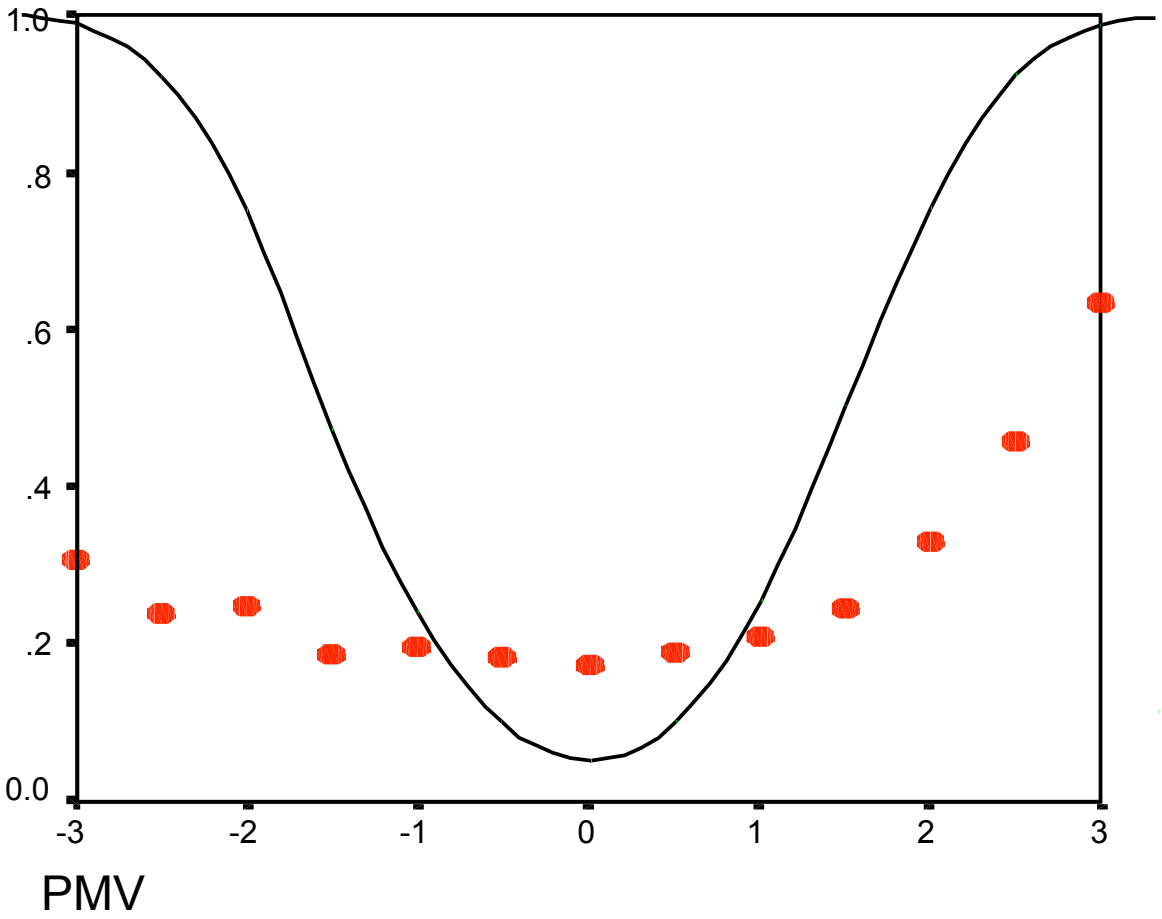
A

B

C

D

Predicted Percentage of Dissatisfied (PPD) vs Actual Percentage of Dissatisfied (APD) in real buildings



- Based on data of ASHRAE RP-884 database, 15000 interviews in 160 bldngs

PPD (ISO 7730)

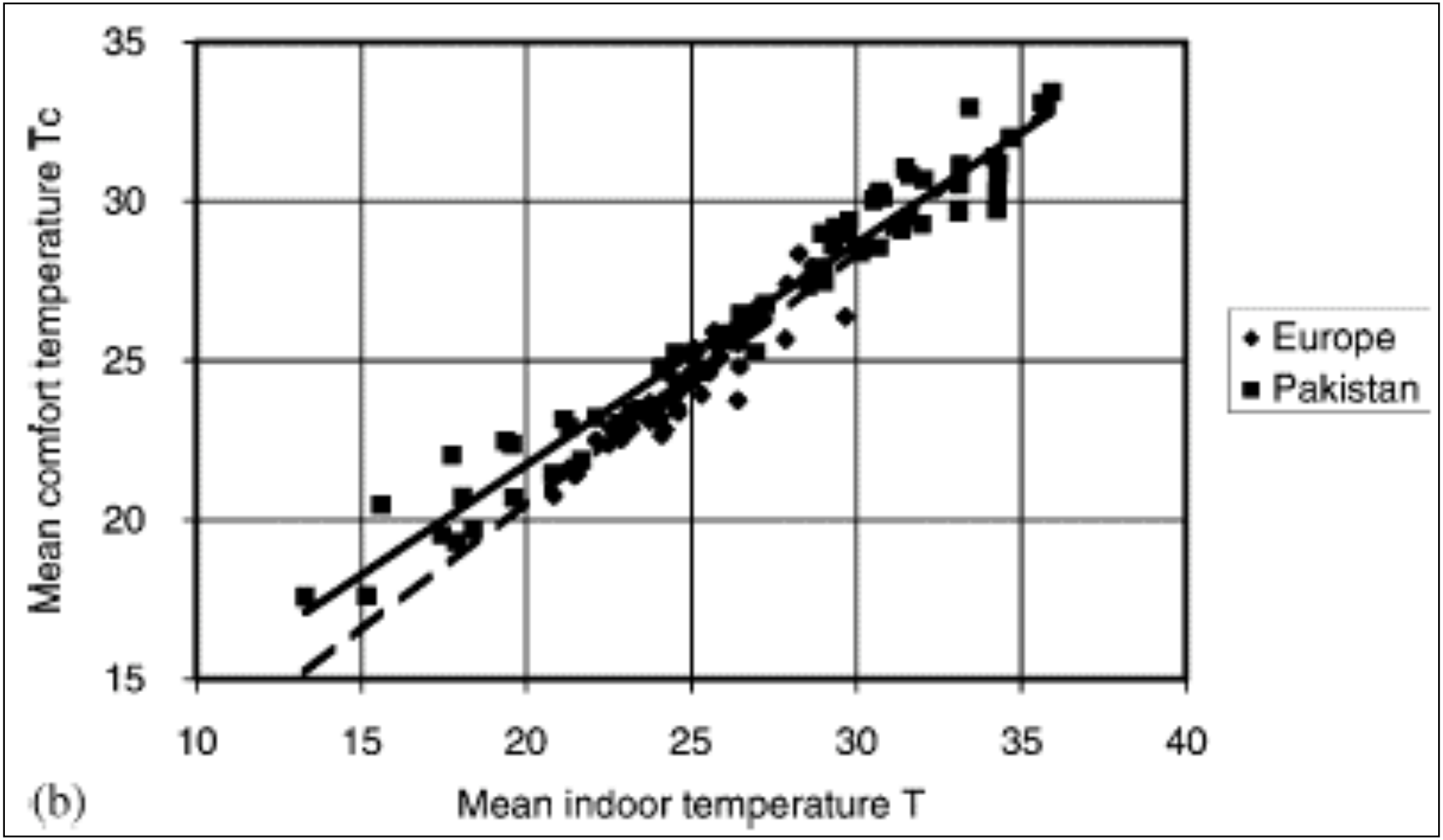
APD (votes -3,-2,2,3) from ASHRAE database 884

Allowance for air movement

ASHRAE Standard 55, EN ISO 7730, then also in EN15251:

Critical issues about PMV

- INDOOR comfort temperature (responses of occupants) vs measured INDOOR comfort temperature



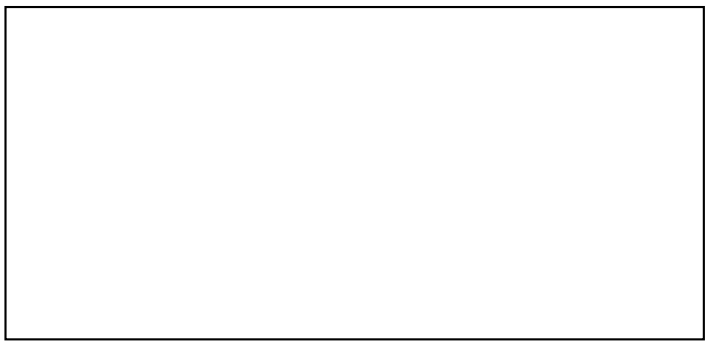
ADAPTIVE COMFORT MODEL (Humprey&Nicol 1972) in EN 15251

- The Adaptive Approach has been developed from field-studies of people in daily life.
- people in daily life are not passive, but tend to make themselves comfortable, by making adjustments (adaptations) to their clothing, activity and posture.
- The ‘adaptive opportunity’ may be provided, for instance, by fans or openable windows in summertime ...
- Dress codes will also have consequences for thermal design, ... and ... for energy consumption.

EN15251: Temperature limits in Free Running Buildings

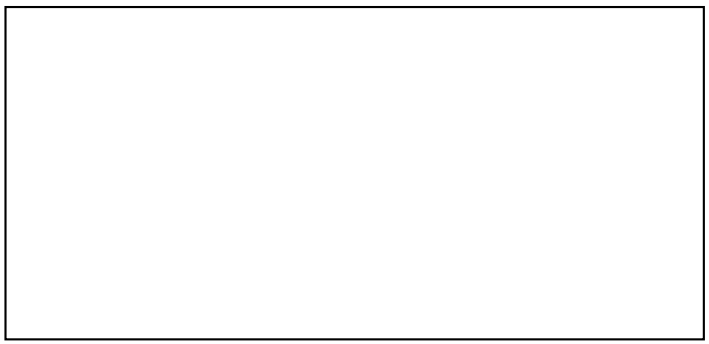
$$T_c = 0.33T_{rm} + 18.8$$

Adaptive vs Fanger (Milan)



Fanger input variable:
clothing thermal resistance = 0.5 clo
metabolic rate = 1.4 met
air velocity = 0.15 m/s
relative humidity = 50%

Adaptive vs Fanger (Rome)



Fanger input variable:
clothing thermal resistance = 0.5 clo
metabolic rate = 1.4 met
air velocity = 0.15 m/s
relative humidity = 50%

COMFORT IN BUILDINGS

prEN15251: Temperature limits in Free Running Buildings (1)

Selected policy recommendations (1)

- Building code and Energy certification: they should explicitly deal with net useful energy demand for cooling
- Inspection of AC systems: energy advice should not relate to the mechanical AC system only but should also include actions for the reduction of the net useful energy demand for cooling

Selected policy recommendations (2)

- Enact legislation and incentives schemes to take full stock of the possibilities offered by the Adaptive model in characterising comfort in non-mechanically cooled buildings
- take full stock of the flexibility present in the Fanger model and its application in ISO 7730 (in mechanically cooled buildings).
- Include a description of comfort models in the curricula for designers and training courses for professionals who will be charged of providing the building energy certification.

Selected policy recommendations (3)
Research strategy

- Include in the "European Strategic Energy Technology Plan (SET-Plan)“ a focus on sustainable summer comfort issues (e.g. through the formation of a European technology platform for envelope and passive cooling technologies);

- Increase the share of demonstration, dissemination and monitoring activities. Promote large, well designed monitoring campaigns

- Promote empirical studies on comfort perception in real, occupied buildings, (mechanically cooled buildings, buildings that apply passive cooling technologies and in hybrid buildings)

Keepcool 2

- More direct activity in promoting pilots
- More industry networking and market transformation (packaged solutions)
- Evaluation of savings by envelope and passive cooling technologies to be used for implementation of the EEESD

Comprehensive evaluation of the national EEAP-s with respect to measures that reduce energy consumption for cooling and information exchange between member countries

on this issue;

- Development of guidelines for public procurement that take into account energy savings

from sustainable summer solutions and compilation of best practice examples relating to

the integration of energy efficiency issues – in this case of sustainable summer aspects

– into public building administrations;

- Making available simplified procedures to evaluate the energy savings related to sustainable

summer comfort (approach for a bottom-up assessment).

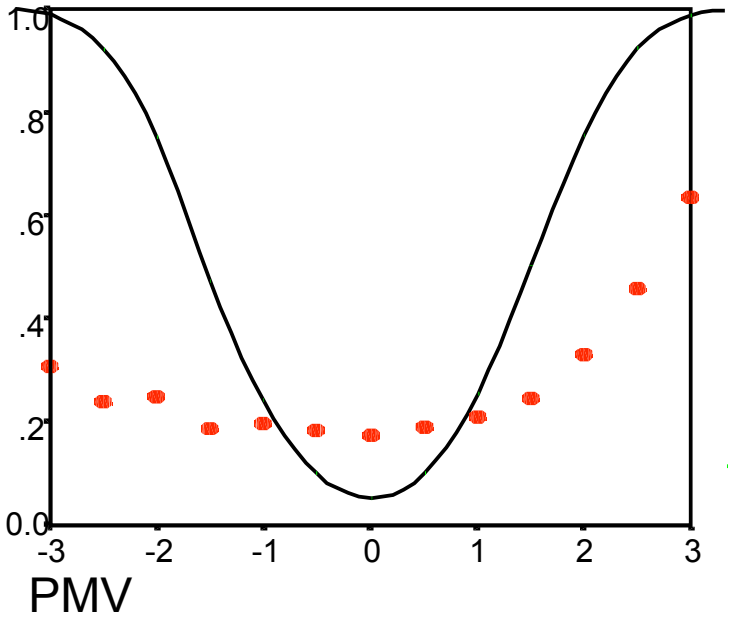
prEN15251: INTRODUCTION

- European Energy Performance of Buildings Directive: *"the displaying of officially recommended indoor temperatures, together with the actual measured temperature, should discourage the misuse of heating, air-conditioning and ventilation systems. This should contribute to avoiding unnecessary use of energy and to safeguarding comfortable indoor climatic conditions (thermal comfort) in relation to the outside temperature".*
- The European Standard prEN15251 *(Indoor environmental input parameters for design and assessment of energy performance of buildings)* defines minimum standards for the internal environment in buildings to complement the EPBD. A major consideration of the prEN is to ensure a correct definition of thermal comfort.

prEN15251: NV and AC Buildings

- International Standard EN ISO 7730 (2006) makes no allowance for differences in comfort conditions in naturally ventilated (NV) and mechanically cooled (AC) buildings.
- prEN15251 makes a distinction between buildings which are HC and those which are FR. Thus NV buildings will be HC during the heating season and FR during the summer; AC buildings are HC throughout the year. In Standard prEN15251, the comfort zone for HC buildings is defined as in EN ISO 7730 (2006).

prEN15251: Examples of recommended categories for design of mechanical heated and cooled buildings



prEN15251: Evaluation of thermal conditions for compliance

- There are two methods suggested in the prEN for evaluating the thermal comfort conditions:
  - Percentage outside range: the proportion of the occupied hours during which the temperature lies outside the acceptable zone.
  - Degree hours criterion: The time during which the actual operative temperature exceeds the specified range during occupied hours is weighted by a factor depending on the number of degrees by which the range has been exceeded.
- Acceptability of the space on the 'percentage' criterion is on the basis that the temperature in the rooms representing 95% of the occupied space is not more than 3% (or 5% - to be decided) of the occupied hours a day, week, month or year, outside the limits of the specified category. Acceptability for the degree hours criterion are still to be decided.

CONCLUSION

- The proposed new European Standard prEN 15251 has been framed to allow the natural variability of the indoor climate in free running buildings to be matched to the natural ability of people in well designed buildings with adequate occupant control, to change their room conditions to suit their needs.

- This will mean that buildings can be designed which are both comfortable and can make full use of passive, low energy cooling and heating technologies.

AKNOWLEDGMENTS

- Evidence supporting the use of the Adaptive Comfort Model, simulations on its application and considerations on categories have been developed, summarised in the appropriate language and formally brought to the attention of the drafting group of prEN 15251 by the authors. This was done within the work programme of the EIE projects KeepCool and Passive-on, and by means of ECOS, European Environmental Citizens' Organisation for Standardisation, which has Associate status with CEN. Some National Standardisation Bodies supported the presentation of parts of the amendments proposed. We would like to acknowledge the role of Prof Michael Humphreys in developing many of the ideas presented.

Modification to PMV proposed by Fanger

P. Ole Fanger*, Jørn Toftum

Expectancy factor: 0,5 to 1 : a change of a factor two

ADAPTIVE APPROACH (3)

- Clothing and other adjustments in response to day-on-day changes in temperature, will occur when a building is responding to weather and seasonal changes. These will occur quite gradually and can take a week or so to complete. So it is desirable that the day-to-day change in mean indoor Operative temperature during occupied hours should not occur too quickly for the adaptive processes to keep pace.
- During the summer months many buildings in Europe are free-running. The temperatures in such buildings will change according to the weather outdoors, as will the clothing of the occupants. Even in air-conditioned buildings the clothing has been found to change according to the weather. As a result the temperature people find comfortable indoors also changes with the weather. Thus the temperature people find comfortable can vary quite considerably depending on the climate, but any change should occur sufficiently slowly to give building occupants time to adapt.

Expected discomfort

Conclusions

- PrEN15251 allows for a variation in comfort temperature in buildings which are not mechanically cooled.
- The comfort temperature can be calculated from the running mean of the outdoor temperature.
- The level of discomfort is a function of the difference between comfort temperature and operative temperature

Policy suggestions

Conclusions

- There is no temperature at which everyone will feel comfortable,
- Minimum discomfort will be experienced within 2^{o}K of the comfort temperature.
- An allowance can be made for air movement

OUTLINE

EN 15251 (on the base of data from SCATS and other surveys of thermal comfort):

- Defines an adaptive comfort temperature for European office workers in free running buildings.
- Defines comfort categories (in terms of use of the building, and range of PMV or operative temperature).
- Provides examples of adaptive comfort temperatures in different climates.

ISO 7730: Validity conditions

- The index shall be used only for values of PMV between -2 and +2 and when the six main parameters are within the following intervals.:
  - Air temperature: 10 °C < *ta* < 30 °C;
  - Radiant mean temperature: 10 °C < *tmr* < 40 °C;
  - Air velocity: *va* < 1 m/s;
  - Activity between 0.8 and 4 met (46 to 232 W/m2)
  - Clothing between 0 and 2 clo (0 m2 K/W and 0,310 m^2 K/W