Trends in national approaches for handling summer comfort and cooling

INTERNATIONAL WORKSHOP

SUMMER COMFORT AND COOLING

Barcelona March 31 – April 1 2009

A series of 4 workshops about trends in national markets regarding

- Ventilation systems
  - March 2008, Ghent, Belgium
- **Summer comfort and cooling**
  - March 31 – April 1, Barcelona, Spain
- Compliance and control
  - September 1-2, Brussels, Belgium
- Innovative systems
  - March 2010, Amsterdam, Netherlands

An initiative by

AIVC

In collaboration with

SAVE ASIEPI

In collaboration with

SAVE BUILDING ADVENT

Organised by

INIVE

Supporting organisations

An initiative by

AIVC

In collaboration with
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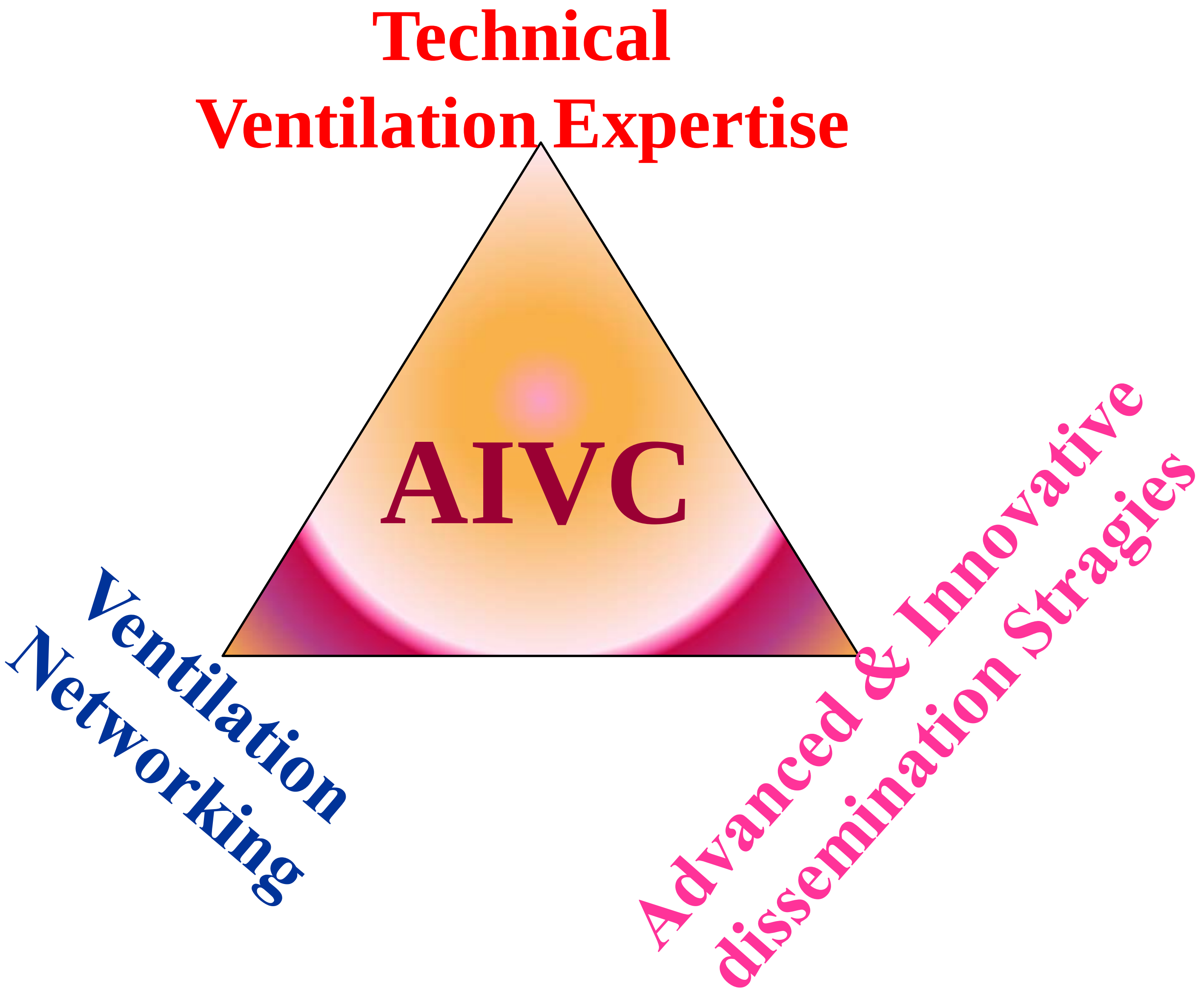
Mission and Vision for … C

(2007-2010)

- The ***mission*** of AIVC is to b… …ence portal for information on ventilati… …ngs to improve the wellbeing of people … …velopment and dissemination of … knowledge.
- Our ***vision*** i… …bally recognized as the leading source … …ion on ventilation in the built envi…
- … …chieve this by combining technical ventilation …tise and ventilation networking with advanced and …novative dissemination strategies

AIVC is the Information Centre of the International Energy Agency (IEA) on energy efficient ventilation


Technical
Ventilation Expertise
AIVC
Ventilation
Networking
Advanced & Innovative
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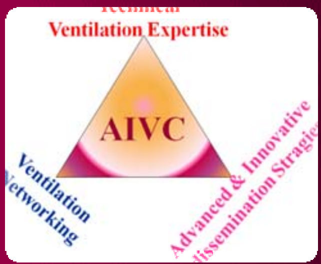
Ventilation Expertise
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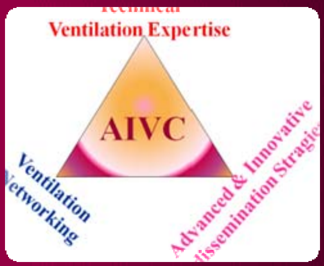
AIVC Countries

- Belgium
- Canada
- Czech Republic
- Denmark
- France
- Greece
- Japan
- Korea
- Netherlands
- Norway
- USA

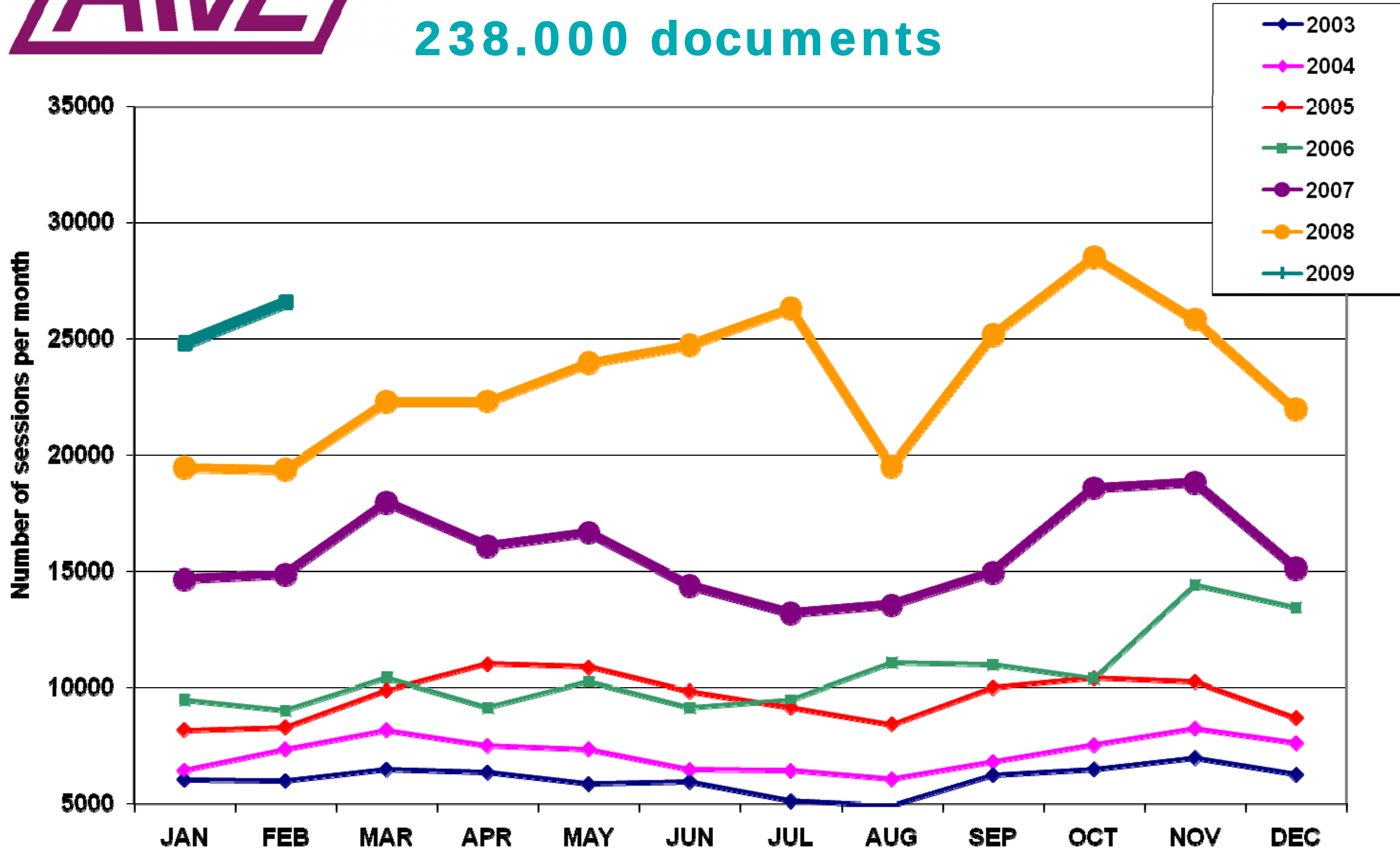


AIVC activities

- **Technical work programme**
  - Technical Notes
  - Information Papers
  - Contributed Reports
  - Annotated bibliographies, literature lists

- **Dissemination programme**
  - Website
  - AIR Newsletter
  - Databases
  - Annual conferences
  - Workshops
  - Collaboration with other organisations

Last 12 months : 290.000 visitors and 238.000 documents



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About the **ASIEPI** project

- ASIEPI aims to **support countries** in their implementation of the EPBD, especially for what concerns :
  - levels of requirements, organisation of control and compliance,
  - thermal bridges, building and duct airtightness,
  - assessment of innovative systems,
  - **summer comfort**
- ASIEPI aims to **support the EC** for the monitoring of the EPBD implementation and for the foreseen EPBD revision.
- ASIEPI collects available information, followed by analysis and structuring, in order to **increase the awareness** of potential problems and solutions.

ASIEPI

Assessment and Improvement of the EPBD Impact

Intelligent Energy Europe

- Home
- NEWS
- Information Papers
- ASIEPI web events
- WP 1 - Management
- WP 2 - Benchmarking
- WP 3 - Compliance and control
- WP 4 - Thermal bridges
- WP 5 - Airtightness
- WP 6 - Innovative systems
- **WP 7 - Summer comfort**
- Workshop

Workshop

International Workshop on Summer comfort and cooling

Barcelona, Spain 31 March & 1 April 2009

This workshop is an initiative of **AIVC**, organised by **INIVE EEIG**, in collaboration with **REHVA** and with the European SAVE **ASIEPI** and SAVE **BUILDING ADVENT** projects.

The main purpose of this workshop is to present and discuss the evolutions in the national regulations related to summer comfort and cooling:
- in terms of standards for achieving good summer comfort,
- for improving energy efficiency during the summer period,
- regarding building solar control,
- regarding amortisation and dissipation techniques,
- regarding night time ventilation for passive cooling,
- regarding (free) cooling techniques.

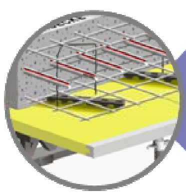
Also, to reply the following questions:
- What are experiences with compliances of regulations?
- What are major trends in the type of systems used?
- Is there a framework for the assessing of innovative passive cooling and low energy cooling systems?

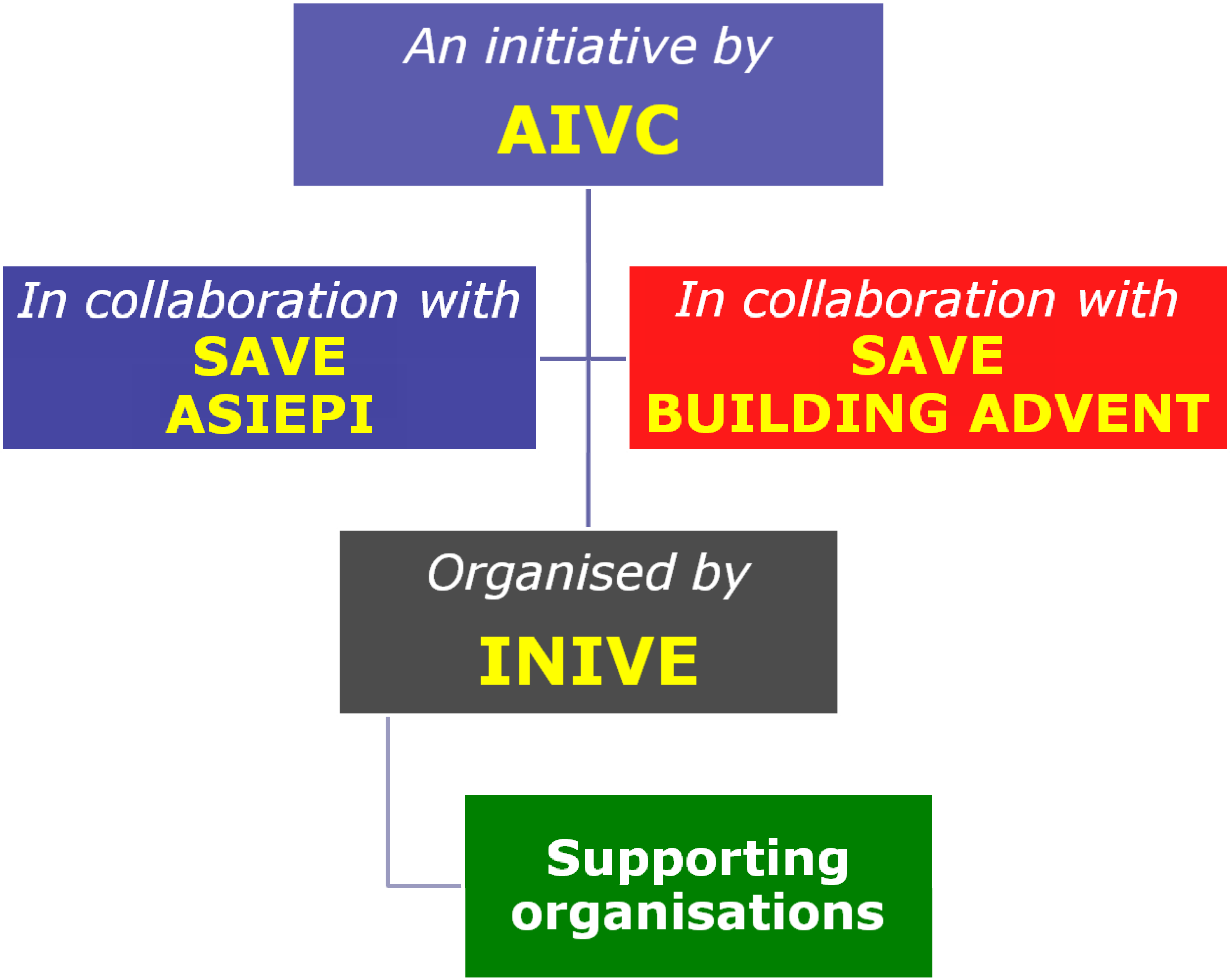
ASIEPI AIVC BUILDING ADVENT

ASIEPI webevents

Webevent	Date
Airtightness and EPBD	12 December
Comparing energy performance requirements accross Europe	27 January
Assessment of innovative systems in the context of EPBD	25 February
An effective handling of thermal bridges in EPBD context	4 March
More to follow...	





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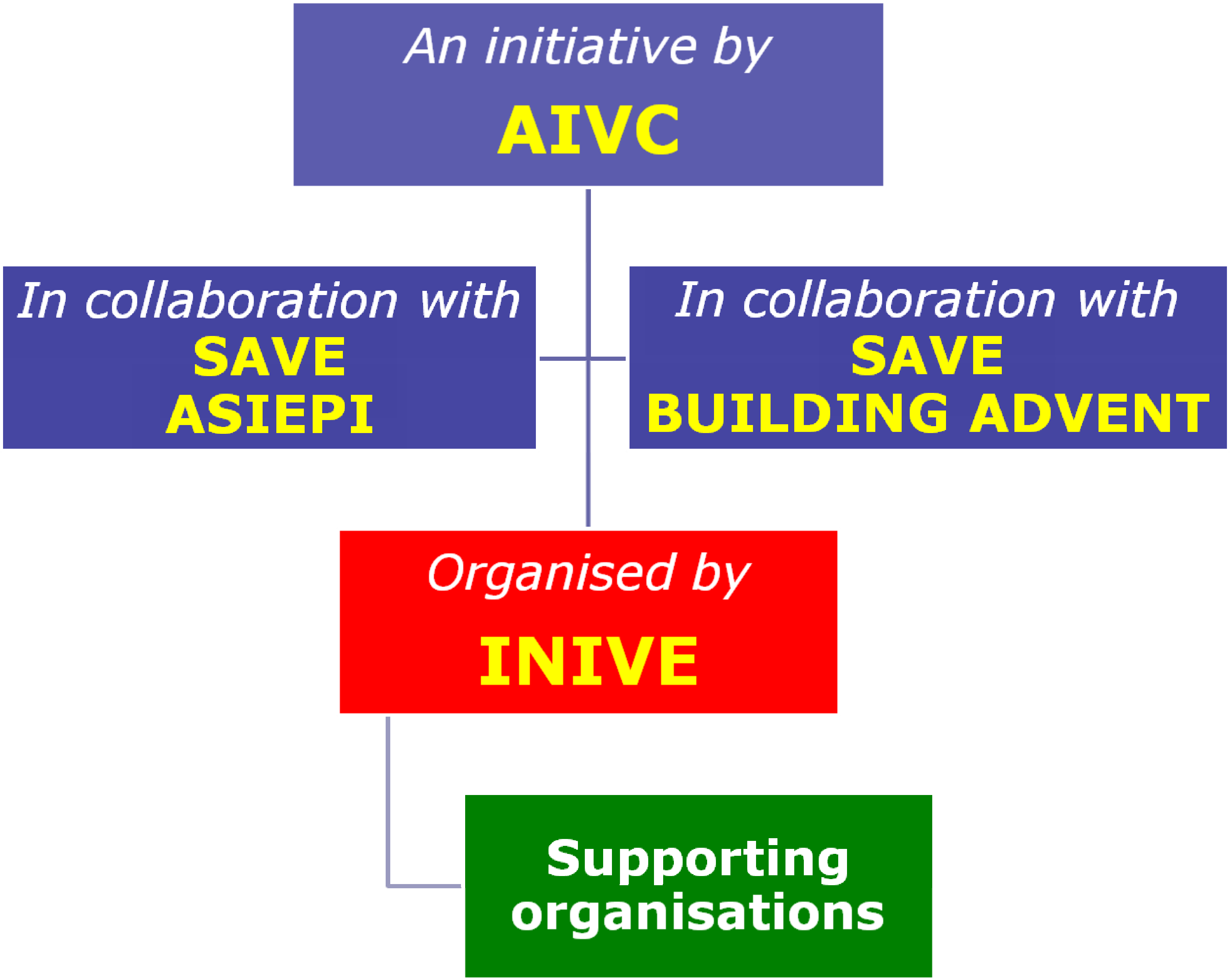
About **BUILDING ADVENT**...

- The main objective is to support a reduction in the energy required to deliver ventilation effectively in non-domestic buildings by capturing good ventilation practice and disseminating it widely
- This will be achieved by developing and promoting examples of successful implementation of low energy ventilation systems to building professionals.

Presentation by Andrew Crips



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INIVE

International Network for Information on Ventilation and Energy Performance

Operating Agent of AIVC and
coordinator of SAVE ASIEPI project, EPBD Buildings Platform and BUILD UP

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This workshop is supported by

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This workshop is financially supported by

EuroACE
The European Alliance of Companies for Energy Efficiency in Buildings

eurima
European Insulation Manufacturers Association

DAIKIN

ES-SO
EUROPEAN SOLAR SHADING ORGANIZATION
Energy Savings & Comfort

PITTSBURGH CORNING EUROPE NV/SA

2009 AIVC conference

30st AIVC conference

Trends in High Performance Buildings
and the role of Ventilation

and

International Conference on Building and Ductwork Air Tightness (BUILDAIR)

former "European BlowerDoor-Symposium"

Hotel Steglitz International
Berlin, Germany

1–2 October 2009

International Workshop on Summer Comfort and Cooling

Scope and Objectives

Mat Santamouris and P. Wouters

The Problem

Construction is one of the most important economic sectors worldwide. The total world’s annual output of construction is about 2000 billion € and constitutes almost one-tenth of the global economy.

About 30% of the business is in Europe, 22% in the United States, 21% in Japan, 23% in developing countries and 4% in the rest of the developed countries.

Buildings use almost 40% of the world’s energy, 16% of the fresh water and 25% of the forest timber, while is responsible for almost 70% of emitted sulphur oxides and 50% of the CO_2

The Problem

Construction represents more than 50 % of the national capital investment. It employs more than 111 million employees and it accounts for almost 7 % of the total employment, and 28 % of the global industrial employment.

Given that every job in the construction sector generates 2 new jobs in the global economy, it can be said that the construction sector is in a direct or indirect way is linked to almost 20 % of the global employment

The Problem

Very rapid penetration of air conditioning

(In thous[illegible] units)

	2000	2001	2002	2003	2004	2005	2006	20[illegible]	2008
World total	**41,874**	**44,834**	***46,840**	**54,379**	**58,147**	**60,422**	[illegible]	**65,663**	**68,654**
Japan	7,791	8,367	7,546	7,307	7,679	7,500	7,500	7,500	7,500
Asia (excl. Japan)	13,897	16,637	*17,761	23,650	26,430	[illegible]	30,340	32,524	34,881
Middle East	1,673	1,730	*1,804	2,218	[illegible]	2,515	2,604	2,660	2,717
Europe	2,907	2,918	*3,412	[illegible]	4,799	5,087	5,382	5,694	6,118
North America	12,322	[illegible]	[illegible]	13,075	12,876	12,881	12,889	12,897	12,905
Central & South America	[illegible]	1,939	*2,036	2,243	2,331	2,418	2,473	2,530	2,592
Africa	664	758	700	814	850	885	915	944	978
Oceania	512	593	671	712	815	825	868	913	963

The Problem

- Energy demand for residential space cooling accounted for 6.4% of total electricity demand in the OECD in 2000
  - 13% growth from 1990 to 2000!
- About 46% of OECD households have some air conditioning, but this varies widely
  - Up to 80% of new homes in the US have central a/c systems
  - The majority of Japanese households have a/c, on average, two and a half room AC units
  - Some 27% of Australian homes have AC
  - Europe had very low rates, around .02 per household on average, but there was a 7-fold increase over the 1990s and now AC saturation could be around 5-7% of households

The Problem

AC electricity consumption in 15 EC Countries :

- 33 TWh in 1995 (11 Mt CO2)
- 51 TWh in 2000 (18 Mt CO2)
- 78 TWh in 2005 (27 Mt CO2)
- 95 TWh in 2010 (33 Mt CO2)

The Problem

Unit: tonnes CO2	1990	1996	20[illegible]0	2020
Austria	157	1 603	[illegible]5 748	31 467
France	26 860	87 377	285 231	468 957
Germany	7 845	25 615	139 241	265 983
Greece	99 235	959 93[illegible]	2 387 187	3 737 087
Italy	182 591	2 2[illegible] 038	2 923 568	3 623 486
Portugal	147 358	[illegible] 099	1 038 841	1 519 546
Spain	n.a. (around [illegible] 000)	1 124 255	4 381 826	7 130 489
UK	[illegible]10	219 640	704 204	1 165 583
Other E.U	4 694	15 369	83 545	159 590
Tota[illegible] E.U	516 451 (606 451)	5 038 935	11 959 391	18 102 187

Important Increase of CO2 emissions

WHAT IS DRIVING THE GLOBAL GROWTH

Increasing affordability

Shifts in comfort culture, behavioural patterns and consumer expectation

Increasing internal loads

Increase in urban heat island phenomenon

Movement toward universal building designs which are poorly adapted to the local climatic conditions

Increase in Cooling Degree days?

PROBLEMS ASSOCIATED WITH THE USE OF A/C

There are different problems associated with the use of air conditioning.

Apart from the serious increase of the absolute energy consumption of buildings, other important impacts include:

- The increase of the peak electricity load
- Environmental problems associated with the ozone depletion and global warming;
- Indoor air quality problems.

Possible solutions include:

•1. Improvement of the urban microclimate to fight the effect of heat island and temperature increase and the corresponding increase of the cooling demand in buildings.

- •This may involve the use of more appropriate materials, increased use of green areas, use of cool sinks for heat dissipation, appropriate layout of urban canopies, etc

2. Use of appropriate technology to improve indoor comfort conditions and reduce cooling needs

Aims

•The aim of the workshop is to examine the evolutions in the national regulations related to passive cooling and summer comfort:

- In terms of standards for achieving good summer comfort
- For improving energy efficiency during the summer period
- Regarding building solar control
- Regarding amortisation and dissipation techniques
- Regarding night time ventilation for passive cooling
- Regarding free cooling techniques

Aims

Also, to reply the following questions :

•What are experiences with compliances of regulations?

•What are major trends in the type of systems used?

•Is there a framework for the assessing of innovative passive cooling and low energy cooling systems?

INTERNATIONAL WORKSHOP

Summer comfort and cooling

Barcelona 31 March and 1 April 2009

Summer Comfort and cooling
in the ASIEPI project

Servando Álvarez Domínguez
Escuela Superior de Ingenieros
Universidad de Sevilla

ASsessment and Improvement of the EPBD Impact (for new buildings and building renovation)

ASIEPI

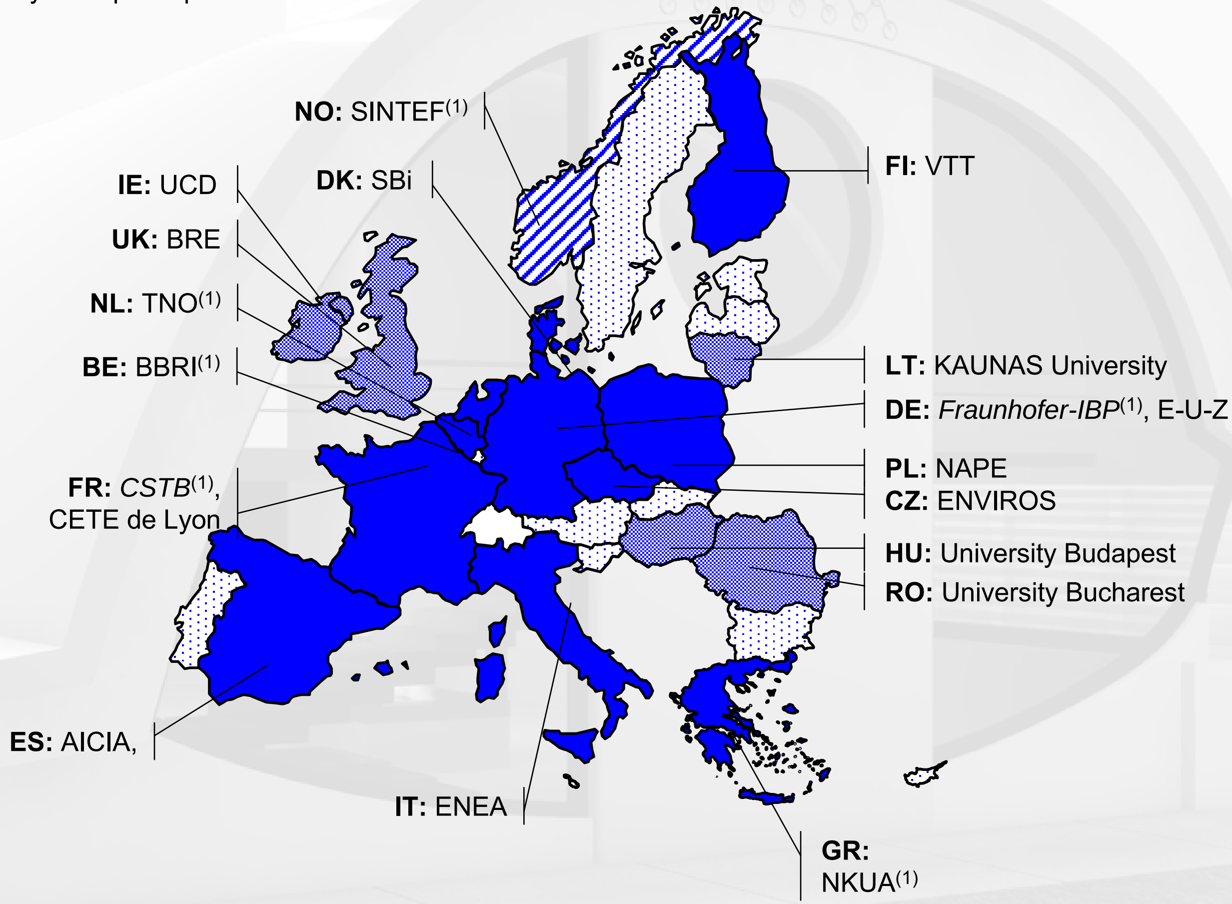
Intelligent Energy Europe

ASIEPI: project summary

- ASIEPI aims to support the Member States in their implementation of the EPBD, especially for what concerns
  - levels of requirements, organisation of control and compliance,
  - thermal bridges, building and duct airtightness,
  - evaluation of innovative systems,
  - summer comfort and cooling.
- ASIEPI aims to support the European Commission for the monitoring of the EPBD implementation and for the ongoing EPBD-recast.
- ASIEPI does not intend to develop its own technical solutions(*) but to collect available information, to analyse and structure it, and to bring it to the appropriate target audiences in order to increase the awareness of potential problems and solutions.
- ASIEPI includes partners from 17 different countries.

Countries covered by ASIEPI

- MS represented by one participant, including INIVE members and national contact points. There might be a second participant from this MS.
- MS represented by a national contact point as subcontractor
- Country outside EU-27 represented by a full participant
- MS not represented



International:
INIVE,
REHVA(2)
EURIMA(3),
PCE(3),
ES-SO(3),
EUROACE(3),
FIEC(3),
Acciona I (for ECTP)(3)

(1) INIVE member
(2) Umbrella association as partner
(3) Umbrella association as associate
In the MS where there are two participants, the national contact point is in *italic*.

Working packages

- WP1: Management
- WP2: comparison of EP-requirement levels
- WP3: compliance and control
- WP4: thermal bridges
- WP5: air tightness of the envelope and ducts
- WP6: equivalence (innovative solutions and buildings)
- WP7: summer comfort and cooling
- WP8: dissemination

WP 7- STIMULATION OF BETTER SUMMER COMFORT BY EPBD IMPLEMENTATION

❖ **Task 1. Approaches used by MS regarding summer comfort and/or air conditioning EP calculation methods**

- How do MS integrate summer comfort and/or energy use for AC in their EP calculation?
- What are the pro's and con's of such calculation methods?

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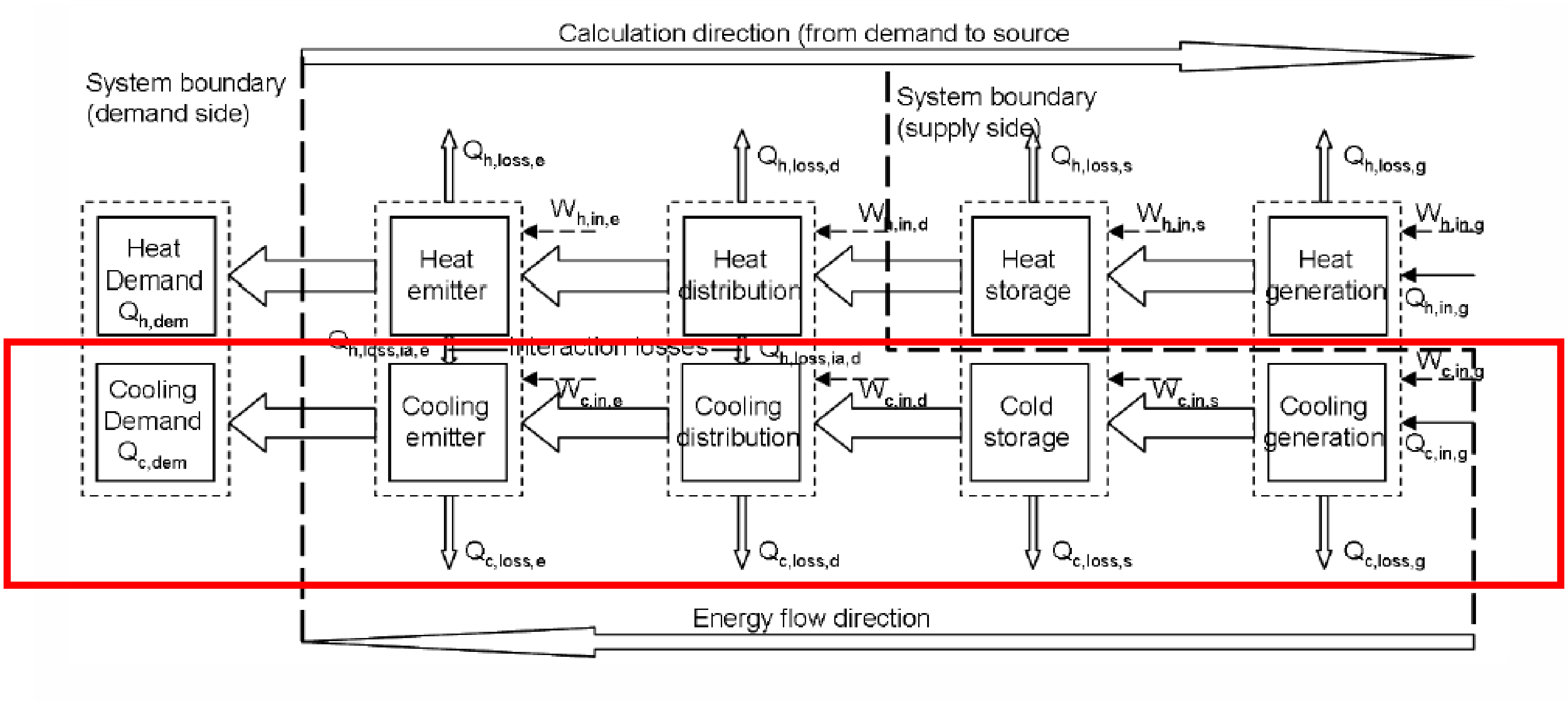
Task 1 summer comfort and/or air conditioning energy performance calculation methods



Scope and general aspects

Preliminary observation

- **information from:**
  - 7(8) countries
  - BE, DE, ES, FR, (GR), IT, NL, PL
- **many misunderstandings**
  - easy to make mistakes (➔ “relativate”/”put into perspective” the value of answers)
  - no common view on the domain yet: no uniform terminology
  - ENs may in due time (partly) help to reduce the problem

Cooling, general tendencies

- **thermal mass:**
  - sensible: all
  - PCM: none
- **solar gains & shading:**
  - thru transparent components: all
  - thru opaque components: some
- **heat transfer:**
  - only BE different U/HT value calculations (default values)
  - wetting: nowhere
- **AHU: partly considered apart**
  - ground HX: no
  - recovery & by-pass: mixed
  - (dir & indirect) evaporative cooling: ES only
  - nighttime operation: mixed
  - latent: if AHU apart
- **intensive ventilation**
  - only in FR fairly elaborated
  - partly higher, fixed values in other countries
- **in/exfiltration**
  - +/- considered everywhere
  - only in BE different default values

Cooling, systems

- **emission & distribution: mostly simplified**
- **storage: only DE**
- **generation:**
  - MVC: yes, or simplified
  - sorption systems:
    - closed: most
    - open (desiccant): DE only
  - passive dumps:
    - only air (ventilation)
    - ground: only BE and NL
    - surface water: no
- **auxiliary consumptions:**
  - +/- taken into account

Overall observations: overheating

- **3 countries only**
  - FR: all bldgs without AC
  - BE & NL: res only (w/wo AC)
  - (DE? Sonneneintragkennwert?)
- **“net energy use”:**
  - same design variables as cooling
- **no central systems**
  - e.g. (high t°) cooling with ground water

❖ **Task 2. Additional requirements related to summer comfort and air conditioning**

– What are (if any) additional requirements imposed by countries in order to limit summer comfort problems and/or the use of air conditioning?
  - Limiting the area of glazed surfaces
  - Limiting the amount of solar gains
  - Specific mandatory overheating criteria
  - Requirements regarding shading
  - Minimum efficiency of active cooling devices

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Possible levels for fixing requirements regarding cooling

Level 1	Level 2	Level 3	Level 4
Overall consumption	Heating		
	Cooling	Reduce energy needs	Reduce gains
		Increase efficiency of cooling systems	Increase losses
	Hot water production		
	Lighting		
	General use of electricity		

Level 1.- Overall consumption

	ES1	ES2	NL	BE1	BE2	FR	PT	DE1	IR/UK	DE2	IT
1. Are there limitations of the overall energy performance of the building including cooling?	NO	NO	YES	YES	YES	YES	YES??	YES	YES	NO	NO

sad@tmt.us.es

Ways to express the overall energy consumption

	NL	BE1	BE2	FR	DE1 Resident.	DE1 Non-resident.	IR/UK
Equation	EP<Equat.	EP<Equat	EP<Equat		EP<Equat		
Using reference building				EP<EP notional building		EP<EP notional building	EP<EP Notional building

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Possible levels for fixing requirements regarding cooling

Level 1	Level 2	Level 3	Level 4
Overall consumption	Heating		
	Cooling	Reduce energy needs Increase efficiency of cooling systems	Reduce gains Increase losses
	Hot water production		
	Lighting		
	General use of electricity		

Cooling consumption

	E1	E2	NL	B1	B2	F	P	D1	D2	IT	IR/UK
2. Are there specific independent limitations for cooling?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

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Possible levels for fixing requirements regarding cooling

Level 1	Level 2	Level 3	Level 4
Overall consumption	Heating		
	Cooling	Reduce energy needs	Reduce gains
		Increase efficiency of cooling systems	Increase losses
	Hot water production		
	Lighting		
	General use of electricity		

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Level 3.- Cooling needs

	E1	E2	NL	B1	B2	F	PT	D1	D2	IT	IR/UK
3. Are there limitations regarding cooling needs?	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO	NO

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Possible levels for fixing requirements regarding cooling

Level 1	Level 2	Level 3	Level 4
Overall consumption	Heating		
	Cooling	Reduce energy needs Increase efficiency of cooling systems	Reduce gains Increase losses
	Hot water production		
	Lighting		
	General use of electricity		

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Level 3.- Efficiency of cooling systems

	E1	E2	NL	BE1	BE2	FR	PT	DE1	DE2	IR/UK	IT
5. Are there limitations regarding efficiency of cooling system?	Yes in some cases	Yes in some cases	NO	NO	NO	NO	NO	NO	NO	NO	NO

Free-cooling and energy recovery systems

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Possible levels for fixing requirements regarding cooling

Level 1	Level 2	Level 3	Level 4
Overall consumption	Heating		
	Cooling	Reduce energy needs Increase efficiency of cooling systems	Reduce gains Increase losses
	Hot water production		
	Lighting		
	General use of electricity		

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Level 4.- Reduction of gains

	E1	E2	NL	B1	B2	FR	PT	DE1	DE2	IR/UK	IT
7. Are there limitations of the glazed area?	YES 60% of the area of every orientat ion	NO	NO	NO	NO	NO	NO	NO	NO	??	NO
8. Are there limitations regarding solar protection?	YES	NO	NO	NO	NO	NO	YES	NO	YES	??	NO

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Comfort

	E1	E2	NL	BE1	BE2	FR	PT	DE1	DE2	IT	IR/UK
6. Are there requirements regarding comfort conditions?	NO	NO.	Indications For residential	YES	NO	YES	NO	NO	YES	NO	Indications for residential

Comfort criteria based on:

- Number of hours where indoor operative temperature > reference temperature
- Number of degree-hours (indoor operative temperature-reference temperature) < value
- Temperature of the building lower than the temperature of the reference building

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❖ Task 3. Handling of alternative cooling techniques.

- What is the experience of MS with alternative cooling techniques?
  - direct/indirect evaporation,
  - earth to air heat exchangers,
  - radiative cooling,
  - night ventilation
  - …
- To what extent are those covered by the procedures used by the MS and how is this done?
- Which alternative comfort techniques are being used?
  - Adjusted comfort according to CEN
  - PMV/PPD

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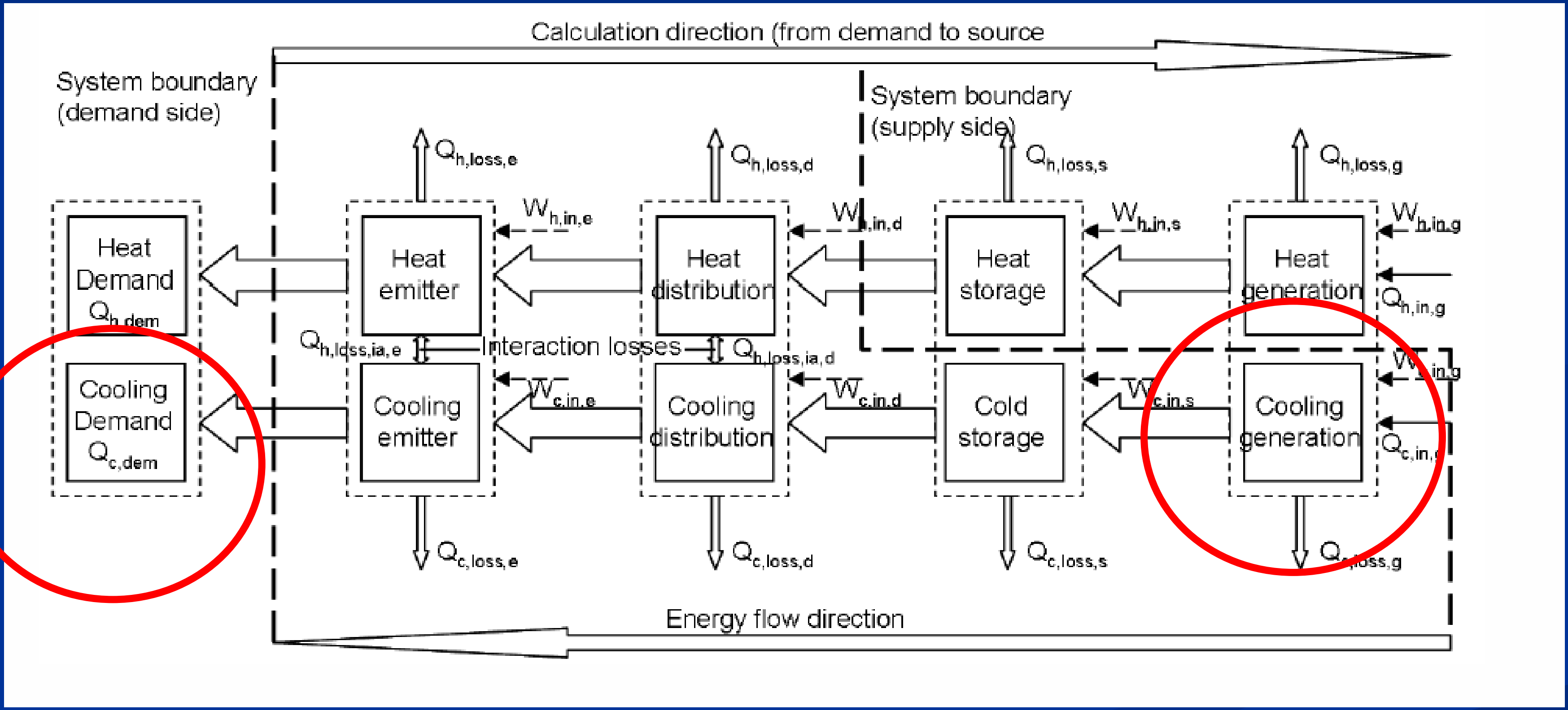
Task 3: alternative cooling techniques



Task 3: Direct alternative cooling (roof ponds, direct ground cooling, evaporative walls, night ventilation, microclimate

Task 3: Indirect alternative cooling (buried ducts, evaporative, radiative)

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❖ Task 4: Alternative cooling calculation methods

- How are worldwide alternative calculations for cooling and summer comfort performed?
- What are the experiences from the use of such alternative calculation methods?
- Advantages, difficulties and constraints and how to overcome them.
- The impact of the methodology on the summer energy consumption of the building stock
- Comparative simulations using present regulatory calculation methodologies against using alternative methodologies for cooling will be performed on reference buildings for each participating country.

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Summary of topics to be revised and compared

- Comfort criteria

- Zoning

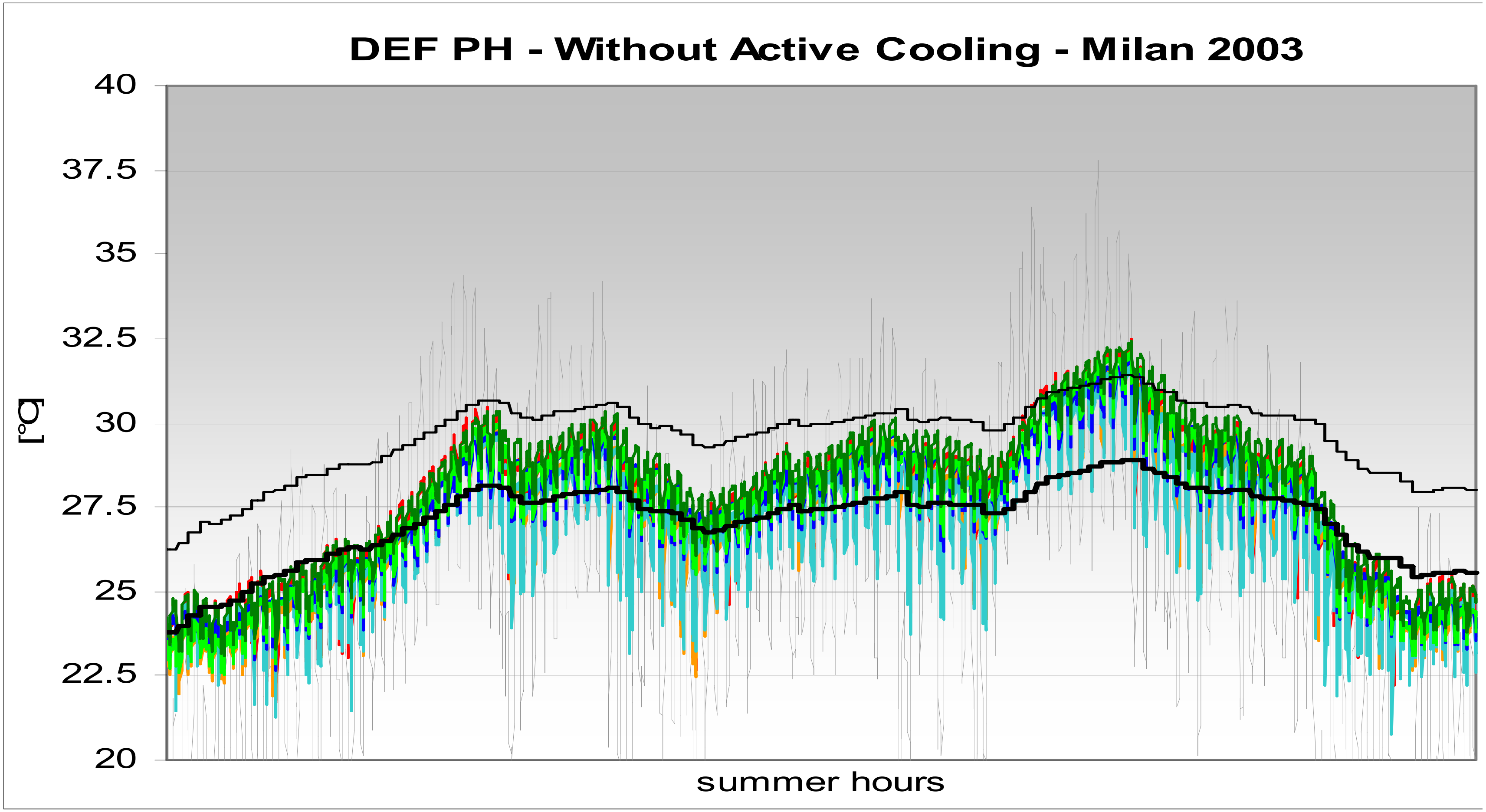
- Solar control.- Quality/scope of the solar control algorithms

- Heat ammortisation.- Thermal mass (influence of redistribution and absorption of solar radiation)

- Heat dissipation by intensive ventilation.- Calculation of the air flow rates, role of the thermal mass

- Missing issues.- dynamic solar control, ground cooling / evaporative cooling……

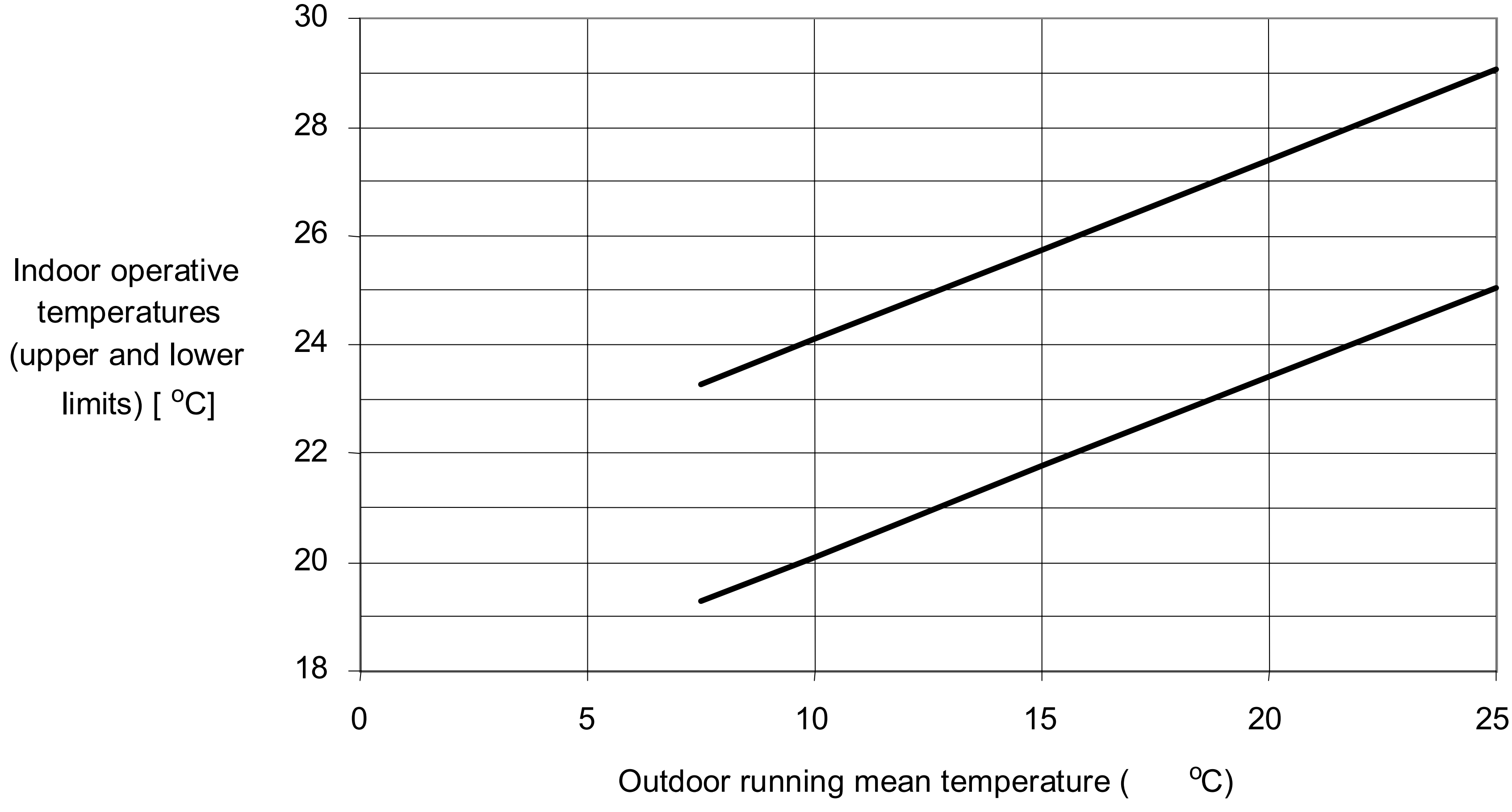
Comfort criteria: Influence on the tolerable frequency of exceeding a certain level of indoor temperature



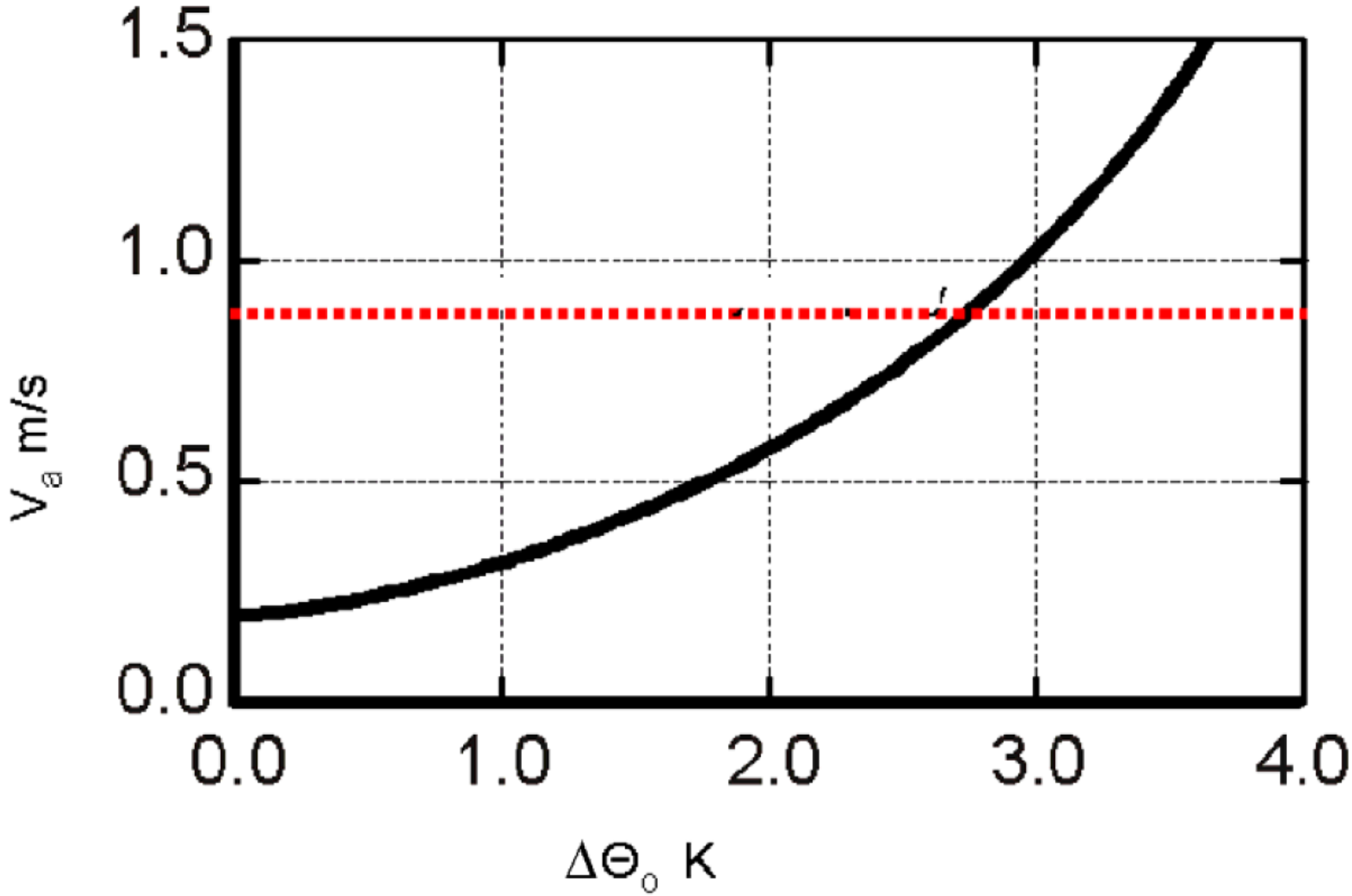
EN 15251

Adaptative comfort Reference.- EN 15251

Adaptive comfort zones for European buildings



Efect of fans



EN 15251

The equations representing the lines in the graph are:

Upper limit $t_{comf\ high} = 0.33 \bullet t_{rm} + 18.8 + \Delta T$ [°C]

Lower limit $t_{comf\ low} = 0.33 \bullet t_{rm} + 18.8 - \Delta T$ [°C]

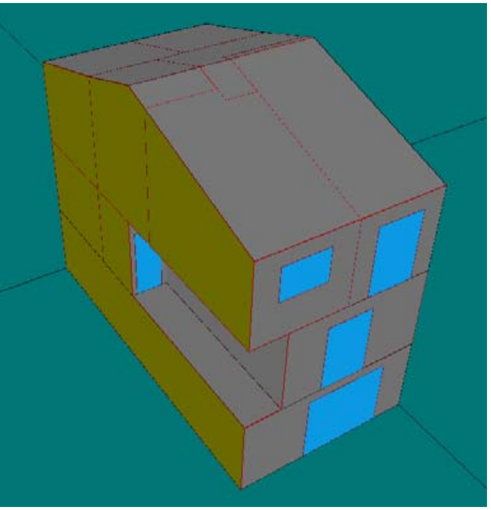
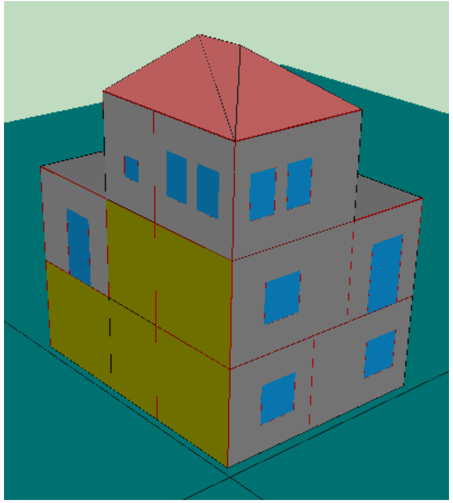
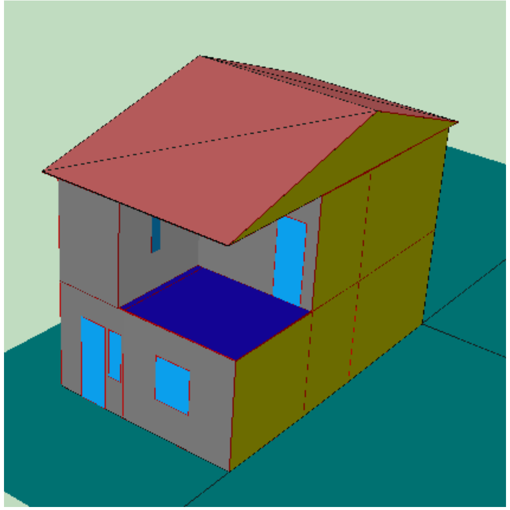
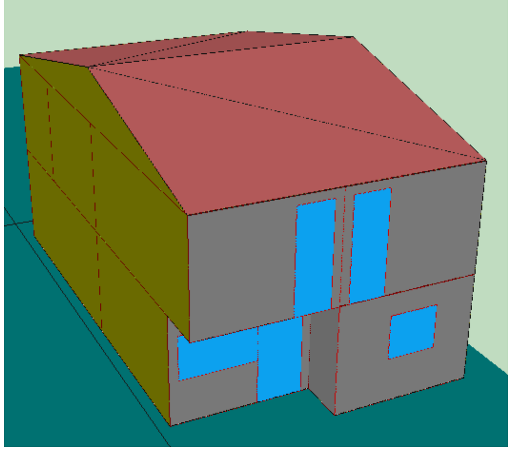
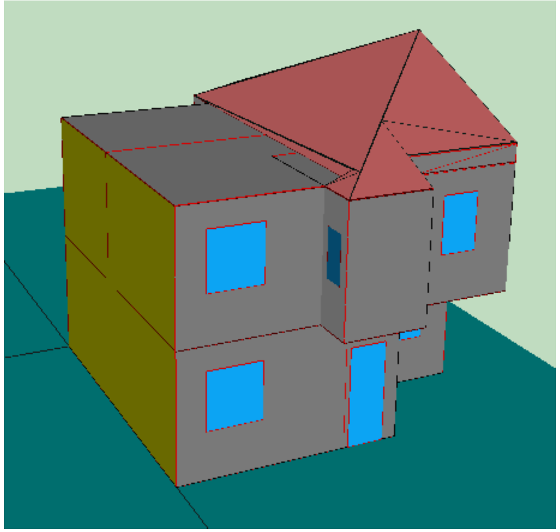
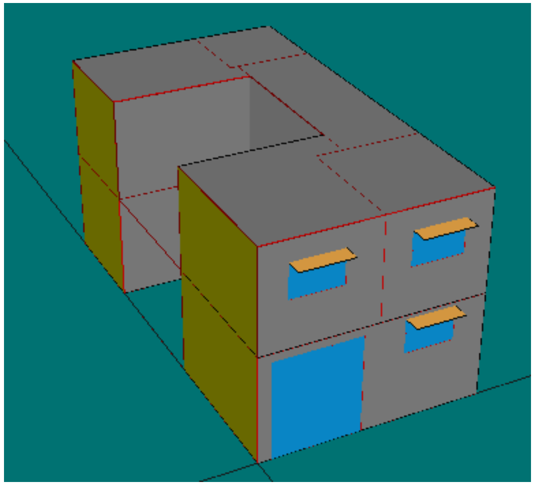
ΔT Values	without fan	with fan
New	2	4.5
Existing	3	5.5

Meythodology for comparison

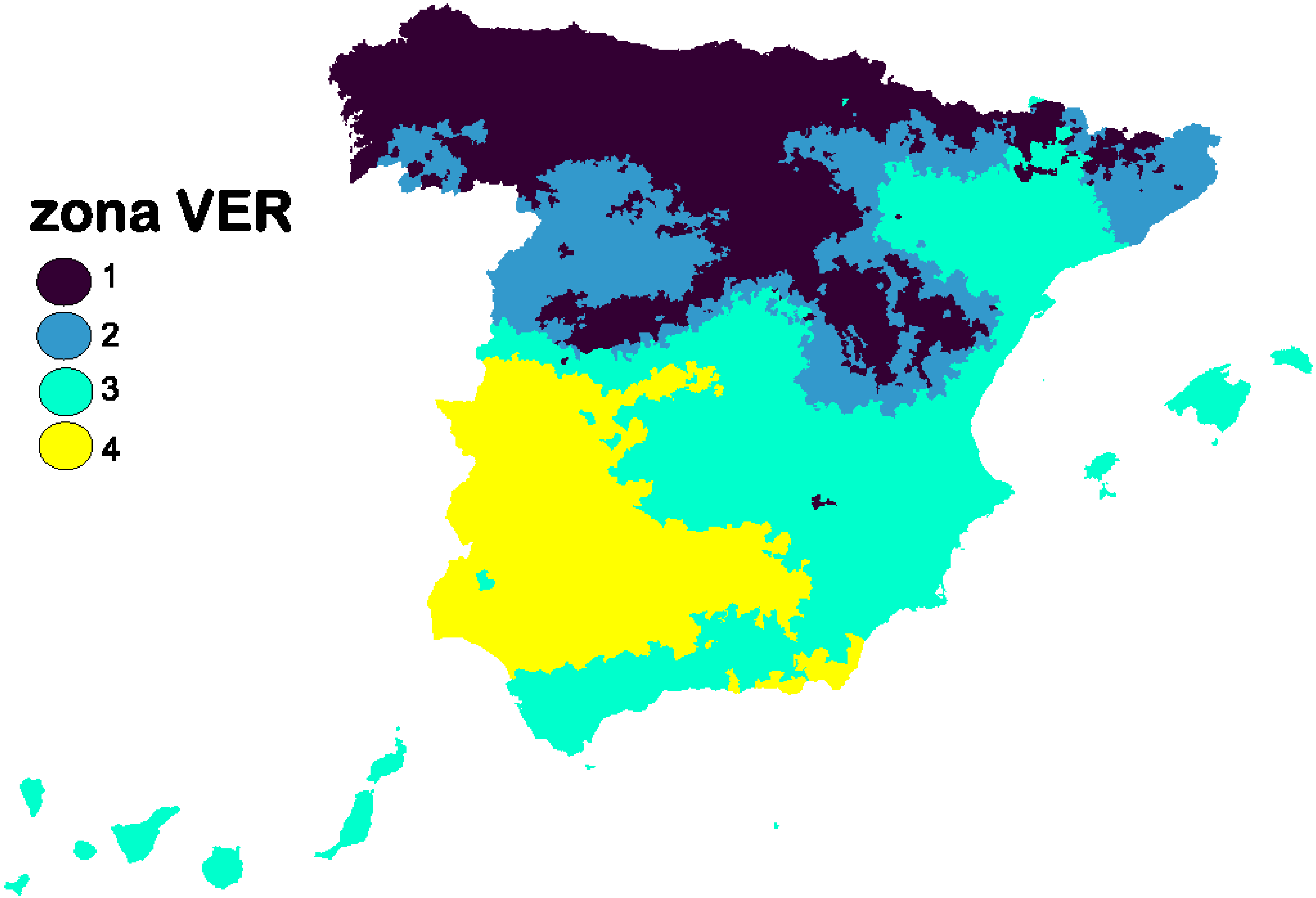
- Selection of buildings
- Selection of climates

- Comparison of the assumptions (constant reference of temperature) with the same approach based on adaptative comfort (variable reference)

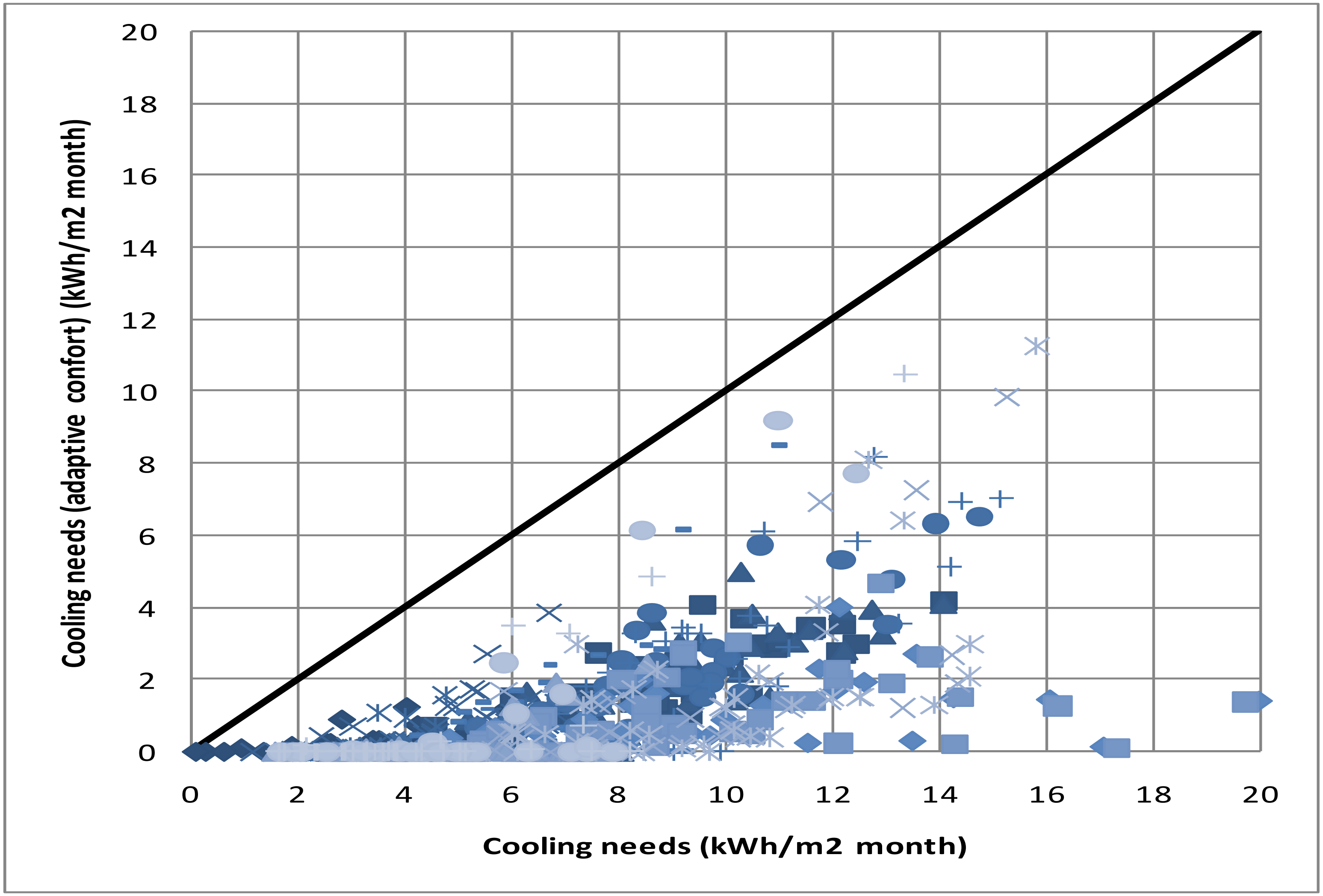
<u>Single family houses:</u>

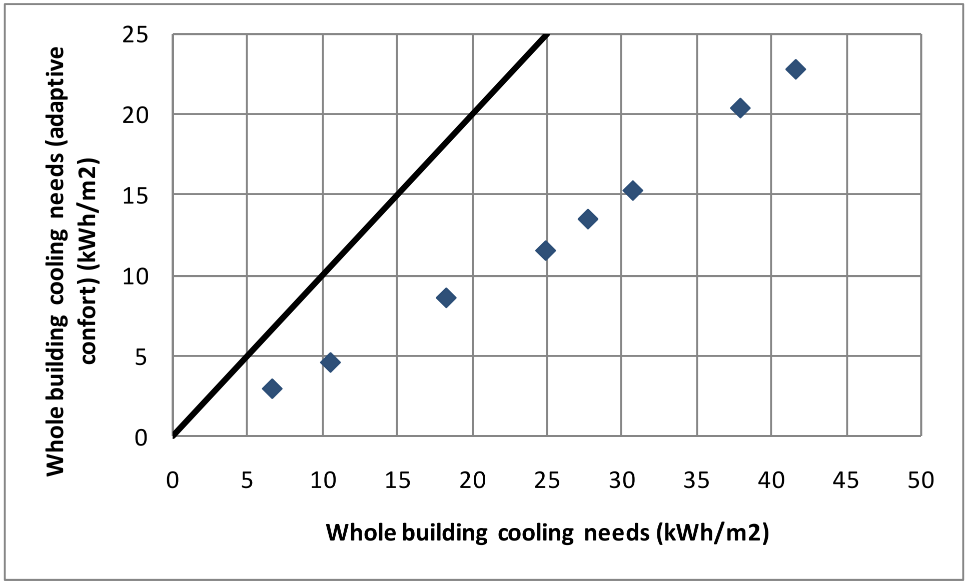
Climatic zones

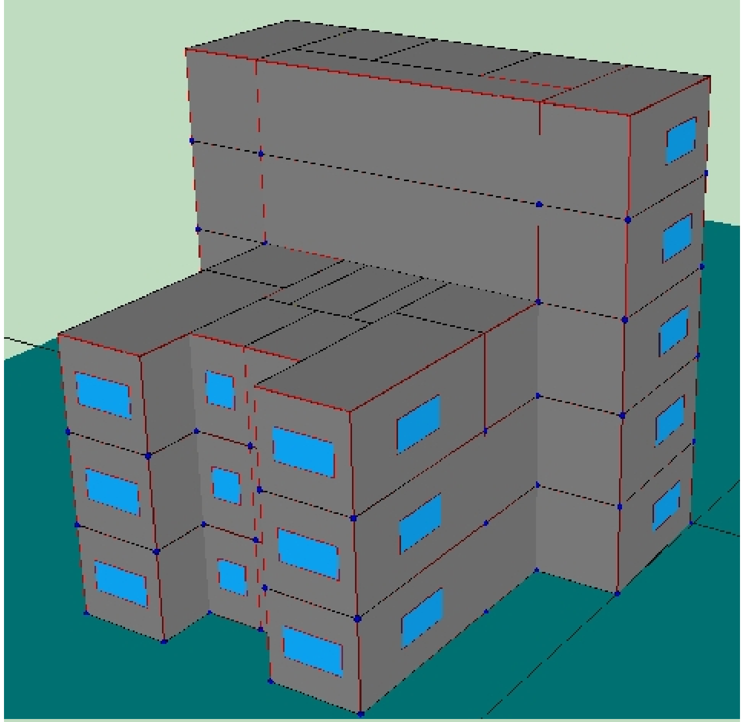


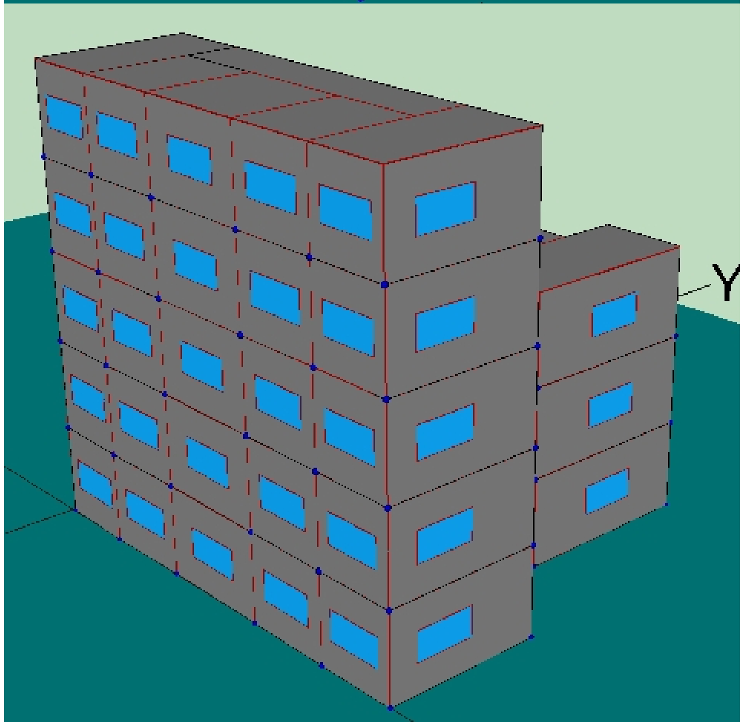
Cooling needs conventional vs. Adaptative (residential)



Cooling needs conventional vs. Adaptative (office)







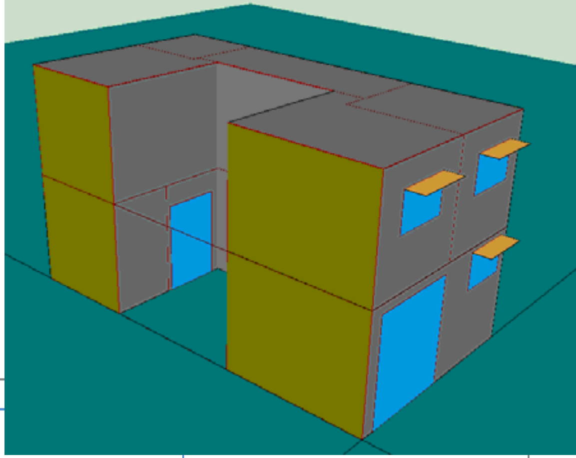
Zoning

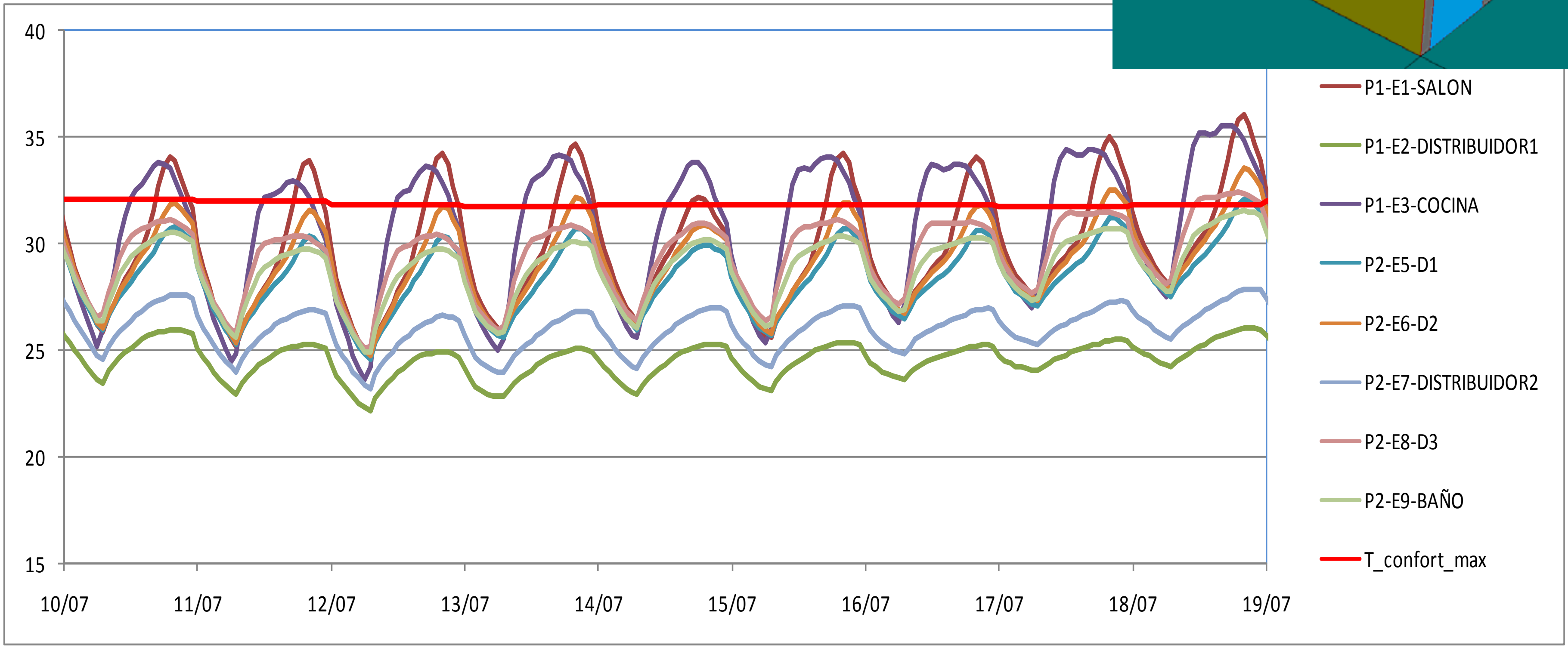
- Single zone versus multizone approach

Partitioning of the building into thermal zones is not required if all of the following conditions apply to spaces within the building.

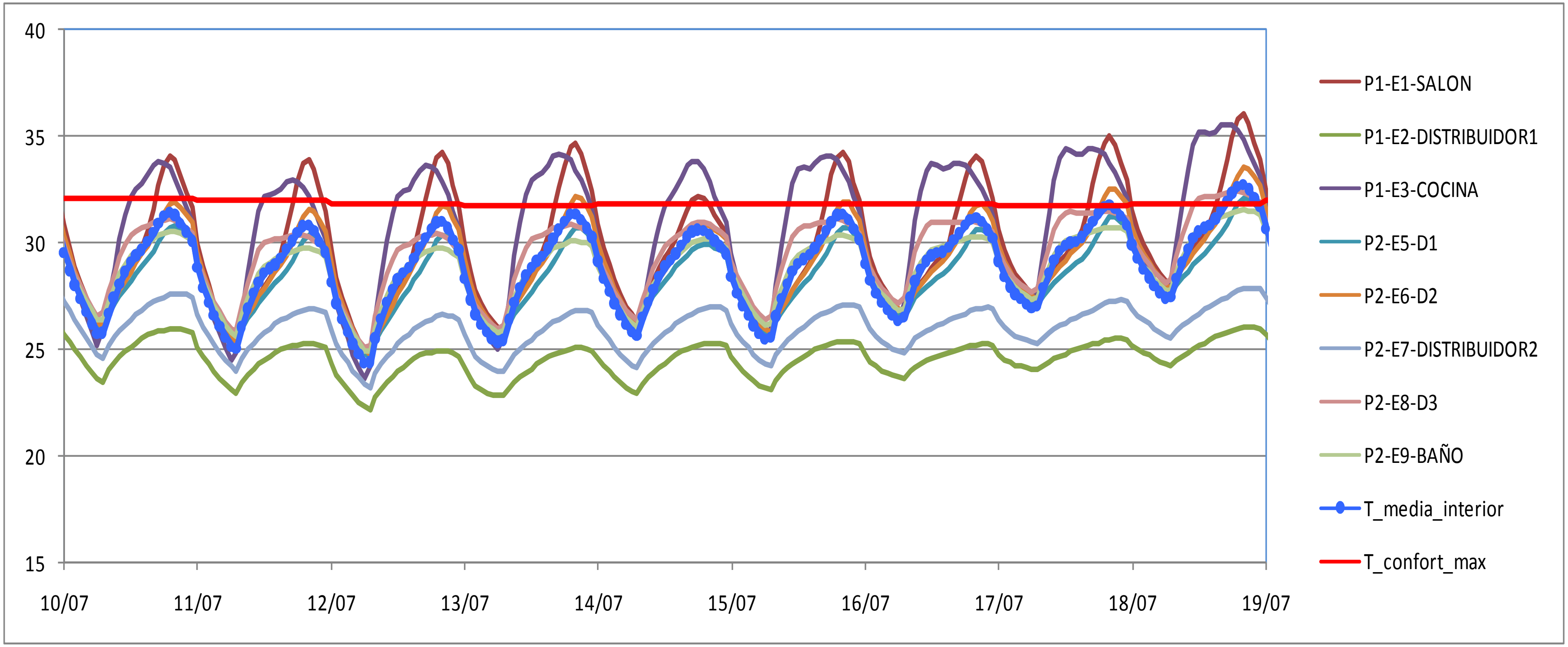
- Set-point temperatures for heating of the spaces differ not more than 4 K.
- The spaces are all not mechanically cooled or all mechanically cooled and set-point temperatures for cooling of the spaces differ not more than 4 K.
- ……….

Temperatures of the different spaces 10-19 July

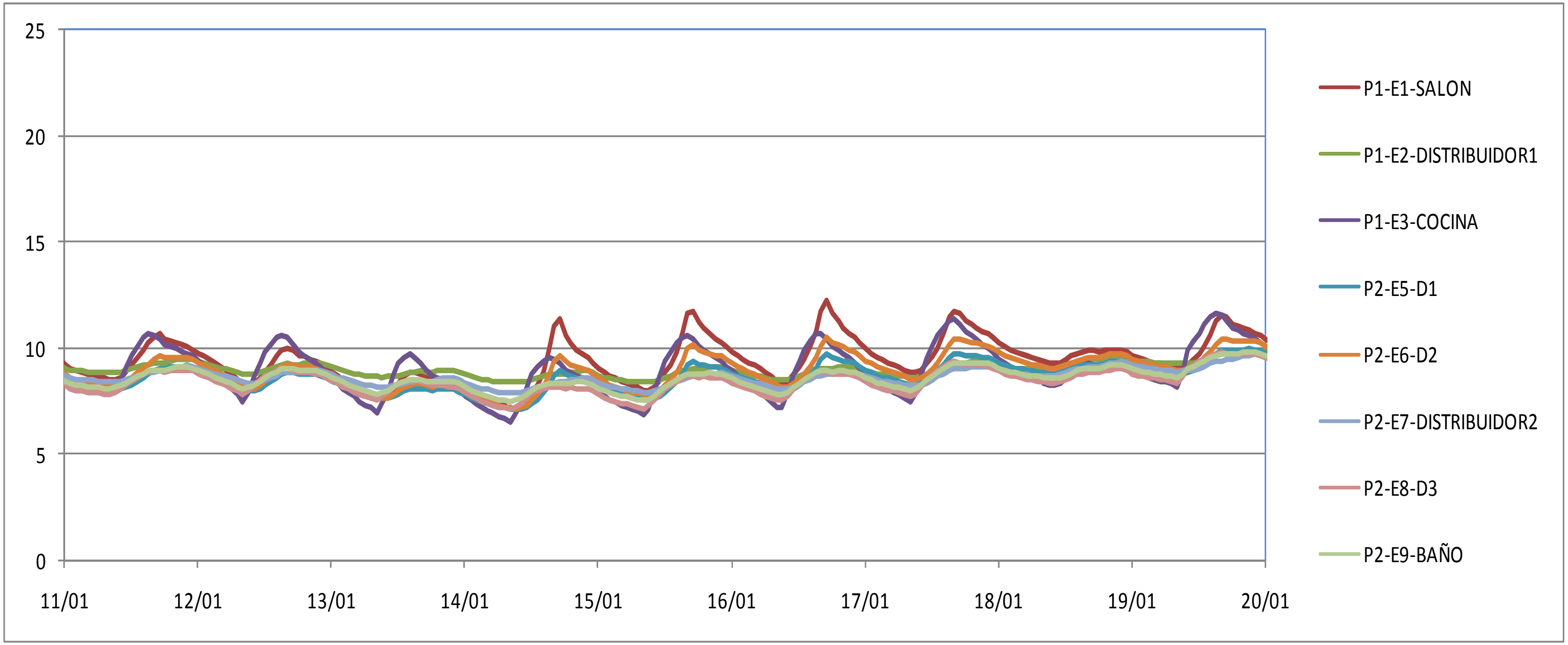




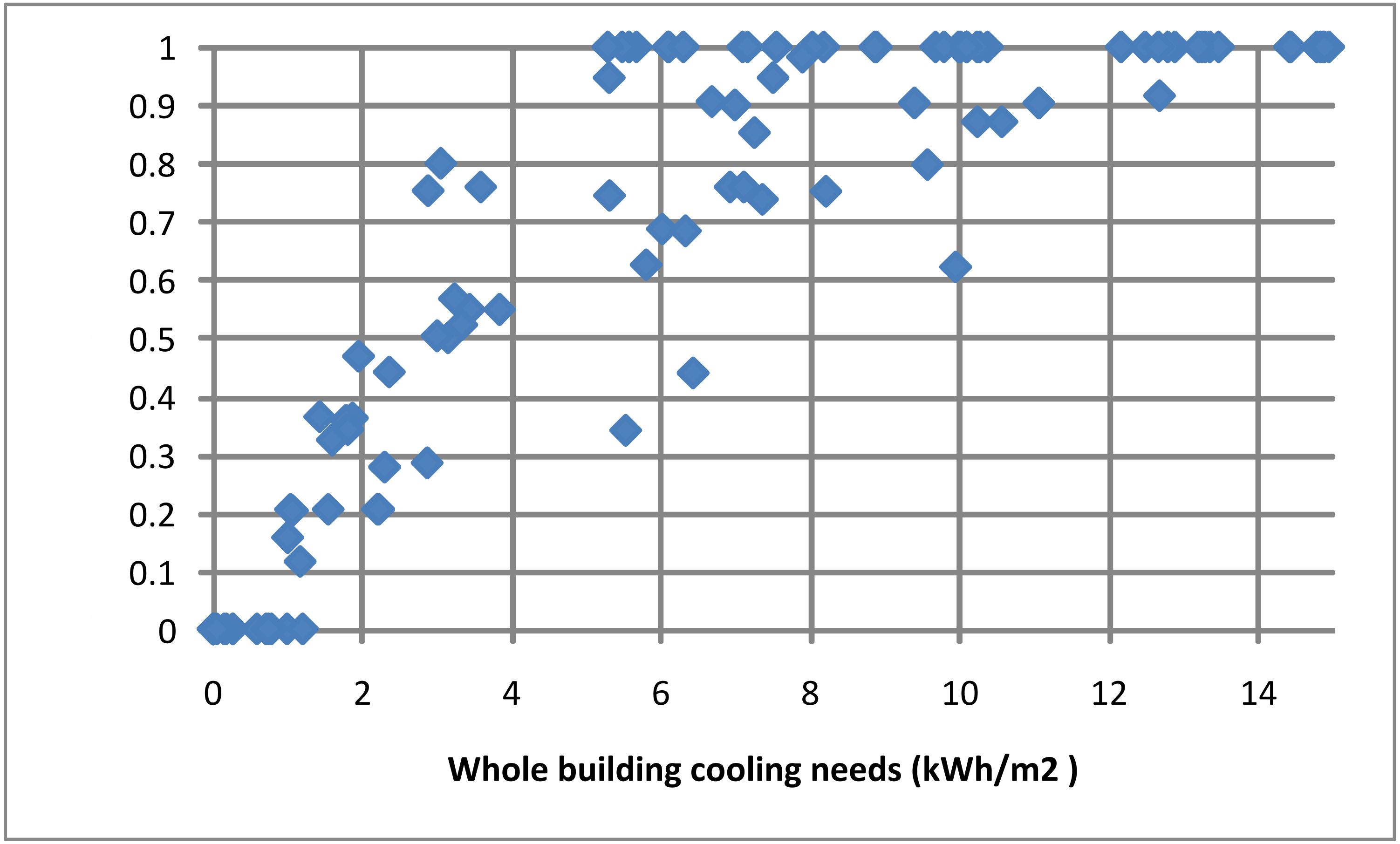
Temperatures of the different spaces and average temperature of the building



Temperatures of the different spaces
11-20 January



Percentage of conditionned area as a function of the cooling needs

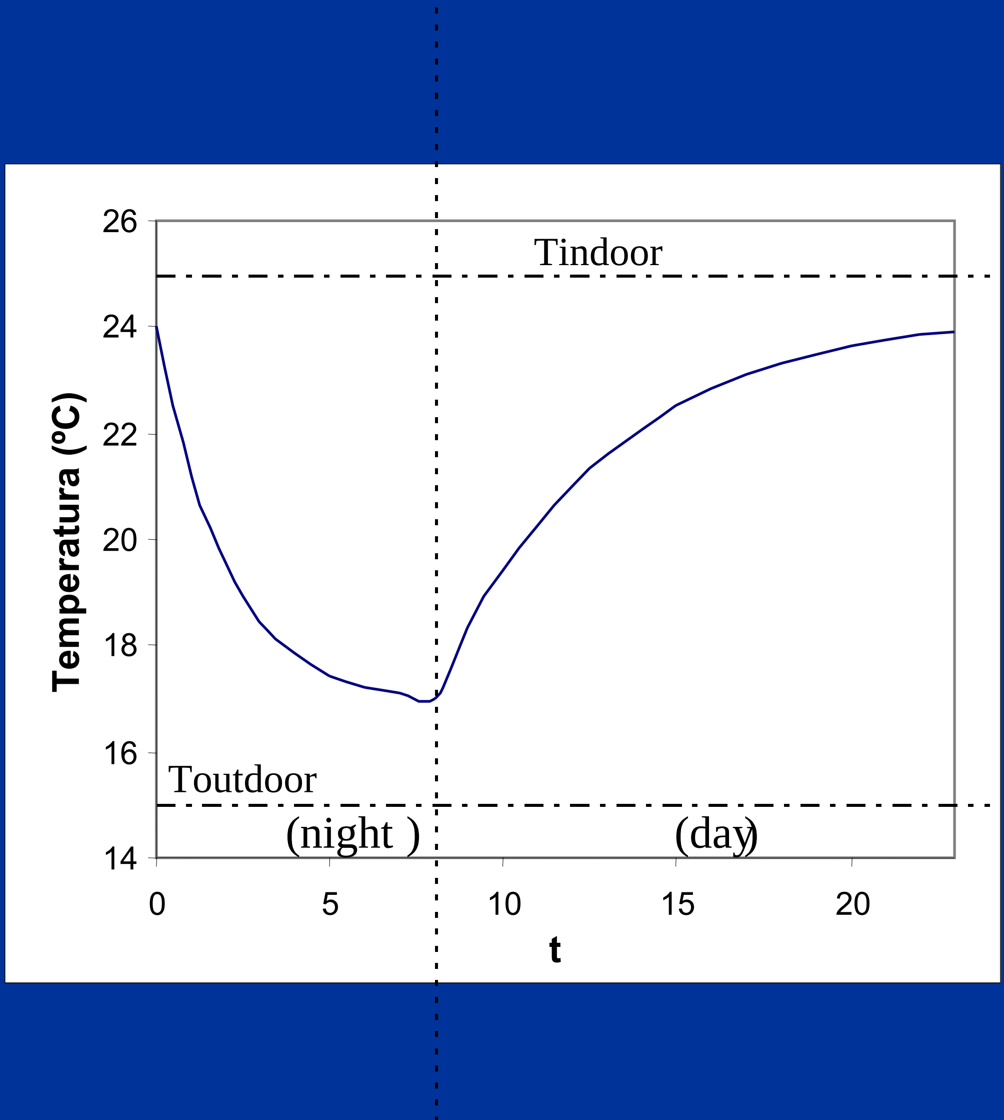


Disipation via ventilation losses in CEN

— the air temperature is uniform throughout the room;

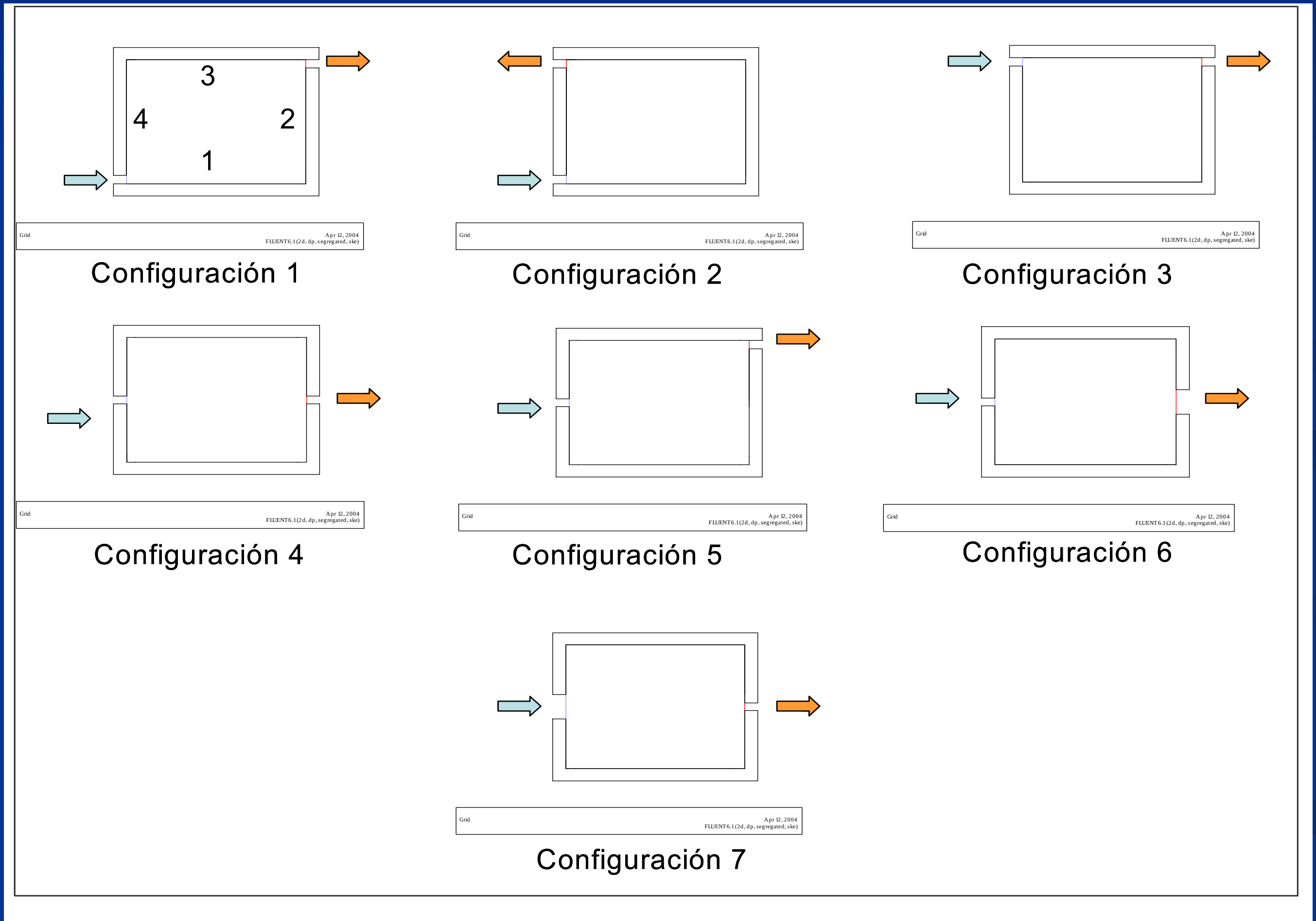
— the convective heat transfer coefficients are fixed;

Disipation via ventilation losses



- Night time outdoor temperatures
- Air changes per hour
- Air flow patterns
- Relative position of the inertia

Air flow patterns



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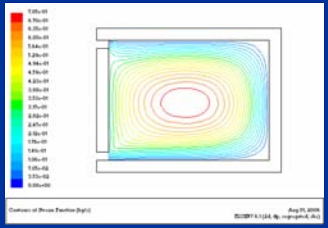
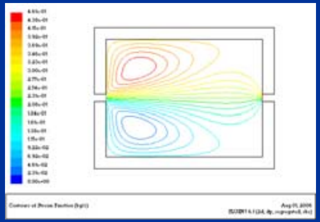
Convective heat transfer coeficients at the different walls

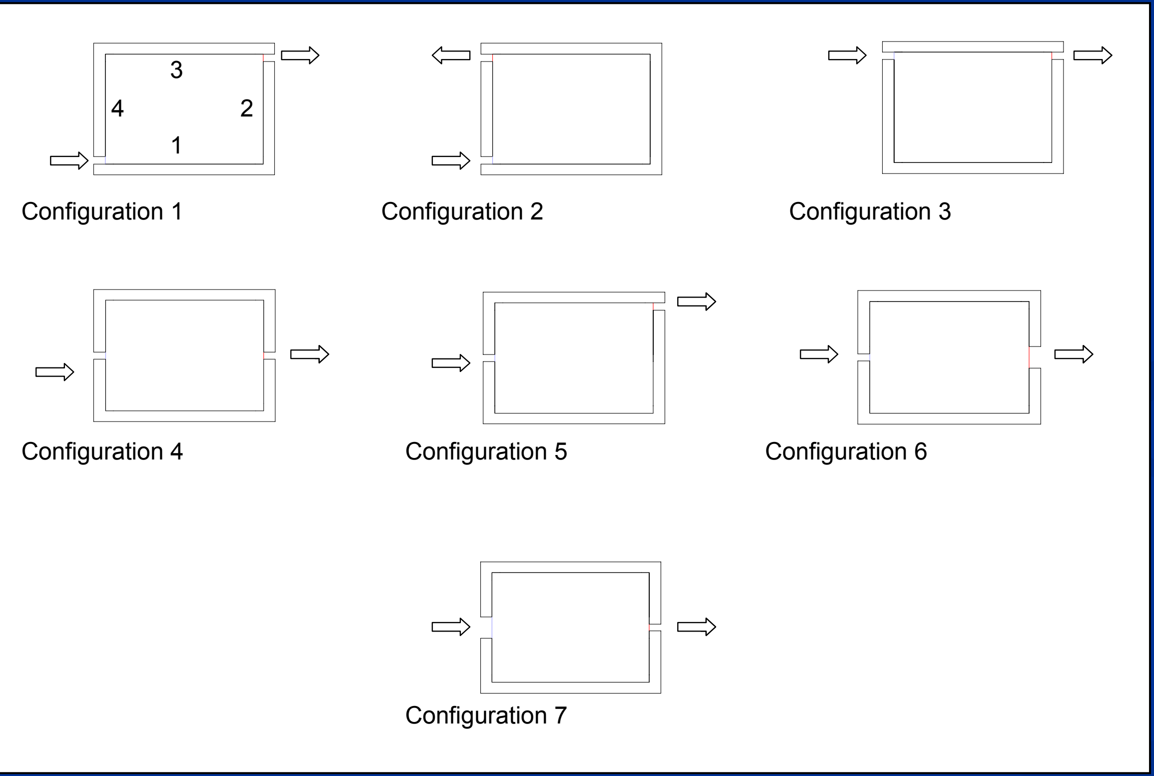




Recintos	Presión(Pa)	h1(W/m²·K)	h2(W/m²·K)	h3(W/m²·K)	h4(W/m²·K)
1	2	7.5332	4.2014	3.9374	3.0682
	4	9.7746	5.7274	5.3421	3.9531
	6	11.4923	6.9010	6.4027	4.6099
2	2	7.7706	3.9052	3.7842	4.4850
	4	10.1395	5.3656	5.2138	5.8791
	6	11.9687	6.5116	6.3213	6.9154
3	2	3.0328	4.6183	7.3520	3.0187
	4	4.1415	6.2518	9.6733	3.8997
	6	4.9867	7.4951	11.4896	4.5492
4	2	2.5180	3.1888	2.5322	4.3629
	4	3.4269	4.2782	3.4451	5.2206
	6	4.1079	5.1115	4.1298	5.8227
5	2	2.2756	2.8092	3.4547	4.3909
	4	3.0469	3.8944	4.7378	5.2557
	6	3.5948	4.7385	5.7372	5.8659
6	2	3.4132	3.0582	3.4274	4.9450
	4	4.8140	4.3464	4.8050	6.0459
	6	5.9094	5.3986	5.7624	6.7669
7	2	2.4818	3.5045	2.4933	3.4893
	4	3.1498	4.5091	3.1631	3.9433
	6	3.6451	5.2446	3.6598	4.2443

sad@tmt.us.es

Influence of the air flow patterns



Configuration	Relative energy stored
1	0,93
2	1
3	0,88
4	0,62
5	0,66
6	0,76
7	0,43

sad@tmt.us.es

Task 5 : Generation of Contents for Dissemination Activities

The collected information will be used to produce guidance for MS regarding the various options (with pro's and con's for the different approaches).

Task 5.1: 5 Information Papers
Task 5.2: Provide WP7 related information to the EPBD Buildings Platform databases (publications, standards, events, websites),
Task 5.3: Handling of a limited amount of specific WP7 related questions asked to the EPBD Buildings Platform helpdesk,
Task 5.4: Content and programme management of 2 internet based information sessions,
Task 5.5: 2 PowerPoint Presentations (including voice recording) to be published as "presentations on demand" that can also possibly translated to national languages by all partners.

ASIEPI contacts

- International Network for Information on Ventilation and Energy Performance INIVE
  c/o Belgian Building Research Institute BBRI
  - Peter Wouters
  - Dirk Van Orshoven
  - Nicolas Heijmans
- c/o National and Kapodistrian University of Athens NKUA
  - Mat Santamouris
  - Marianna Papaglastra
- Contact: asiepi@asiepi.eu

www.asiepi.eu

INTERNATIONAL WORKSHOP

Summer comfort and cooling

Barcelona 31 March and 1 April 2009

GRACIAS POR SU ATENCIÓN

Servando Álvarez Domínguez
Escuela Superior de Ingenieros
Universidad de Sevilla

Supported by

Intelligent Energy Europe

BUILDING AdVENT

Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions

Andrew Cripps, Buro Happold, London

Contract number: EIE/06/063/SI2.448101

Buro Happold?

Buro Happold is
a world class
multi-disciplinary
engineering consultancy.

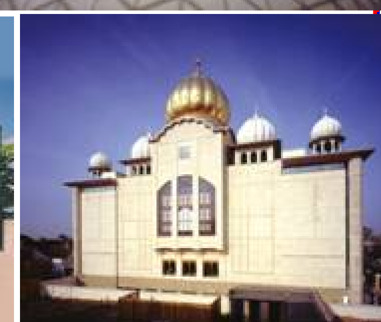
Our core activities
span all aspects
of engineering
the built environment





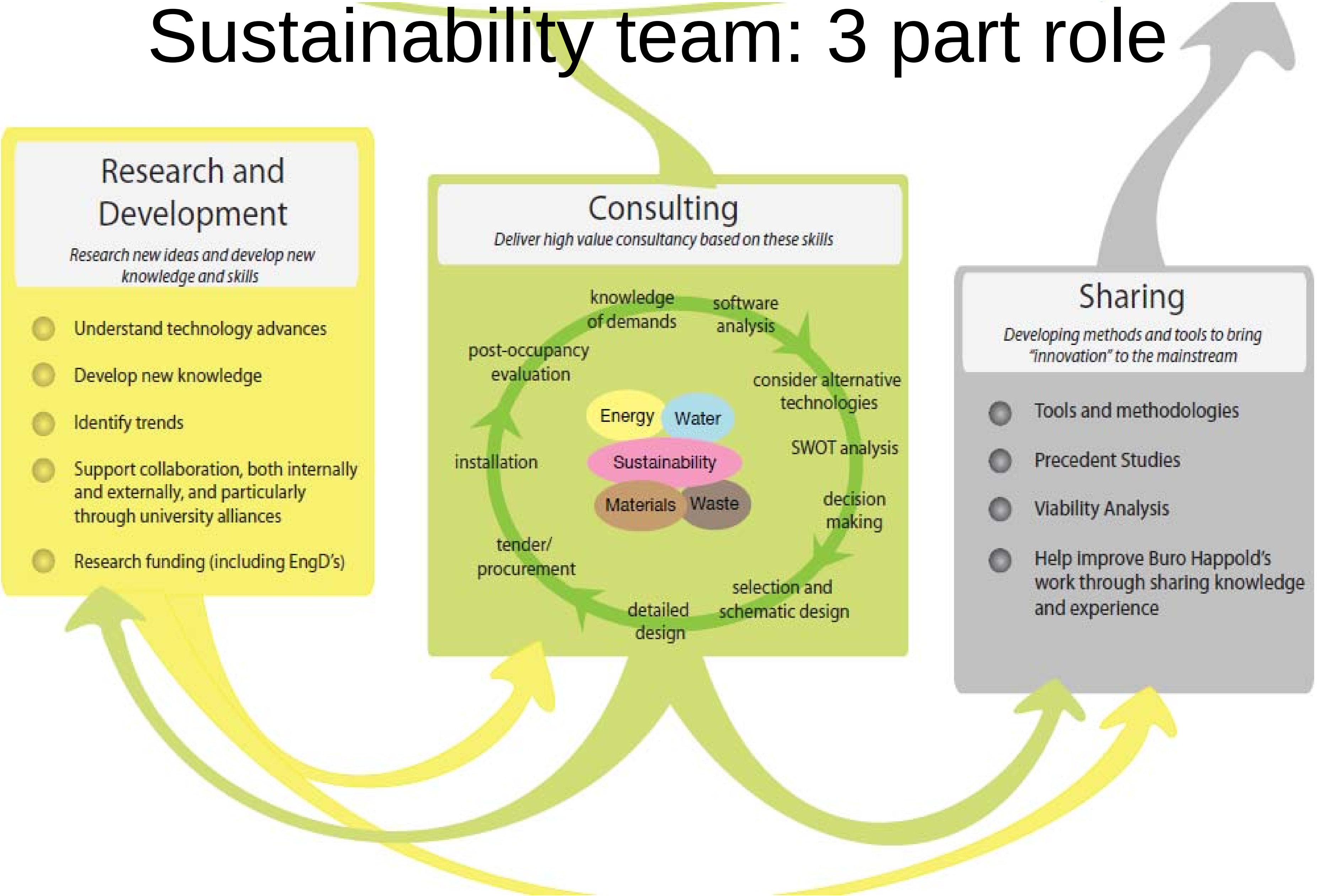




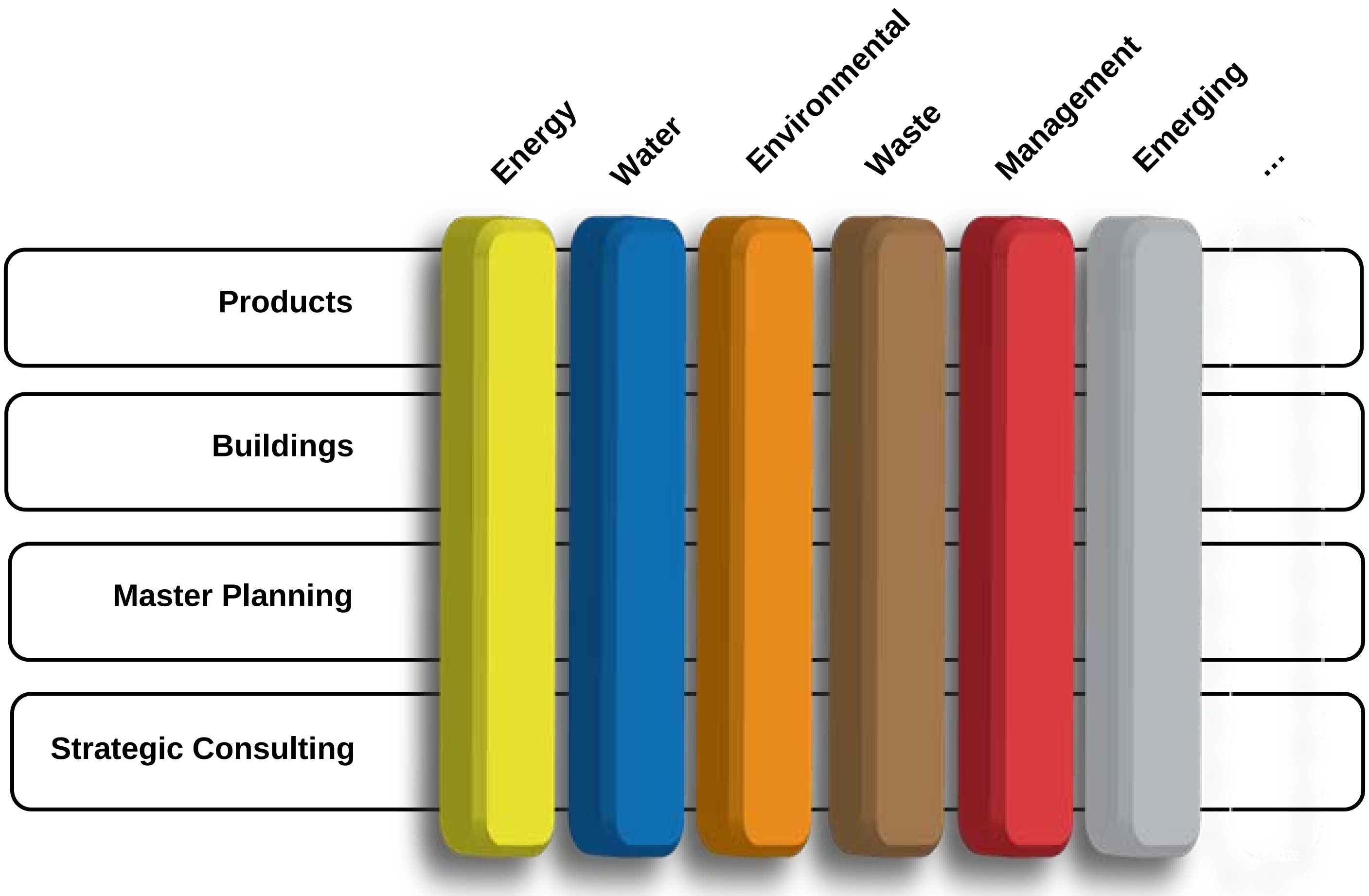


Buro Happold offices

Sustainability team: 3 part role



What we do…

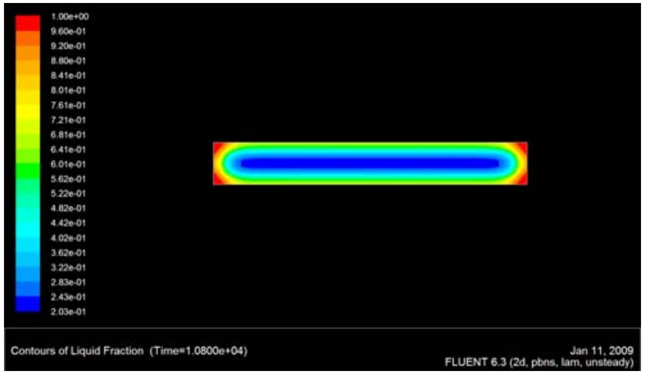

Energy
Water
Environmental
Waste
Management
Emerging
…
Products
Buildings
Master Planning
Strategic Consulting

Using Phase Change Materials to Cool Buildings

- Fabric-incorporated PCMs have reached the market.
- Claimed that up to 35% of cooling costs may be saved through use of PCM wallboards.
- Barriers of limited storage capacity, heat absorption and heat rejection mean that cooling plant cannot be reduced.
- The proportion of cooling load covered may be increased and the requirement for cooling plant reduced by optimising the function of the PCM.

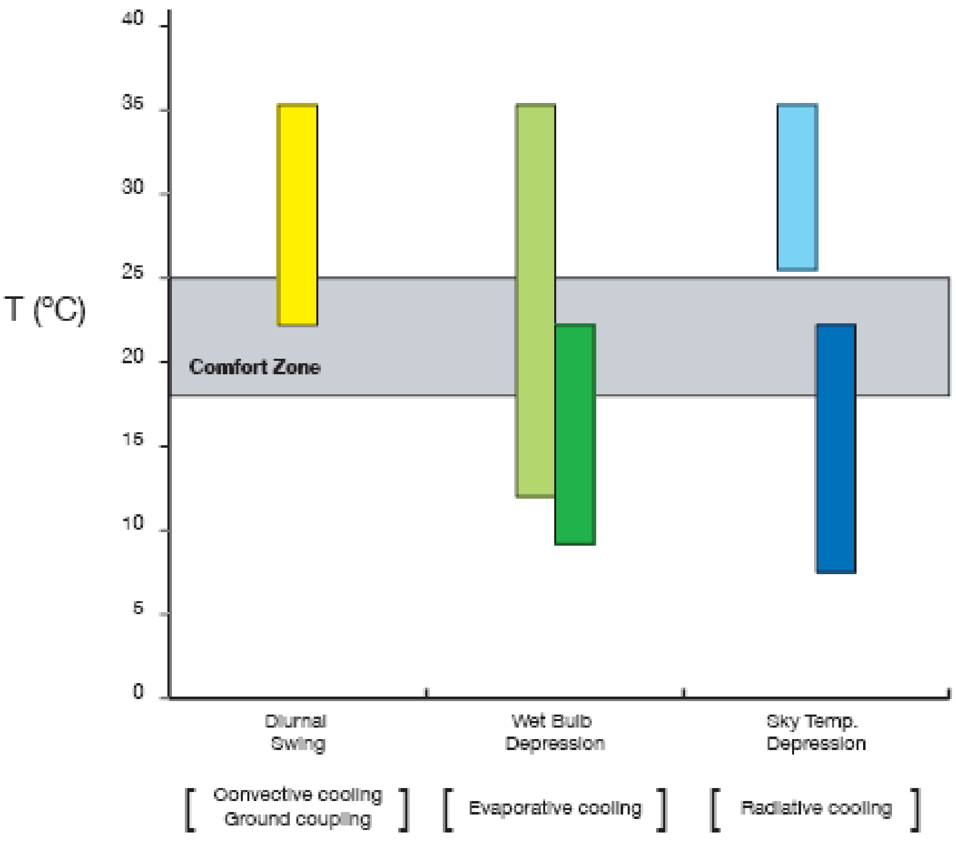
Gideon Susman: EngD research

- A new PCM cooling product is being developed.
- The design will be informed by the results of prototype installation tests.
- FLUENT CFD modelling to understand thermal capacity and heat transfer rate.
- Results combined with TRNSYS building simulation to predict performance of new design.



Radiative Cooling

Comparison of natural heat sinks,
Riyadh, Saudi Arabia



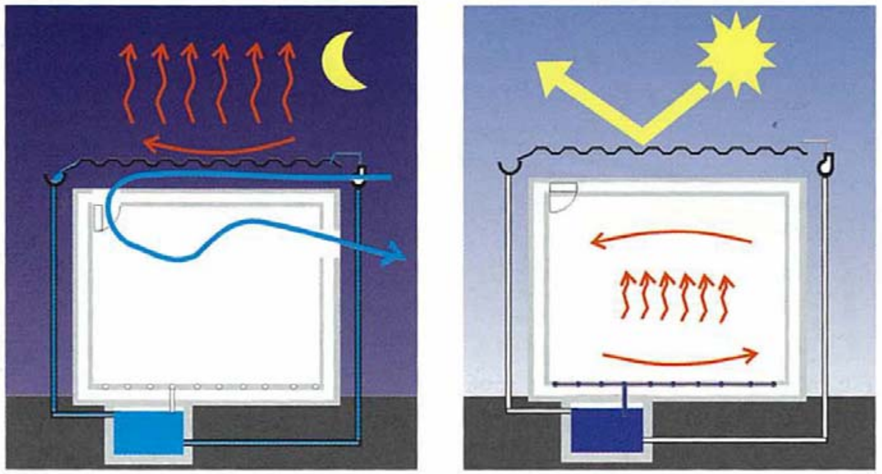


Fig. 4.3 Radiator in cooling mode: night (left) and daytime (right) operation.

Ground heating / cooling

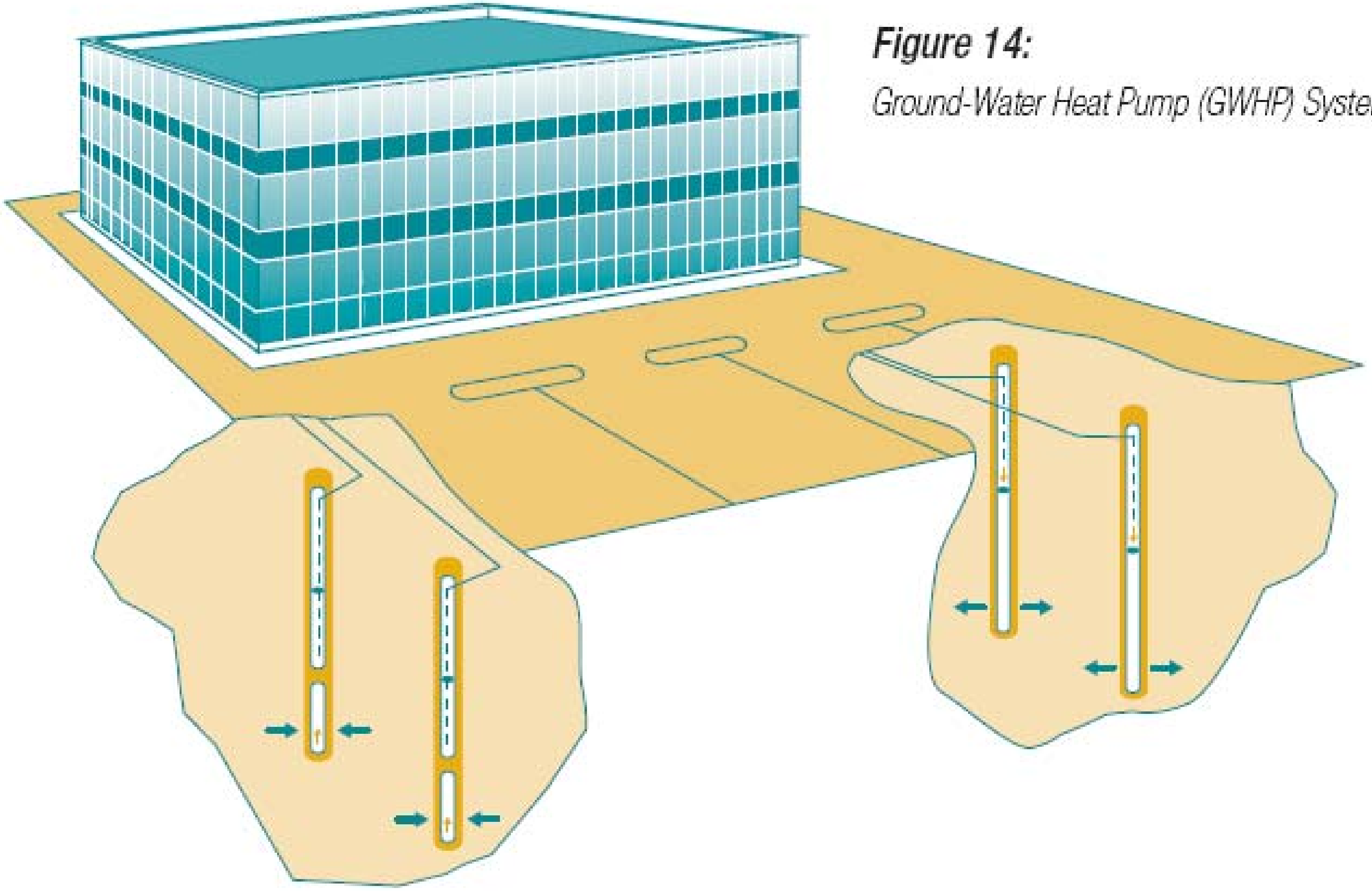
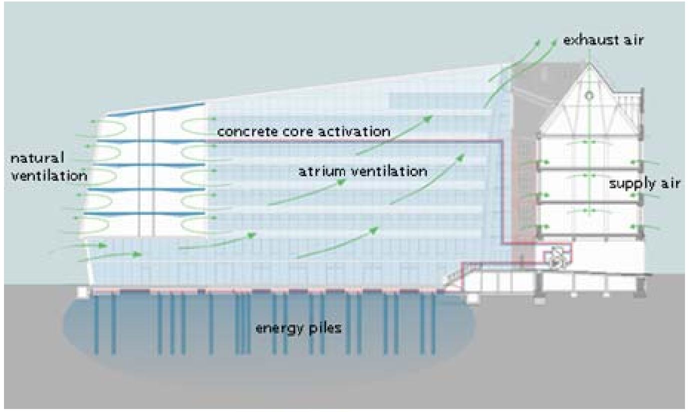


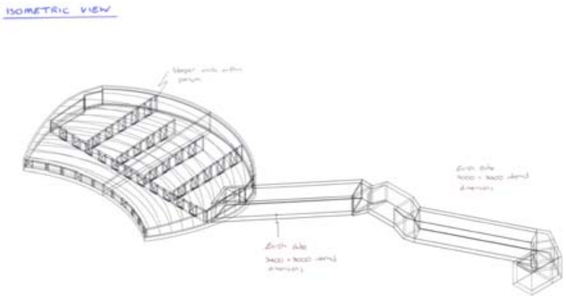
Figure 14:

Ground-Water Heat Pump (GWHP) System.

Advent: Basic principle

This project will greatly contribute to the use of low energy ventilation systems by disseminating information on buildings that incorporate low energy techniques, thereby helping to overcome a general lack of knowledge and confidence amongst engineers and architects.

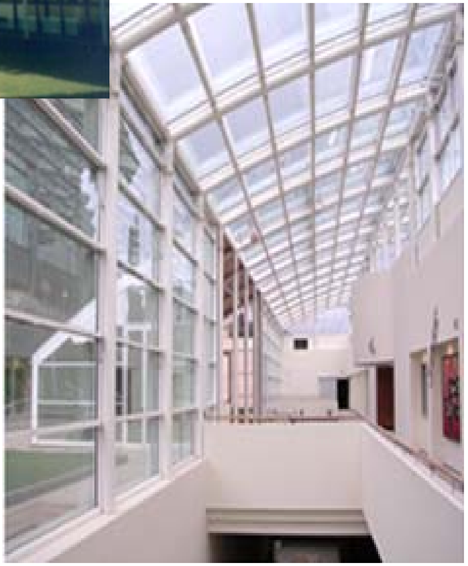


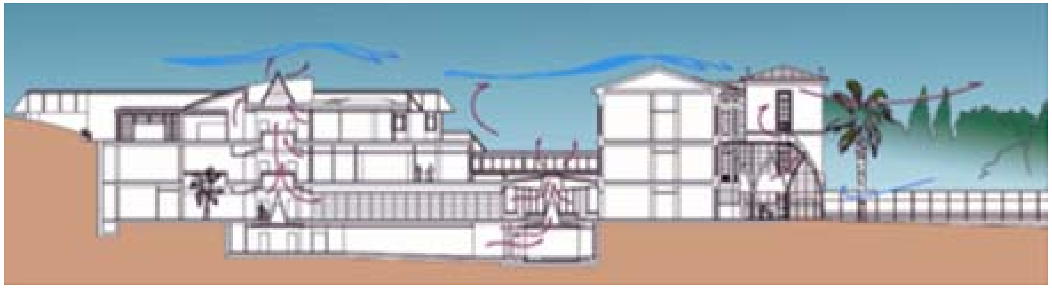


Project Summary

The Building AdVent project will disseminate information to designers on 18 non-domestic buildings that are examples of successfully implemented low energy ventilation systems. The buildings are spread throughout the various climates of Europe.

Partners from six European countries will collaborate to obtain, collate and disseminate this information.





Partners

• Buro Happold Consulting Engineers	UK
• Brunel University	UK
• National and Kapodistrian University of Athens	Greece
• Helsinki University of Technology	Finland
• Aalborg University	Denmark
• Faculdade de Engenharia da Universidade do Porto	Portugal

Dissemination focussed partners

- INIVE
- UIA
- REHVA

Work packages

Work Package	**Status**
1. Project Management	Ongoing
2. Classification of existing building ventilation technologies	Complete
3.Collection of additional information on building performance	Nearly complete
4. Identification of barriers for future application	Nearly complete
5. Development of material	Current
6. Communication and Dissemination	Ongoing

WP2: Basic Classification

Characteristic Principle		Characteristic Parameter
Ventilation Principle	Natural Ventilation	Single-Sided
		Cross
		Stack
	Hybrid Ventilation	Natural and Mechanical in combination in the building
		Fan Assisted Natural Ventilation
	Mechanical Ventilation	Mechanical Exhaust
		Mechanical Supply
		Balanced Supply and Exhaust
Air Distribution Principle	Mixing	
	Displacement	Temperature and Ventilation Effectiveness
	Ceiling supply	

Energy Efficiency Principle	Transport	Wind tower, Wind scoop, Low Pressure Ducts, Atrium
	Heating	Heat Recovery
		Solar Preheating
		Earth Coupling
	Cooling	Free Cooling Outdoor Air
		Night Cooling
		Earth Coupling
		Chilled Beams and Ceilings
		Fan-coils
		Comfort cooling (temp control)
		Air conditioning (temp and humidity control)
	Control	CAV
		VAV (Demand Control)
		Automatic and/or User Driven
		IAQ and/or Thermal Comfort
		Air Tightness
	Energy Storage	Thermal mass, PCM
		Water and Ice Storage
		Concrete Core Activation
	Commissioning/ Maintenance	

Systems used by country

	Ventilation Technologies	UK	GR	FI	DK	PO
Natural Ventilation	Single sided	X	X		x	X
	Cross flow	X	X		Sometimes	X
	Stack	X			x	X
	Atrium	X			x	
Mixed Mode Ventilation	Natural and mechanical	X			rarely	
	Fan assisted natural ventilation	X	X		x	
Mechanical Ventilation	Mechanical exhaust		X			X
	Mechanical supply	X	X			
	Mechanical supply & exhaust	X	X	X		X

Greece, Offices and paper storage

Aggelidis & Georgakopoulos
21^{o} klm national highway Athens-Thessaloniki, Krioneri Attiki
Offices & paper storage
2001
Architect : N. Nikolaidis office

Ventilation system

Mechanical ventilation in the offices (VRV for heating and cooling), heat recovery, natural ventilation in the paper storage, use of buried pipes for ventilation in the paper storage rooms at ground floor

WP3: Data gathering

- Projects chosen to be able to deliver:
  - Energy consumption data (totals and breakdown)
  - Thermal Comfort conditions (readings and survey)
  - Indoor Air Quality Data
- Comfort Surveys complete – analysis now

Footprint results

Classification based on occupants responses	Percentage
	WHOLE YEAR
People finding overall indoor environment acceptable	72%
People finding the thermal environment acceptable	61%
People finding the air movement and IAQ acceptable	50%
People finding the noise level acceptable	66%
People finding the level of lighting acceptable	83%

Table 3-1. 'Footprint' of GSIS building

More detailed results

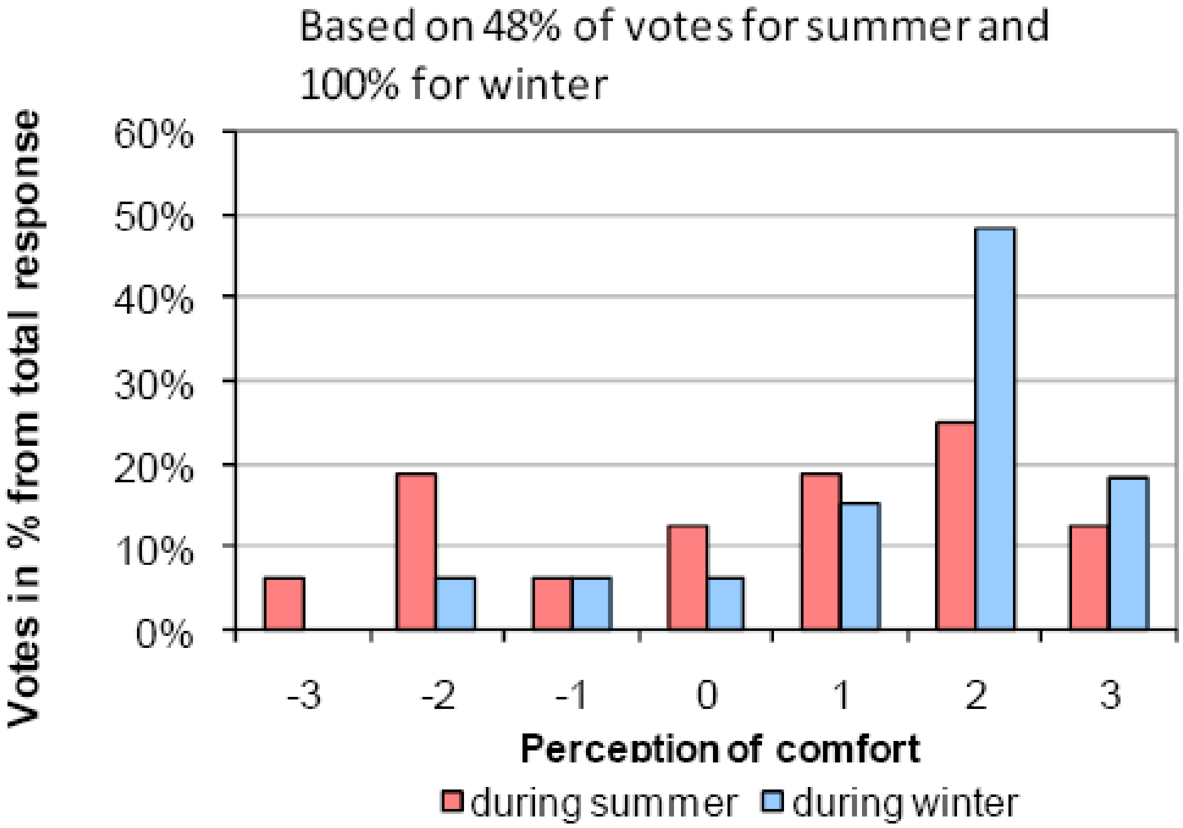


Figure 4-3. Overall perception of indoor environment and comfort.

WP4: Identification of barriers

- To develop the best guidance we need first to understand barriers
- Builds on learning from Gent workshop
- Computer simulations and analysis underway

WP5: Development of materials

- Preparing the main outputs
  - Detailed brochures on each of the buildings, aimed at assisting architects and engineers in low energy ventilation system design.
  - Powerpoint lecture slides.
  - A project website containing information and links. www.buildingadvent.com

Building Advanced Ventilation Technological
examples to demonstrate materialised energy savings for
acceptable indoor air quality and thermal comfort
in different European climatic regions

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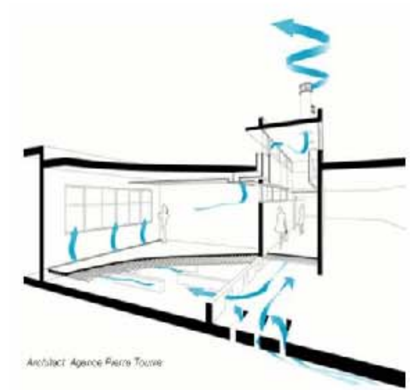
The Building AdVent project

Mankind's contribution to climate change through gross consumption of energy and the associated CO_2 emissions that accompany this, is a well established phenomenon. Energy use by ventilation losses and fans accounts for almost 10% of energy use in the EU. About 1/3 of this could be saved through improved ventilation systems.

The Building AdVent project will disseminate information to designers on 18 non-domestic buildings that are examples of successfully implemented low energy ventilation systems. The buildings are spread throughout the various climates of Europe.

This project will greatly contribute to the use of low energy systems by disseminating information on actual buildings that incorporate low energy techniques, thereby helping to overcome a general lack of knowledge and confidence amongst engineers and architects.

This project has been developed through discussions and a contractual agreement between the partners involved. It has been funded by the Intelligent Energy Executive Agency (IEEA), which was created by the European Commission to implement the Intelligent Energy Europe (IEE) programme.



Site last updated on: 17th September 2007

Brochures: in draft

Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions.

Advanced Ventilation Technologies

Case Study NoX –
FREDERICK LANCHESTER LIBRARY, COVENTRY, UNITED KINGDOM

Supported by

Intelligent Energy Europe

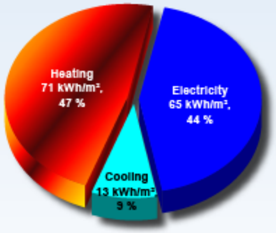
INTRODUCTION

The building is in an urban location, close to the centre of the city of Coventry. It is on a compact site, with adjacent buildings of a similar height. It is exposed to traffic noise from a nearby inner ring road.

Summary Table of key design parameters.

Building data	
Building type	Library
Total floor area	9 100 m²
Mean occupant density	N/A
Occupied hours	4 000 h/a
HVAC data	
Ventilation system type	Natural
Cooling system	Natural
Ventilation rate (or CO_2 concentration)	N/A
Heat recovery efficiency	None
Cooling load (typical)	N/A
Heating load (typical)	N/A
Building fabric data	
Window U-value	2.0 W/(m² K)
Window g-value	?
Exterior wall U-value	0.26 W/(m² K)
Base floor U-value	?
Roof U-value	0.18 W/(m² K)
Climate data	
Design outdoor temperature for heating	3°C
Heating degree days (Include base temperature)	2284 d (base 15.5°C)
Cooling degree days (Include base temperature)	18 d (base 18.3°C)

Building is situated in a climatic zone with moderate heating and cooling loads.



Breakdown of energy use (total 149 kWh/m²)

Description

BUILDING DESCRIPTION

The Frederick Lanchester Library is unusual in that, although it is a deep-plan building occupying a 50 m by 50 m footprint, it is ventilated naturally with no artificial cooling, except for a separate basement area which is air-conditioned. It has a gross floor area of 9 100 m². Figures 1 and 2 show the general layout of the building.

By its nature the building has a large number of transient occupants. At the design stage 2 500 entries per day were anticipated. In practice, this has increased to 5 000. In addition a number of staff work permanently in the building. The building is open for use for approximately 4 000 hours per year.

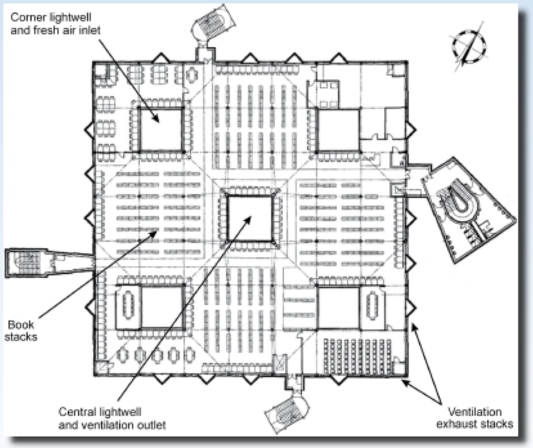


Figure 1 Plan view of building.

Case Study No X Frederick Lanchester Library, Coventry, United Kingdom

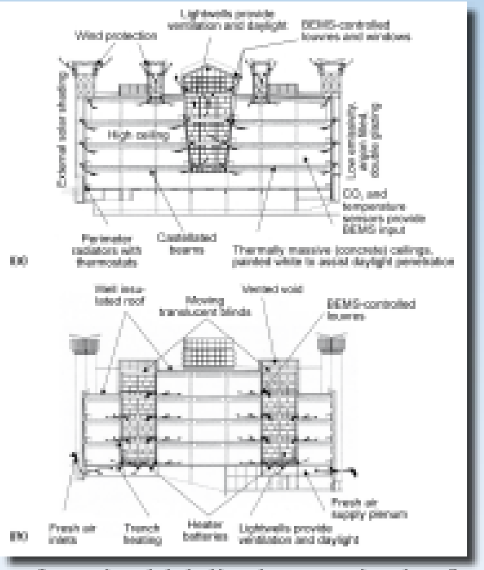


Figure 2 Sections through the building, showing natural ventilation flows.

DESIGN SOLUTIONS

Apart from a basement, comprising about 12% of total gross floor area and containing central computer equipment, the building is naturally ventilated. The deep plan of the building is broken up by multiple lightwells to provide both daylight and air flow paths. Heavyweight construction is used with exposed concrete ceilings. Apart from air-conditioning for the basement, summer temperatures are controlled by a combination of internal blinds, deep window reveals, fixed screens and night cooling by ventilation. High-frequency lighting is provided with daylight-linked dimming. Luminaires have a 60%/40% split down/up distribution. Medium temperature hot water provided by high efficiency, non-condensing boilers, supplies perimeter heating (principally radiators) and preheats incoming air through the natural ventilation system, using trench heaters. The heating, lighting and ventilation systems are controlled by a BEM system. U-values of the roof and walls are respectively 0.18 W/m²K and 0.26 W/m²K. Windows are doubleglazed, argon-filled, low-emissivity with a U-value of 2.0 W/m²K.

VENTILATION

In order to provide natural ventilation a tapering central lightwell provides extract ventilation, supplemented by 20 perimeter stacks with a 1.8m by 1.8m cross section. The stacks terminate 6m above roof levels with fittings to prevent reverse flow due to wind pressure. Air entry is via a plenum under the ground floor to the base of four 6m by 6m square corner lightwells. Under the influence of stack effect air is drawn via the four corner lightwells (Figure 3(a)) into each floor and extracted via the central lightwell (Figure 3(b)) and the smaller stacks. In winter the incoming air is warmed by pre-heating coils at the base of the supply lightwells and by trench heating at the point that the air from the lightwells enters each floor. Cooling is provided passively by thermally heavy-weight ceilings.

The BEM system controls dampers and operable windows depending upon indoor and outdoor temperatures, wind speed and direction and internal carbon dioxide concentrations. The system incorporates a self-learning algorithm to estimate the need for overnight cooling. Over-cooling is prevented by monitoring slab temperature.

PERFORMANCE

Energy performance

The energy used for heating, cooling and electricity was obtained from meter readings. The total annual delivered energy consumption for 2004 was 149 kWh/m² (corrected for hours of use) with a breakdown as follows: (i) heating – 71 kWh/m², (ii) electricity – 65 kWh/m² and (iii) cooling – 13 kWh/m². Figures 4(a) and 4(b) compare the annual heating and electrical energy consumption by the building with energy consumption with the benchmarks currently used for office buildings in the UK and show that consumption is considerably better than for air-conditioned buildings and comparable with good practice naturally-ventilated open-plan buildings.

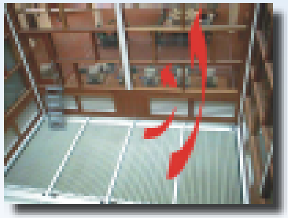


Figure 3(a) Bottom of a light-well: air rises vertically past heating fins and then through BMS-controlled louvres into library.

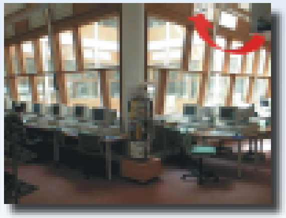


Figure 3(b) Mid-height of central light-well: air at ceiling level passes out through control louvres into the central well.

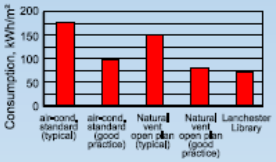


Figure 4(a) Comparison of heating consumption with benchmark values.

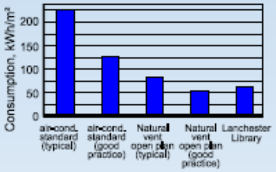


Figure 4(b) Comparison of electricity consumption with benchmark values.

Indoor environment performance

Thermal

Internal air temperatures measured over a full year from June 2004 to June 2005. The data were taken from 8 BEMS sensors situated at two positions on each floor, located on different walls at a height of 1.5m.

Temperatures were measured at hourly intervals and averages over all eight measuring locations.

Table 1 shows the number of hours and percentage of occupied hours that the air temperature exceeded the following values: 25°C, 27°C and 28°C.

Current national benchmark figures (CIBSE 2006) for a naturally ventilated building require that an operative temperature 28°C should be exceeded for less than 1% of occupied hours. Even allowing for the fact that there will be small differences between air and operative temperature, the building clearly meets this criterion.

Ventilation

Carbon dioxide concentrations were measured over a representative six week period at four locations on one floor. There are no specific UK standards for carbon dioxide concentration in library or office buildings, although a maximum of 1000 ppm is used for schools. In the Coventry Library carbon dioxide did not exceed 350ppm above ambient during the measurement period. Indicating that it would be fall within Category I according to EN 15251 (Table B4).

Occupant assessment of indoor environment

A summary of the results of a sample survey of building users and full-time occupants, carried out in 2008, is given in Table 2.

Table 1 Percentage of occupied hours for which selected air temperatures are exceeded.

Reference temperature	Number of hours over stated temperature, h / Percentage of occupied hours over stated temperature, %				
	Ambient	Ground floor	1st floor	2nd floor	3rd floor
25°C	149h/4.1%	78h/2.0%	0h/0%	32h/0.8%	152h/3.8%
27°C	73h/2.0%	0/0	0/0	0/0	0/0
28°C	48h/1.3%	0/0	0/0	0/0	0/0

Table 2 Summary of occupant assessment of indoor environment.

	Summer %	Winter %
People finding the overall indoor environment acceptable	83	62
People finding the thermal environment acceptable	79	58
People finding the indoor air quality acceptable	70	77
People finding the acoustical environment acceptable	66	60
People finding the lighting acceptable	90	90

In general, occupants are satisfied with conditions in the summer but are less so in the winter. Dissatisfaction is primarily with thermal comfort in the winter with complaints of cold and draught, particularly by occupants located on the north-east and north-west sides of the building.

DESIGN LESSONS

While the building has generally performed well, there are a number of recommendations which might benefit the design of future buildings using the same principles.

Areas which are occupied for longer periods of time could be colocated and access to other areas limited. This would enable night-time ventilation to be operated without affecting the comfort of night-time occupants.

The performance in summer can be improved if air inlet dampers are closed down when the internal dry-resultant temperature is below outdoor temperature. CO_2 control can be used to over-ride such closure if required.

Consideration could be given to controlling the extent of opening of automatic vents on a seasonal basis. This would reduce the risk of over-ventilation in the winter, thereby reducing both energy consumption and the possibility of draughts.

Experience has also shown that is important that facilities management staff are fully aware of the principles of the natural ventilation system and its controls.

GENERAL

Key points concerning the design

A deep-plan, multi-storey building can be adequately ventilated naturally, using appropriately placed light-wells and stacks.

Designers and contractors	
Client	Coventry University
Architects	Short & Associates
M&E Engineers	Environmental Design Partnership

REFERENCES

Krausse B, Cook M J and Lomas K J. Environmental performance of a naturally ventilated city centre library. Energy and Buildings, 39, 2007, pp791-801.

Lomas, K.J. Architectural Design of an Advanced Naturally Ventilated Building Form, Energy and Buildings, 39 (2007) pp166-181.

Cook, M J and Short C A. Natural ventilation and low energy cooling of large, non-domestic buildings - Four case studies, International Journal of Ventilation, 3 (4) (2005), pp283-294.

BUILDING ADVENT

Full title of the project: Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions. Building AdVent is funded by the European Commission, Directorate-General for Energy and Transport as part of the Intelligent Energy - Europe Programme.

It is estimated that energy consumption due to ventilation losses and the operation of fans and conditioning equipment is almost 10% of total energy use in the European Union and that about one third of this could be saved by implementing improved ventilation methods. A number of projects have been undertaken under the auspices of the European Union (under the SAVE and ALTENER programmes) and the International Energy Agency (Energy Conservation in Buildings and Community Systems Annexes 26 and 35) to identify and develop improvements in ventilation technology.

The AdVent programme is intended to build on these and has three principal objectives:

- Classification of existing building ventilation technologies as applied in built examples and collection of information on building performance.
- Identification of barriers for future application.
- Preparation of case-studies in a common format, together with training material

BUILDING ADVENT PARTICIPANTS

Coordinator:

Buro Happold Consulting Engineers .... UK

Participating Organisations:

Brunel University .... UK
National and Kapodistrian University of Athens .... Greece
Helsinki University of Technology .... Finland
Aalborg University .... Denmark
Faculdade de Engenharia da Universidade do Porto .... Portugal
International Network for Information on Ventilation and Energy Performance (INIVE) .... Belgium

Major Sub-Contractors:

Federation of European Heating and Air-Conditioning Associations (REHVA) .... The Netherlands
International Union of Architects .... France/Greece
—Architectural and Renewable Energy Sources Work Programme (UIA - ARESWP)

WP6: Dissemination

- The most important part!
- Getting it out there, through all the routes we can:
  - Universities
  - Our dissemination partners
  - Newsletter
  - Website
  - Events like this one
  - You!

Conclusions

- Advent: Coming towards the end
- Comments on outputs welcome
- We look forward to sharing more of this with you all in the future
  - AIVC conference, Oct 2009, Berlin
  - CommonCense IEE project workshop, Porto (to be confirmed), Oct 2009

Portuguese Building Regulations to obtain Summer Comfort and to reduce Cooling Needs

Eduardo Maldonado

Univ. Porto, Portugal

AIVC Barcelona Workshop

31 March 2009

Universidade do Porto
Faculdade de Engenharia
FEUP

The first Regulations

- Portugal was one of the first countries with cooling requirements in its regulations (since 1990)
- Two main requirements:
  - Maximum cooling needs (calculated by a very simple methodology)
  - Minimum shading for every glazed area (except those facing “North”±45º)

Required Shading Factor →

Inertia	Climatic Zone		
	V_1	V_2	V_3
Low	0,15	0,15	0,10
Medium	0,56	0,56	0,50
High	0,56	0,56	0,50

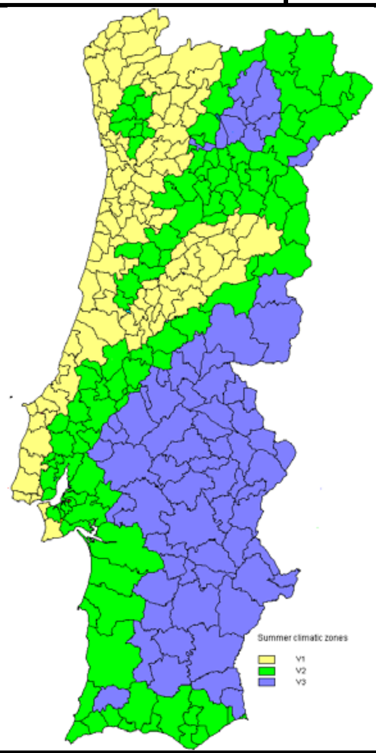
Climatic division

Portugal has three climatic zones that are characterised by:

- mean outdoor temperature
- mean daily temperature swing
- mean duration of the cooling season

Summer zone	Outdoor Temperature (ºC)*	Daily Amplitude (ºC)	Insolation mean value for cooling period (month)	
V1 - yellow	28	10		
V2 - green	32	13	North	South
V3 - blue	35	16	1,6	3,4
	Indoor Temperature (ºC)		2,2	
	25		2,8	

*Summer desing temperatures are used with ocurrency acumulated probability of 97.5 %



Solar shading requirements

Most buildings were required to have outdoor shading, especially for low-inertia buildings.

Designers were strongly encouraged to use high inertia construction techniques – combined with comfortable mean outdoor temperatures and high daily temperature swings, night cooling by ventilation ensured comfortable conditions throughout, except maybe during the hottest (short) periods during Summer.

The reference building approach

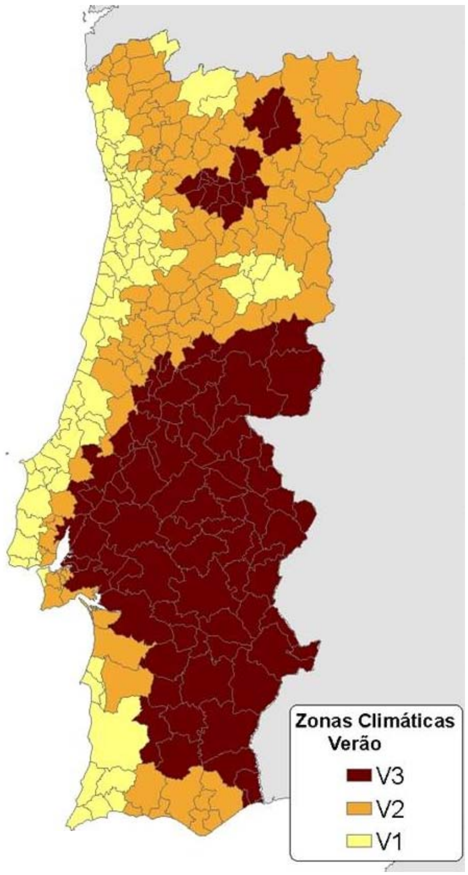
- In the 1990 regulations, the maximum cooling needs were calculated using a similar building of the same shape and size, with reference thermal characteristics:
  - Opaque envelope with reference U-values and painted with a light color (walls and roofs);
  - Solar gains through windows with a max ~0.35 solar factor.
- Internal gains were not counted.
- There was a small distinction between residential and non-residential, where the maximum allowable total cooling needs were 20% lower than in residential buildings.

2002

- **In 2002, the EU adopted the Energy Performance of Buildings Directive (EPBD).**
- **Among other requirements, the Member States had to adopt a methodology for energy evaluation of build-ings (regulations) with the following requirements:**
  - **integrate insulation, heating, cooling, ventilation, lighting and daylighting, renewable energy installations, passive solar heating and cooling systems, CHP, DH/C, position and orientation of the building**
  - give **flexibility** to designers to meet energy reduction standards in the most cost-effective way
  - can be expressed in **simple energy indicators**
  - **are adopted by Member States** for different categories of build-ings taking into account climatic differences

The current regulations (2006)

- Clear distinction between residential and nonresidential buildings.
- Full compliance with EN-ISO 13790.
- Climatic zoning was adjusted, with a larger area now within the most demanding climatic zone (V3).
- The reference building approach was dropped – a maximum level of primary energy needs becomes the target to meet – lower CO_2 emissions are the main target.
- The new regulations are fully performance-based, innovation-friendly.



All buildings

Every building, residential or non-residential, must also comply with the same minimum shading requirements for non-North facing glazings, including rooflights, already defined in the 1990 building regulations.

This applies to every glazed area that exceeds 5% of floor area on a room by room basis.

Required Shading Factor →

Inertia	Climatic Zone		
	V_1	V_2	V_3
Low	0,15	0,15	0,10
Medium	0,56	0,56	0,50
High	0,56	0,56	0,50

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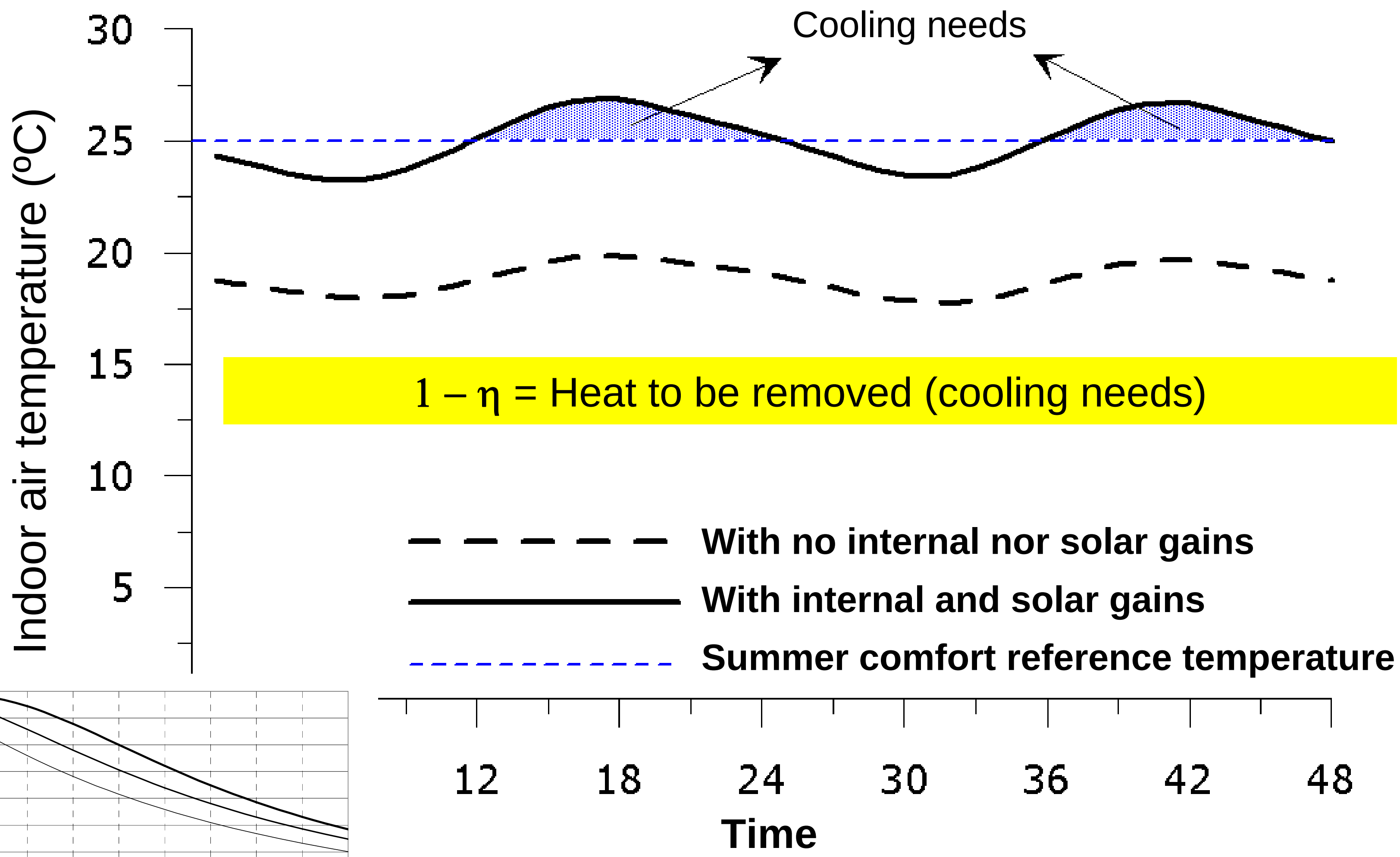
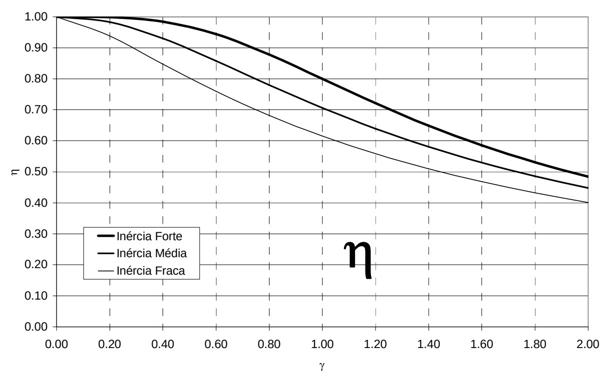
Residential buildings

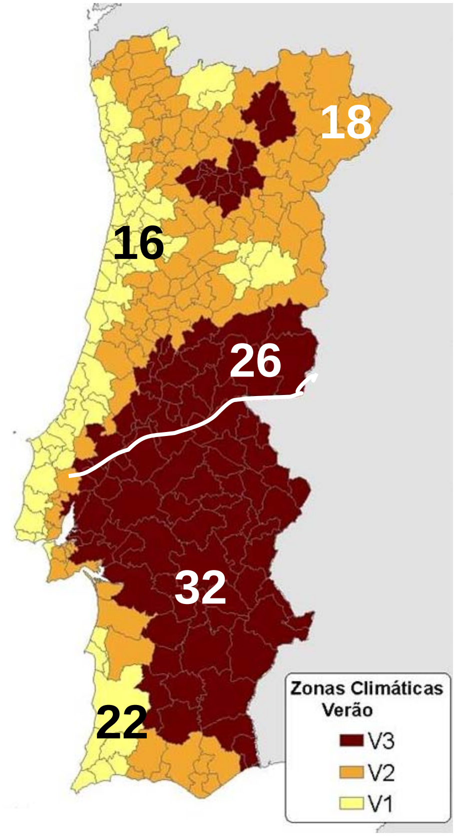
Cooling needs calculated using EN ISO 13790 lumped model





Residential buildings

- **Nominal cooling needs are calculated using actual construction design features;**
- **Then they are compared (and must be lower than) a reference value, by climatic zone, defined on the basis of a sensitivity study run on a extended database of several hundred typical Portuguese buildings under the following base conditions:**
  - Envelope U is 50% of 1990 regulations (0.4-0.6 W/m².ºC)
  - Window area is 15% of floor area
  - Window solar factor is 0.35
  - Windows all face East and West (worst case scenario)
  - Medium inertia construction
  - Internal gains: 4 W/m² as set in EN ISO 13790 (including lighting)
  - Nominal air exchange rate: 0.8 ACH



Max cooling needs

(kWh/m²)

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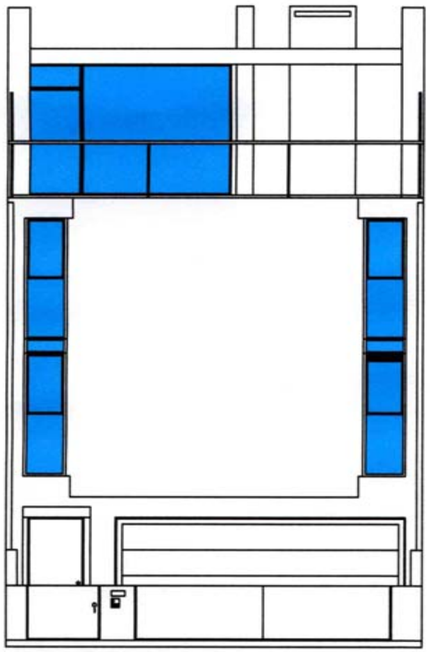
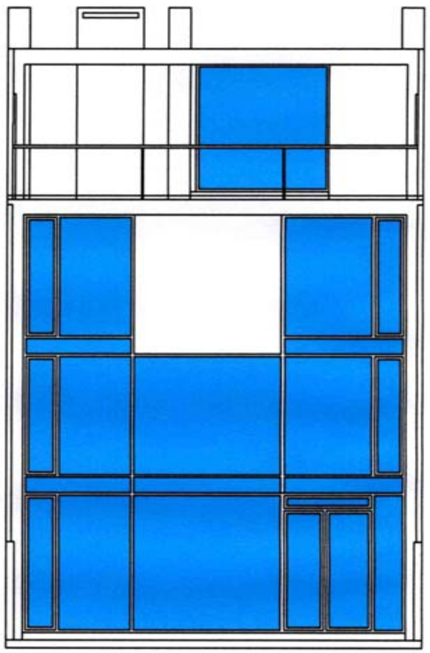
Are these regulations good enough?

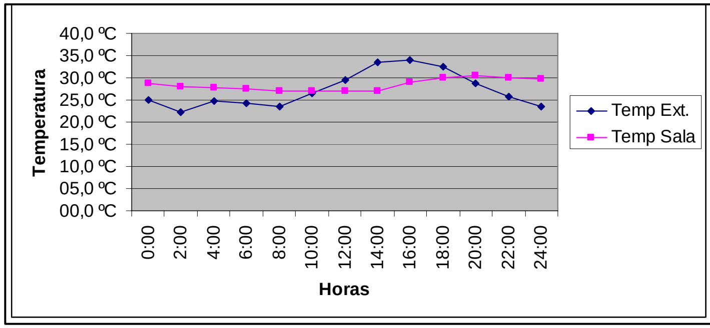


North view



70% of the façade
is glazed

South view

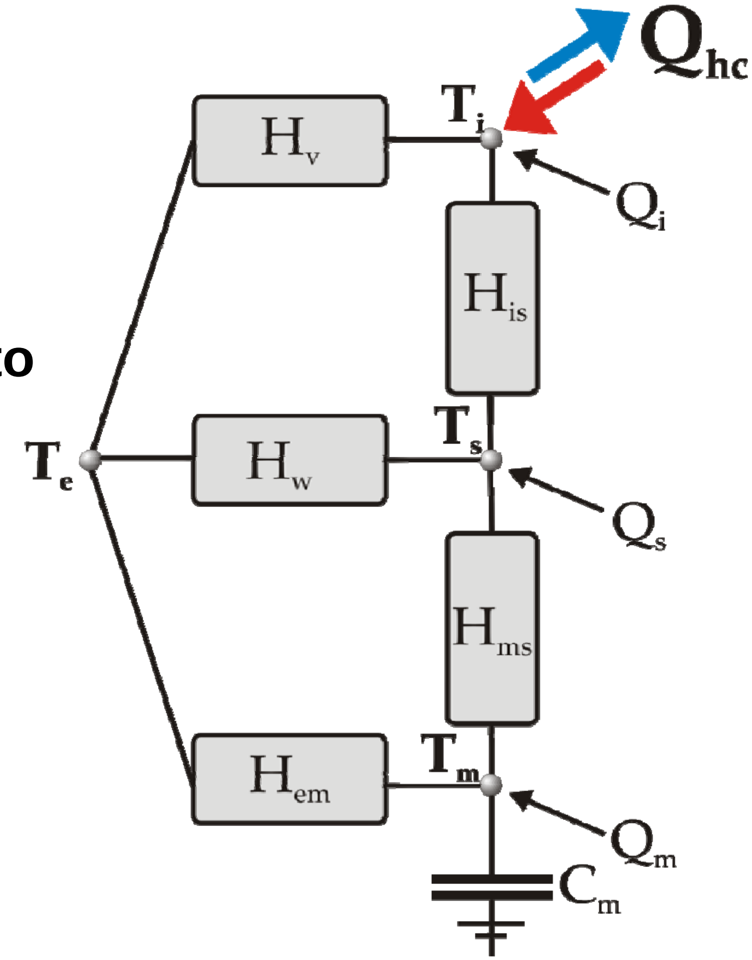


This residence (barely) meets the regulations requirements in the cooler climatic zones, yet, it is quite uncomfortable in warm sunny days in Summer.

Zona climática	Nvc (kWh/m^2.ano)	Nv (kWh/m^2.ano)	Verificação
V1 NORTE	14,86	16	OK
V1 SUL	24,08	22	KO
V2 NORTE	17,24	18	OK
V2 SUL	36,41	32	KO
V3 NORTE	31,11	26	KO
V3 SUL	37,61	32	KO

Non-Residential buildings

- **A detailed hourly simulation on a yearly basis is required.**
- **The default software is the single-zone model defined in EN ISO 13790 – suitable climatic data files are provided in the regulations.**
- **For multi-zone buildings, it is acceptable to "add" the results for each individual zone (assuming no interaction between zones).**
- **However, designers can choose more accurate software models: anything that meets criteria based on ASHRAE's 150 Standard (AIE BESTEST). This is highly recommended for complex buildings and HVAC systems (the simple model overestimates cooling needs)**



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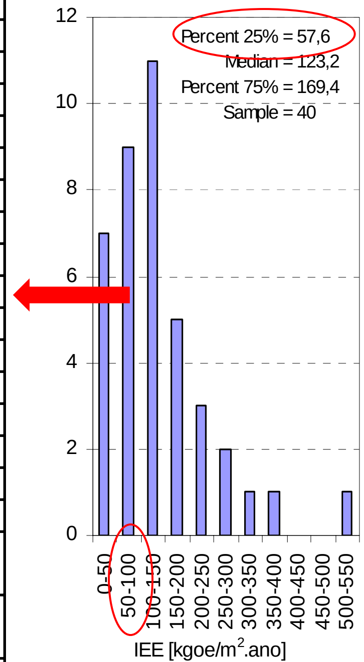
Non-Residential buildings

- **There is no specific limit for cooling needs in non-residential buildings.**
- **The regulations set a limit for the overall primary energy needs of the building under nominal conditions, including heating, cooling, lighting, and other energy use (fixed nominal pattern), by building type.**
- **Buildings that are licensed under these conditions and later exceed the declared targets must take corrective action (first check – 3 years after occupation starts).**

IEE [kgoe/m².ano]	
Hypermarkets	255
Retail shops	45
Supermarket	150
Shopping centers	190
Small shops	75
Restaurants	170
Bakers	265
Fast Food	210
Hotel 4 or more stars	60
Hotel 3 or less stars	35
Cinema and theatre	25
Discos	55
Bingo and social clubs	45
Sport club with pool	35
Sport club without pool	25
Offices	40
Bank and insurance headquarters	70
Bank and insurance agencies	60
Communications	40
Libraries	20
Museums and galleries	10
Courthouses	10
Prisons	20
Schools	15
Hospitals	40



hotel energy consumption

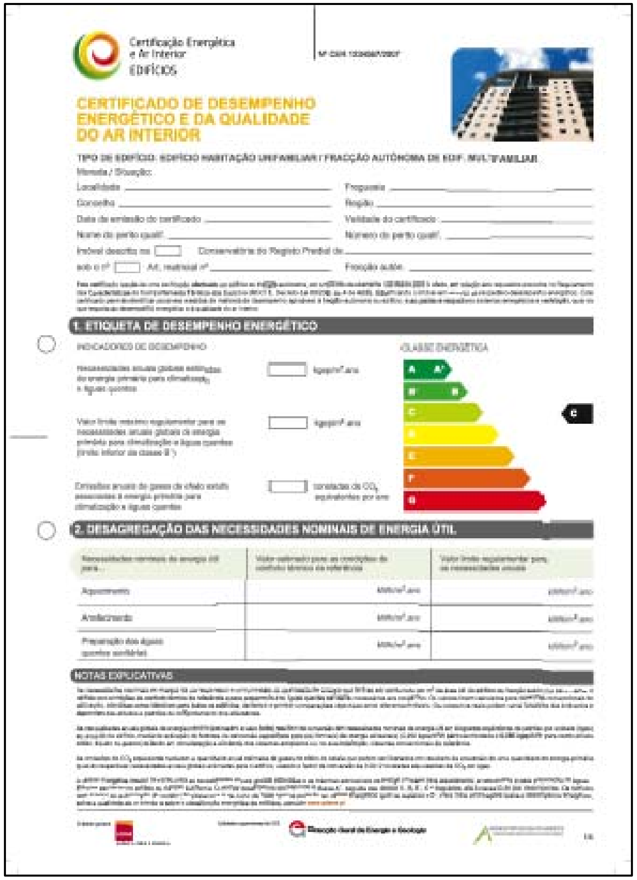
K_{goe} – kg of oil equivalent

Non-Residential buildings

- **HVAC systems for cooling must meet stringent quality requirements**:
  - Minimum air exchange rates must be ensured:
  - Electric motors must meet minimum efficiency targets;
  - Free-cooling is mandatory when air movement exceeds 10,000 m^3/hr in the building;
  - The ductwork must meet minimum airtightness standards;
  - Indoor air quality must be monitored and pollutants kept below rather demanding levels (e.g., $CO_2 < 1000$ ppm)
  - Construction must use clean techniques and systems kept clean during use (inspected every 2 or 3 years)
  - Energy audits carried out every 6 years

Compliance

- **Every new building and major renovation is being checked by a Qualified Expert within the Building Certification System in Portugal.**
- **Every building must meet regulations or a certificate cannot be issued and no construction or use permit is awarded by the Municipality.**
- **Quality of the Certificates is checked on a random sample of 5% of the issued Certificates by the authorities.**



The Future

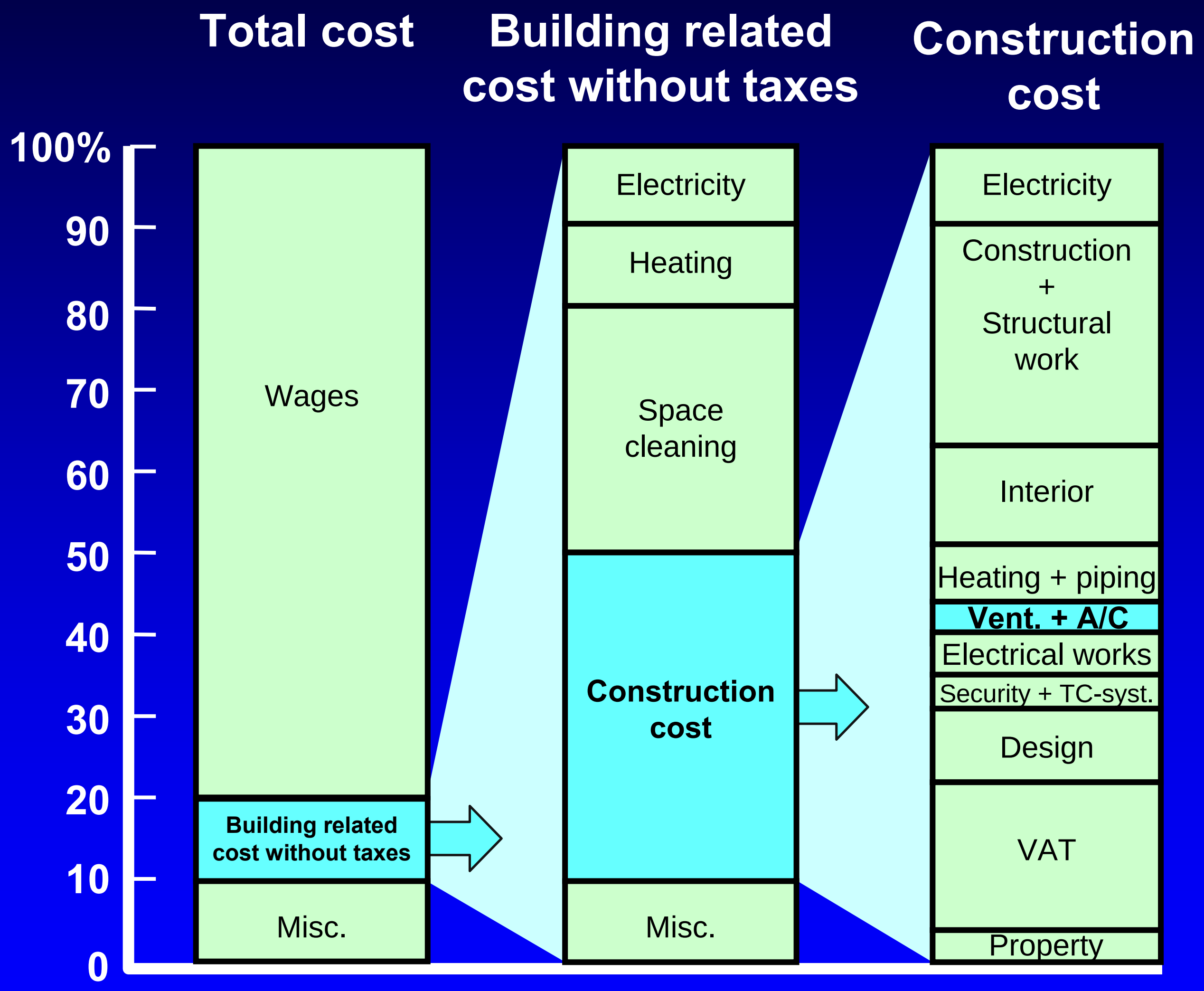
- Clearly, there is room for improvement - summer requirements for residential buildings should be made tighter – this is planned for the 2011 revision, as mandated by the EPBD;
- Some criteria based on indoor overheating might be desirable, but there is no certainty that will happen;
- The current regulations, together with the new Certification system, have proven to be a very useful tool to improve the quality of the design of the new buildings in Portugal;
- It remains yet to be seen if this will be also the case with the built reality, as buildings subject to these regulations are mostly still under construction now – very few are already finished, but hopes are high.

Summer Comfort and Cooling in Finland

Olli Seppänen
Professor, emeritus
Helsinki University of Technology

Secretary General
Federation of European Heating and Air-conditioning Associations

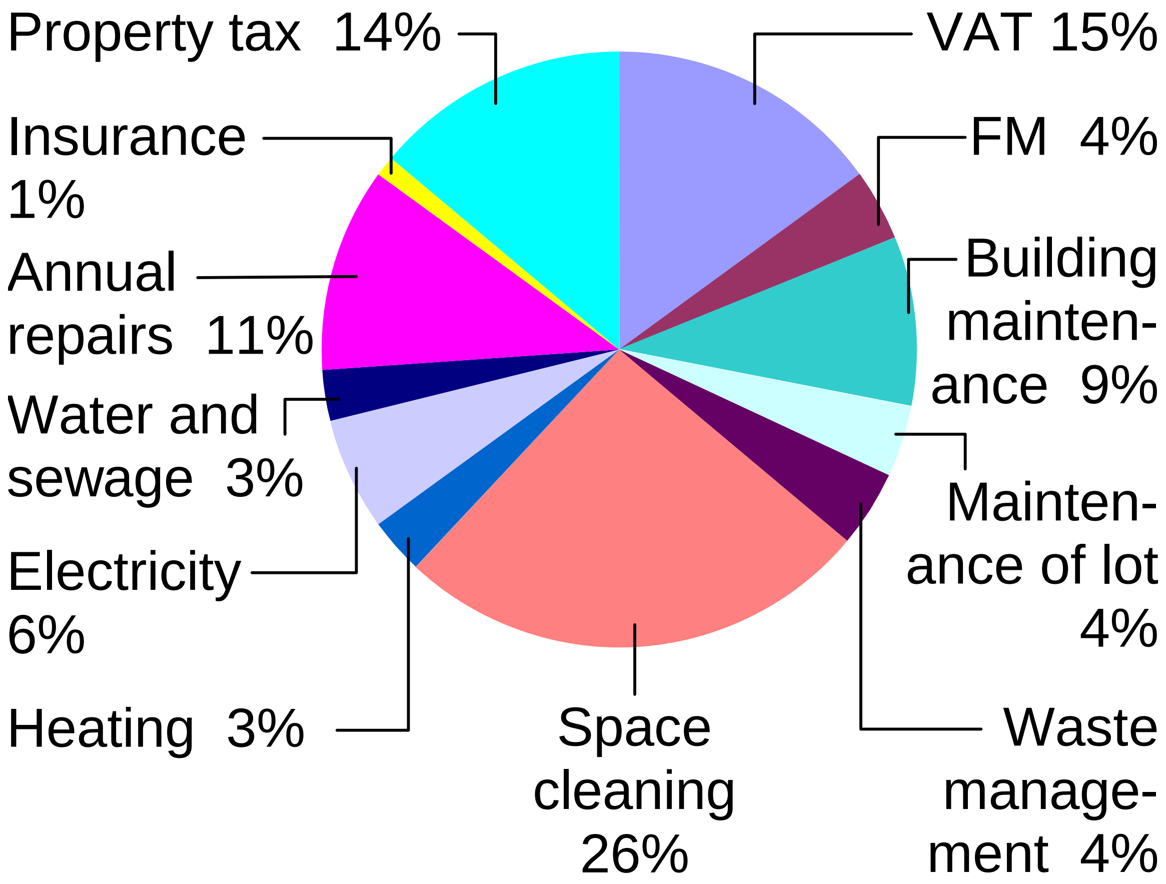
Relative costs of an office building



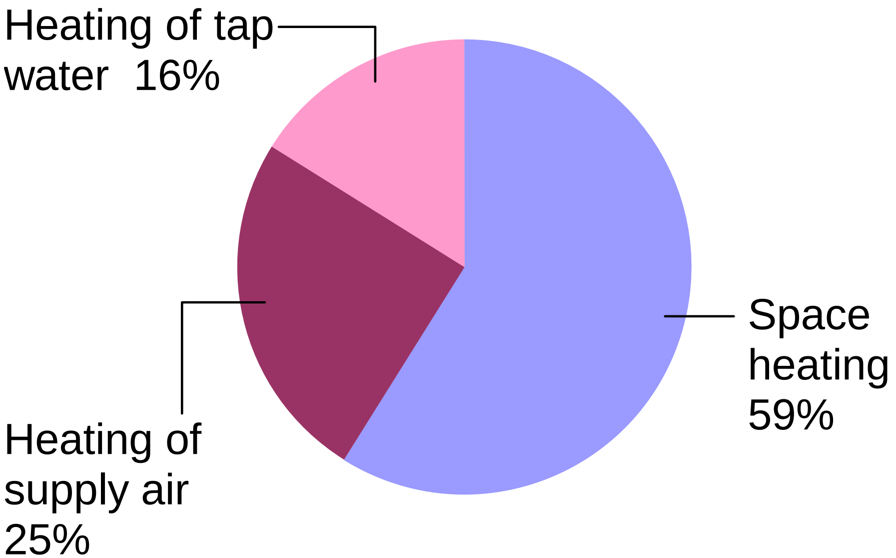
Even small increase in productivity is much greater than increase of investment cots for better indoor climate

REHVA Guidebook No 6 Indoor Climate and Productivity, 2006

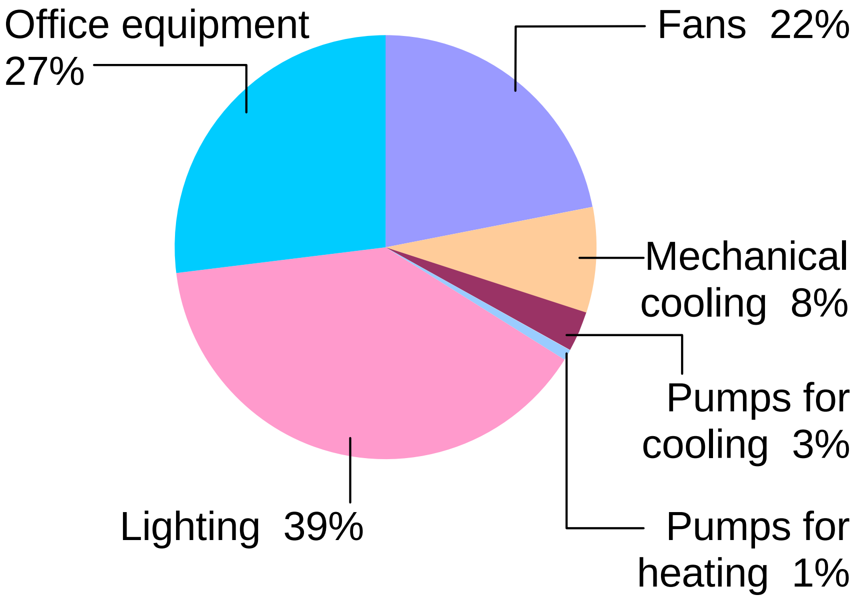
Typical breakdown of annual operating cost of a Finnish high quality office building



Typical breakdown of energy use in a Finnish high quality office building



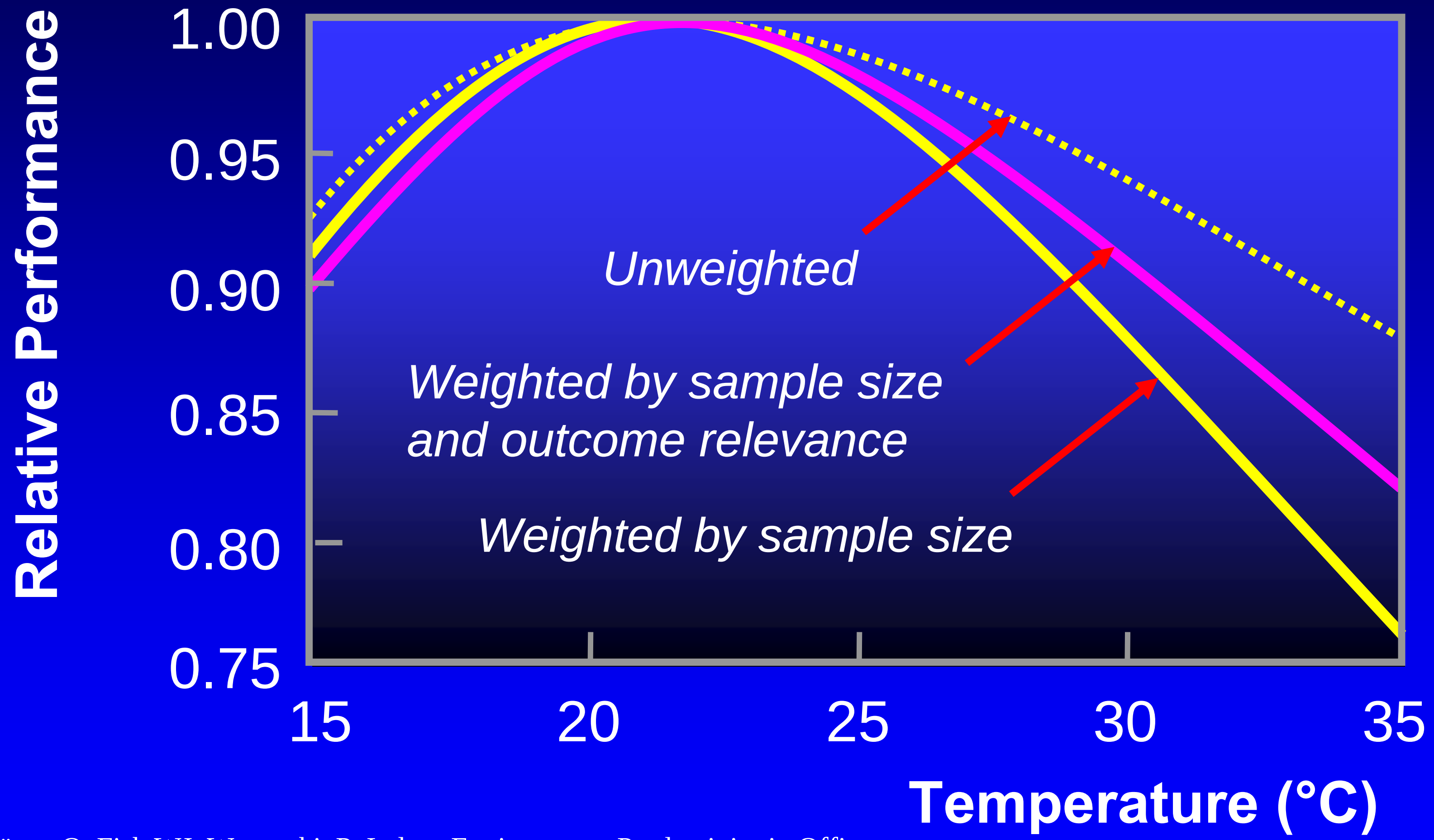
Heating energy 44 kWh/m2



Electricity 75 kWh/m2

Relative performance vs. temperature compared to the maximum

$$RP = 0.1647524 \cdot T_C - 0.0058274 \cdot T_C^{\,2} + 0.0000623 \cdot T_C^{\,3} - 0.4685328$$

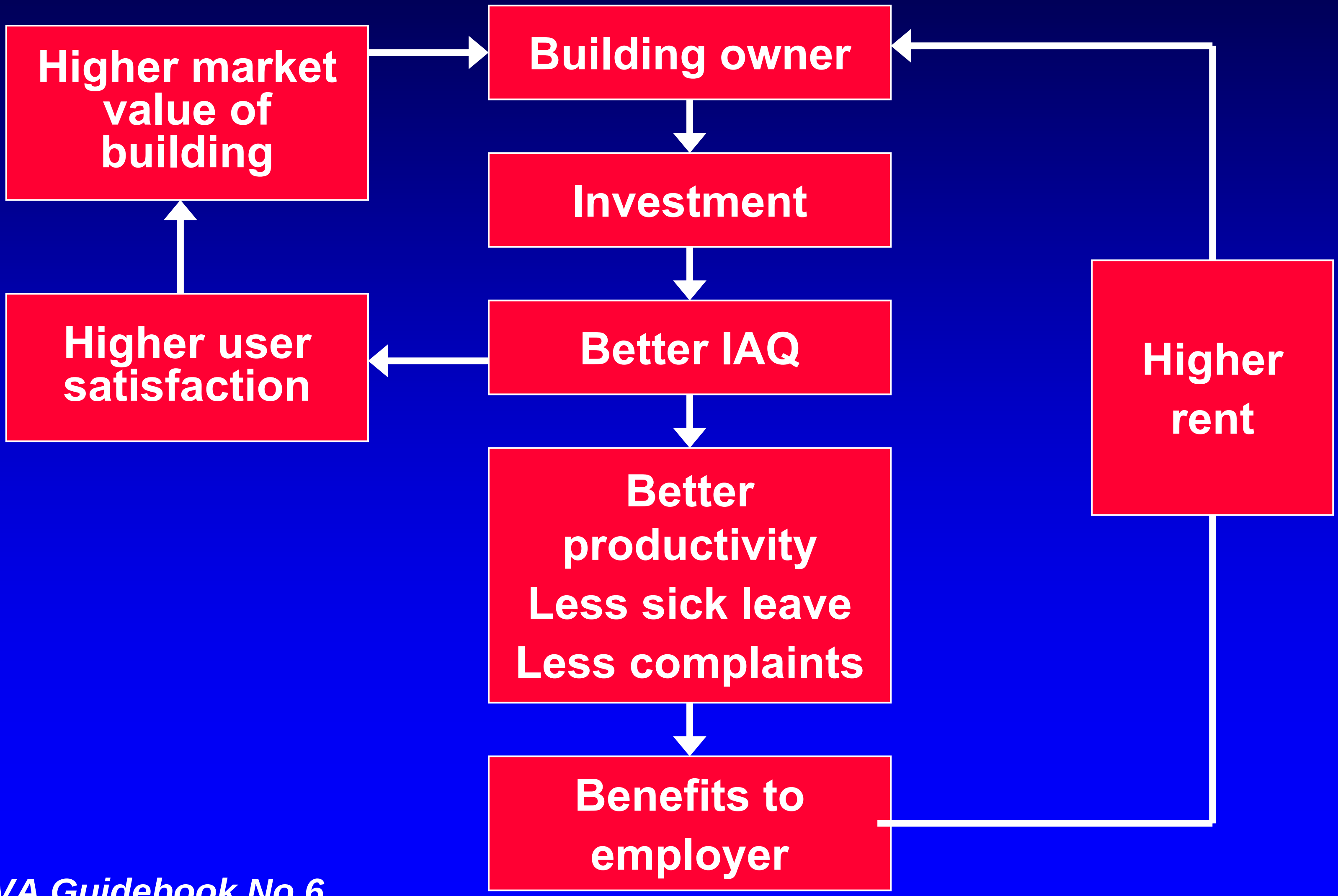


Seppänen O, Fisk WJ, Wargocki, P. Indoor Environment, Productivity in Offices, *ASHRAE IAQ Applications*, pp 1-6 Vol 8 No 1, 2007

Seppänen O, Fisk W, Lei QH. 2006. Room temperature and productivity in office work. Proceeding of Healthy Buildings Congress 2006. Vol **1**, pp 243-247.

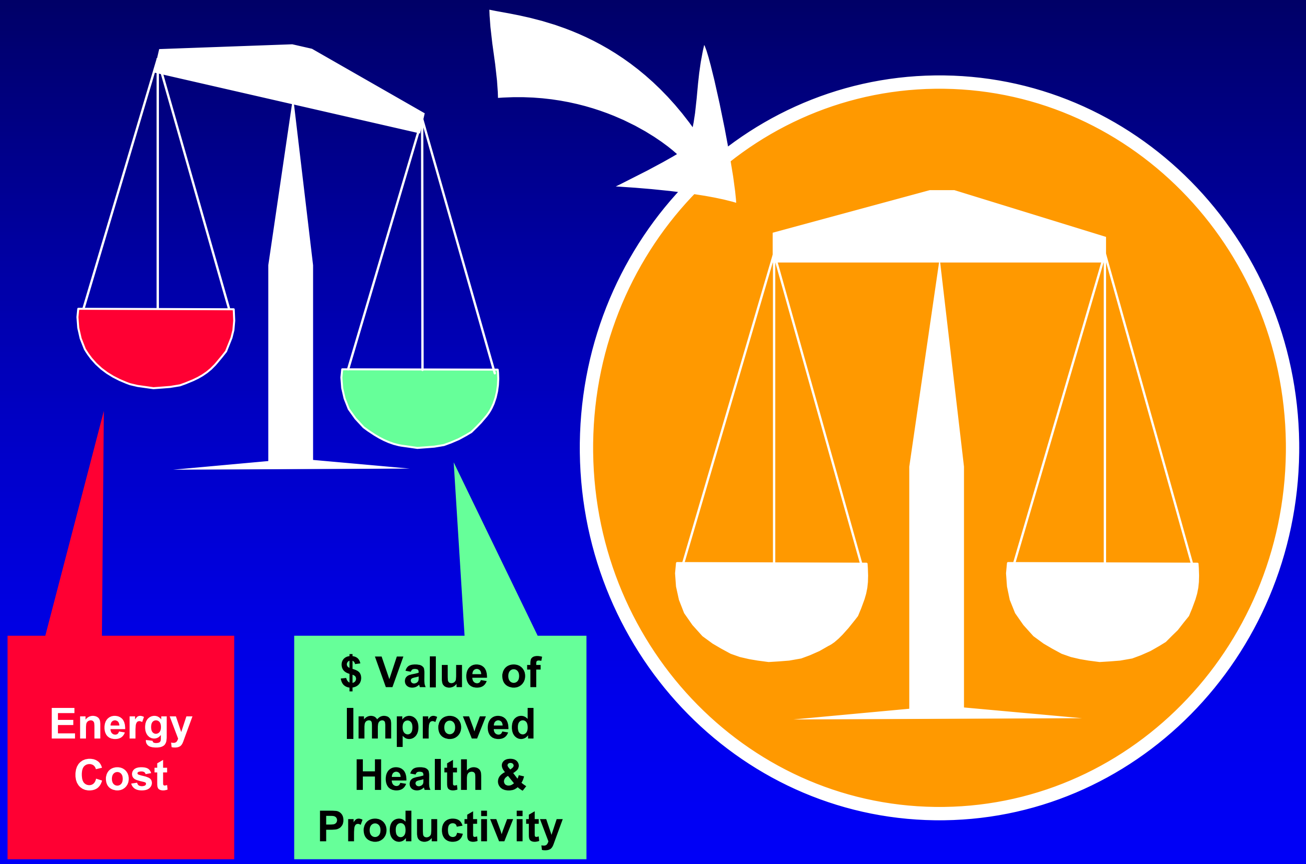
Motivation of building owner to IAQ investments

Leased office building



REHVA Guidebook No 6
Indoor Climate and Productivity, 2006

The Basic Challenge



More ventilation

- Increased energy use for heating, cooling and fans
- Better work performance and health

Air Conditioning

- Increased energy use for cooling
- Better work performance

Fisk 2007 Clima Congress workshop

EN 15251:2007

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

Design temperatures for dimensioning the mechanical systems

(EN 15251)

Type of building/ space	Catego ry	Operative temperature ºC	
		Heating (winter season), ~ 1,0 clo	Cooling (summer season), ~ 0,5 clo
Single office (cellular office) Sedentary ~ 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0

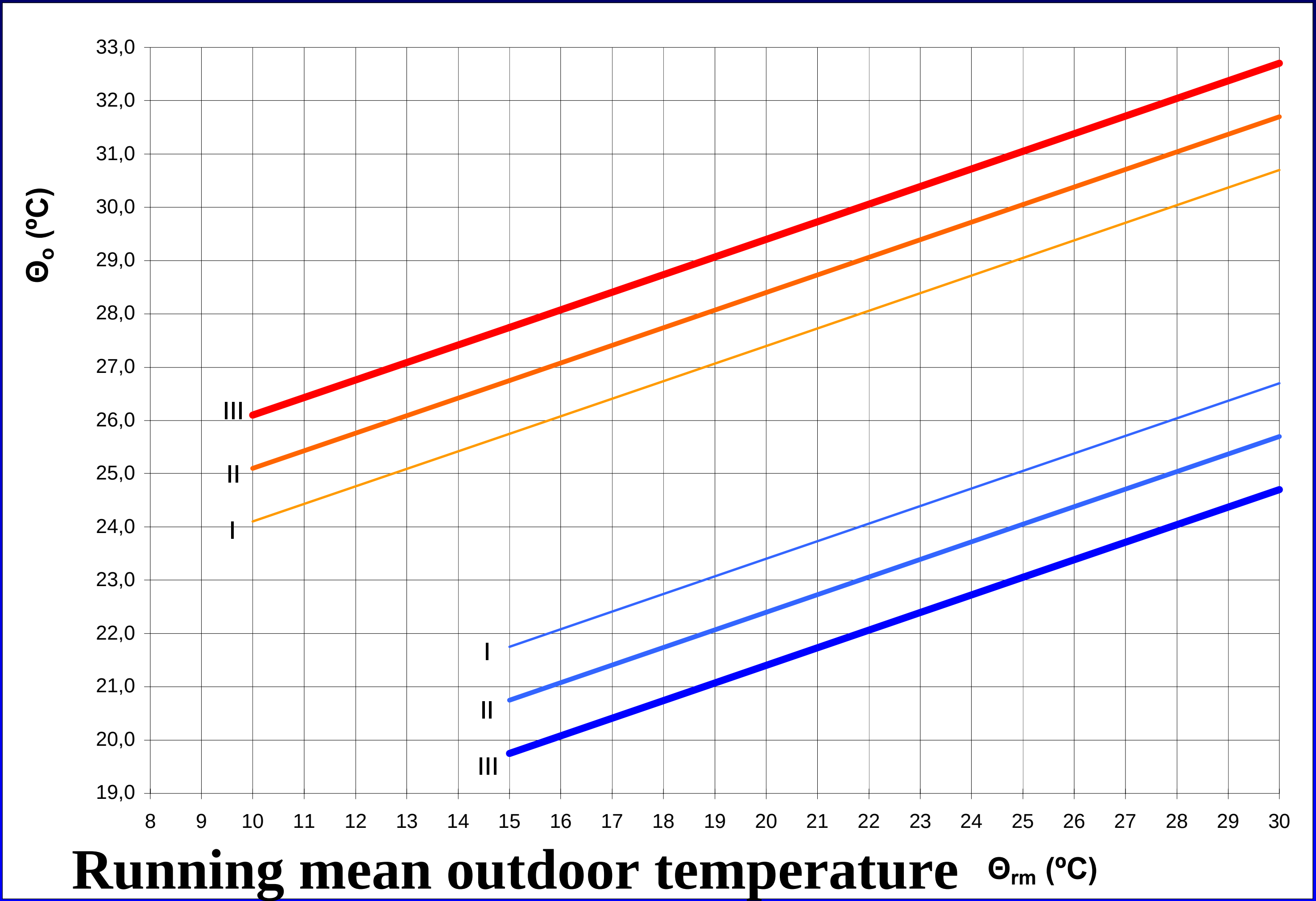
Indoor temperature range for energy calculations
(EN 15251)

Category	Temperature range for heating, °C Clothing ~ 1,0 clo	Temperature range for cooling, °C Clothing ~ 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

Adaptive thermal criteria

Design values for the indoor operative temperature for buildings without mechanical cooling

EN 15251:2007



Finnish Building Code
Indoor Climate and Ventilation of Buildings
December 2008

- In general during the occupied hours indoor temperature (operative temperature) should be < 25 oC
- …but during warm periods indoor temperature can be up to 5 oC higher than 5 hour mean outdoor temperature (when outdoor temperature < 20 oC)

Desing outdoor conditions

- Design outdoor temperature for the whole country 25 oC
- Design outdoor enthalpy 55 kJ/kg (except in Lapland 50 kJ/kg)
- Test reference year summer period for simulation

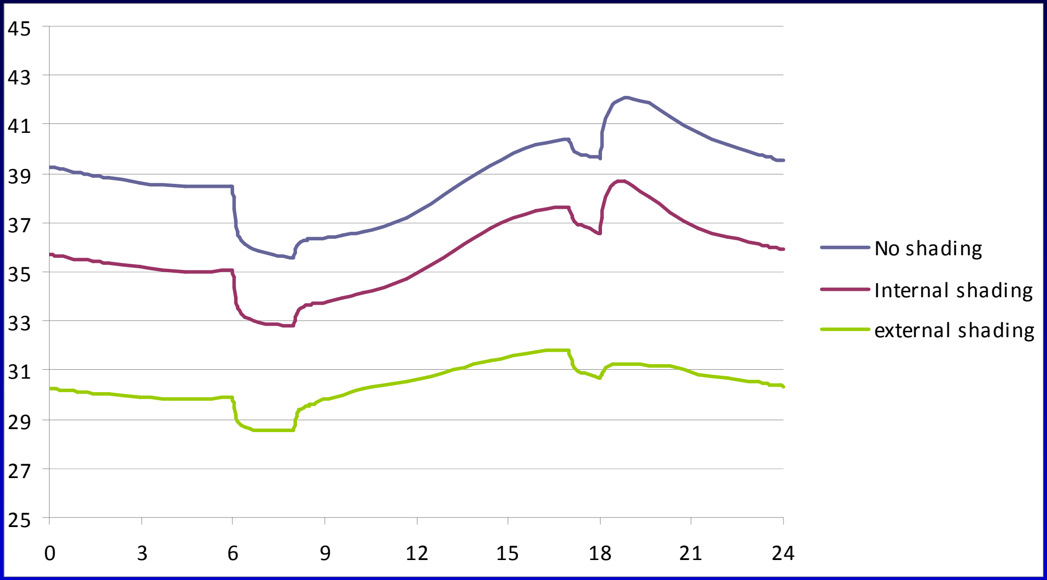
Other indoor environmental criteria

- Max air velocity in the occupied zone
  - In offices: winter 0,2 m/s summer 0,3 m/s
- Operative temperature has to be calculated and used if surface temperature differ significantly from air temperature
- Noise level defined as db(A)
  - Equivalent noise level in offices 33 dB(A)
  - Max noise level 38 dB(A)

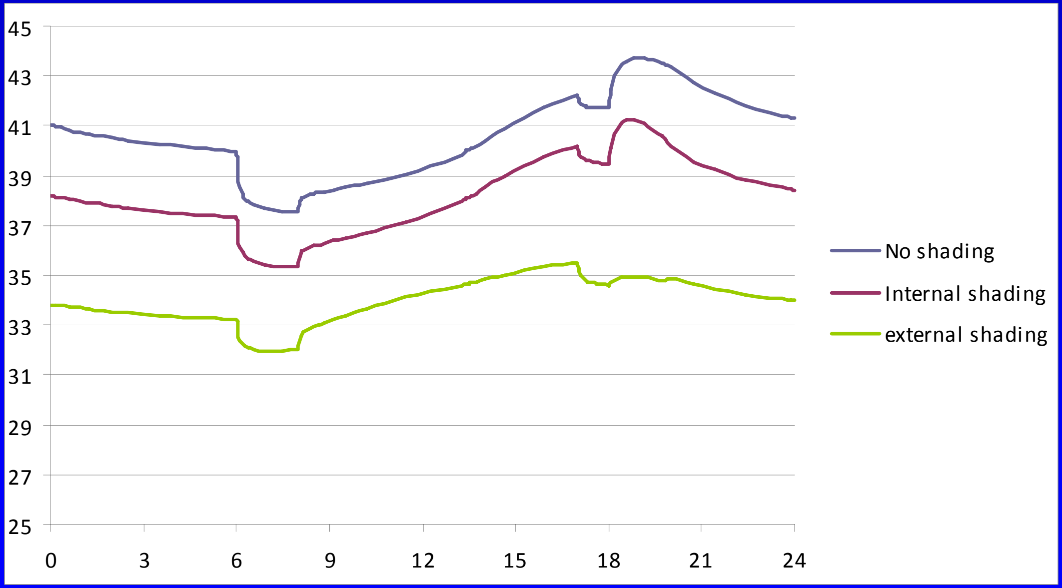
Finnish Building Code and December 2008 Thermal Insulation C3 and Energy Efficiency of Buildings D5

- Primary focus on reduction of cooling loads
  - Window area limited – max 15% from floor area and 50% from façade
  - Solar shading and selection of glasses
  - Control of lighting and other internal heat loads
  - Thermal insulation: walls U < 0,17 W/m2K
- Use of low energy cooling methods
  - Use of thermal capacity
  - Night time ventilation for cooling
  - Ground source cooling
  - Water source cooling (lakes, sea water)
- High performance mechanical cooling
- No specific numeric performance requirements for cooling energy use

Daily indoor temperature without cooling with outdoor air flow 3 L/s,m2



Stockholm



Milan

Needed cooling energy for 10 m2 office for max 26 oC devide by COP = 3-4 for electricity

Stockholm			Paris			Milan		
Room [kWh]	AHU [kWh]	Sum [kWh]	Room [kWh]	AHU [kWh]	Sum [kWh]	Room [kWh]	AHU [kWh]	Sum [kWh]
539,1	50,2	589,3	602,6	114,6	717,2	821,7	223,9	1045,6
352,7	50,2	402,9	412,6	114,6	527,2	577,7	223,9	801,6
74,2	50,2	124,4	125,5	114,6	240,1	200,5	223,9	424,4

1 Without shading

2 With shading inside

3 With shading outside

Office room with floor area 10 m2

Concrete construction

Triple glazed windows

Opertation time 6 -18

Max room temperature 26oC

Ventilation rate 1,5 L/s per m2

Air leakage 0,2 ach

Internal loads 8-17 12 W/m2 (lighting and one occupant)

Finnish Classification of Indoor Environment 1995, 2001, 2008

Target values for indoor air quality and climate, acoustics and lighting (S)

Instructions for design and construction (P)

- Building and constructions
- HVAC systems

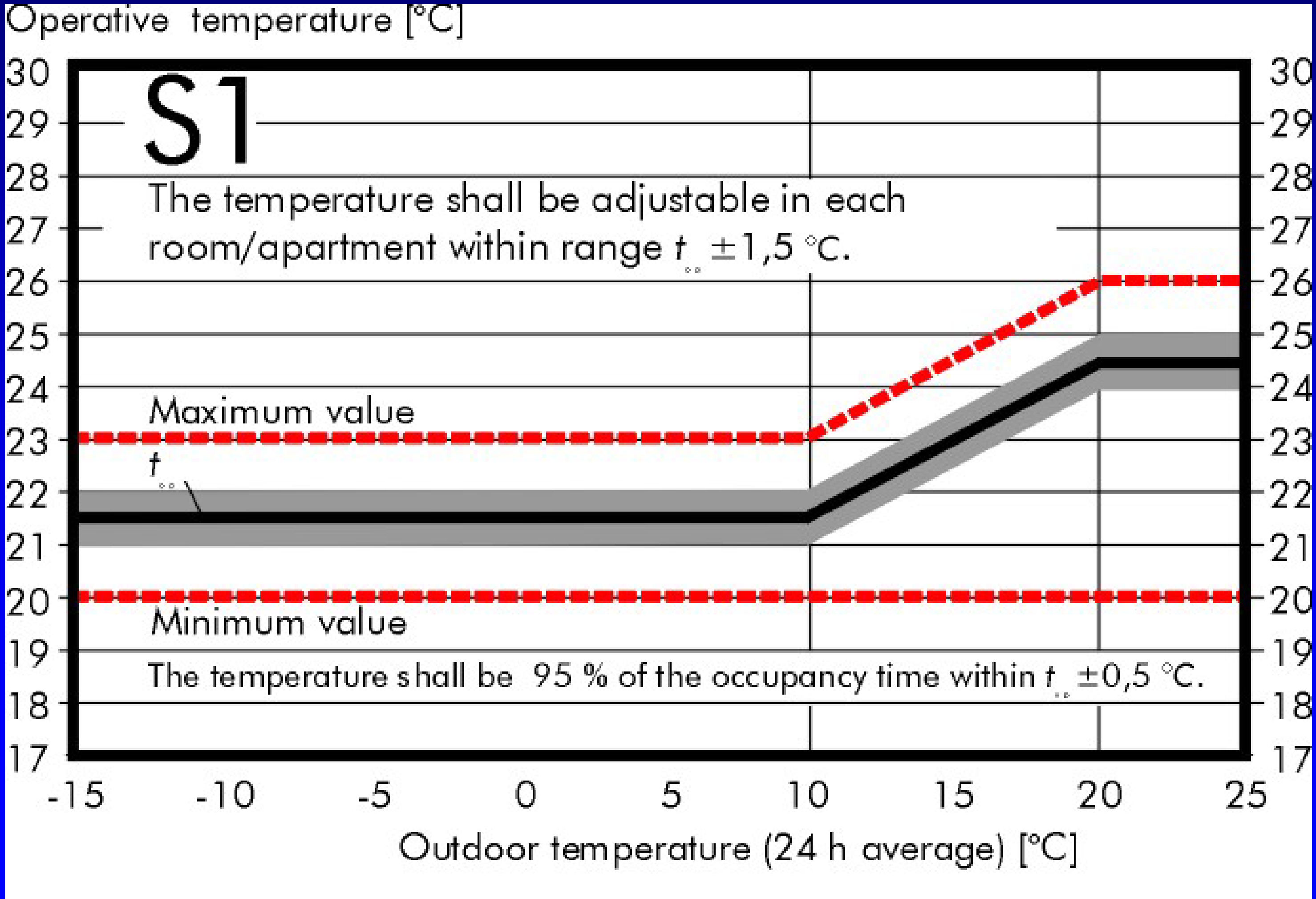
Requirements for building products (M)

- Classification of emissions from building materials
- Classification of clenliness of ventilation components

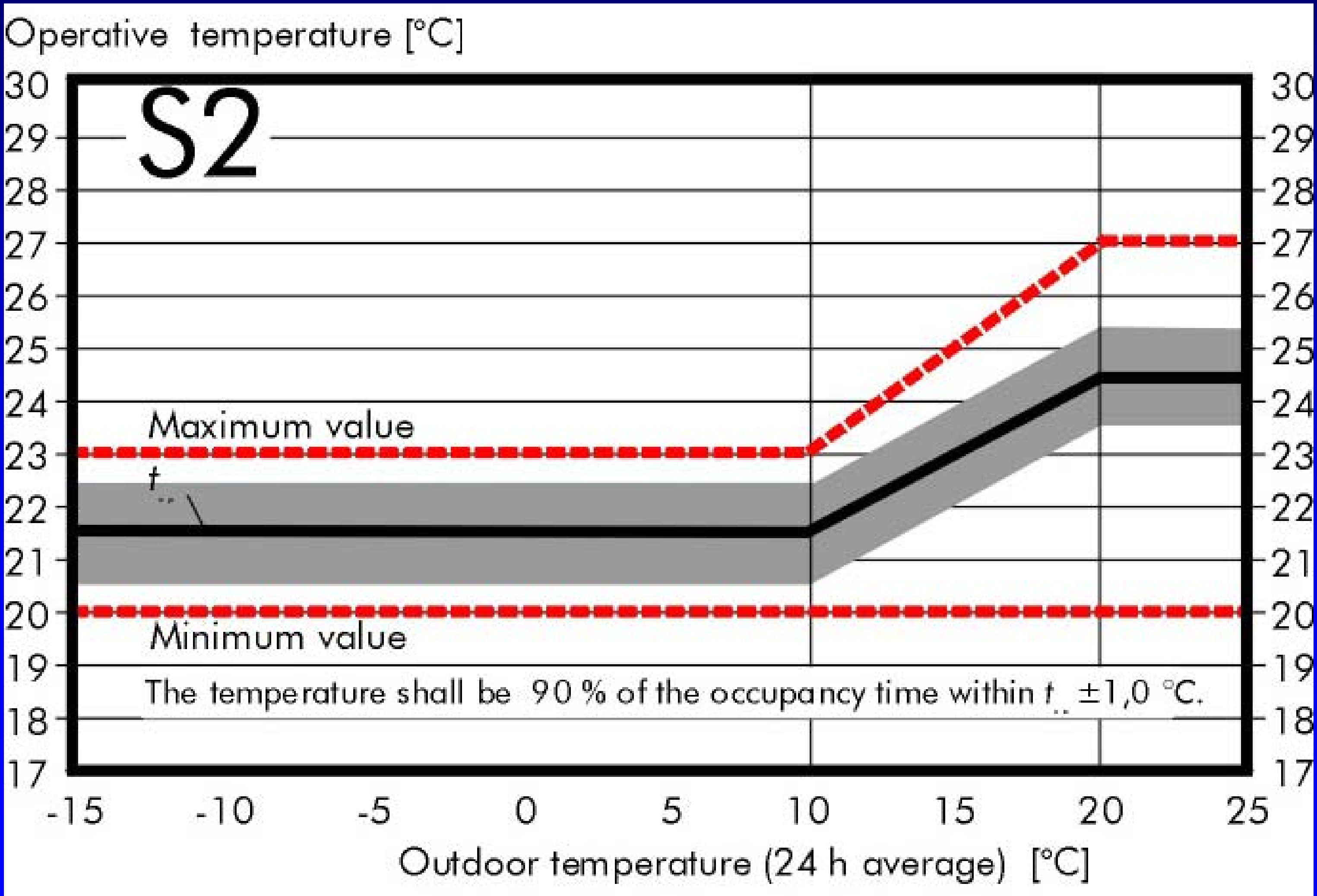
Target values (S)

- Three categories
  - S1 “individual” ~ cat I of EN15251
  - S2 “comfortable” ~ cat II
  - S3 “satisfactory” – building code level
- Specified from client’s and engineer’s viewpoints

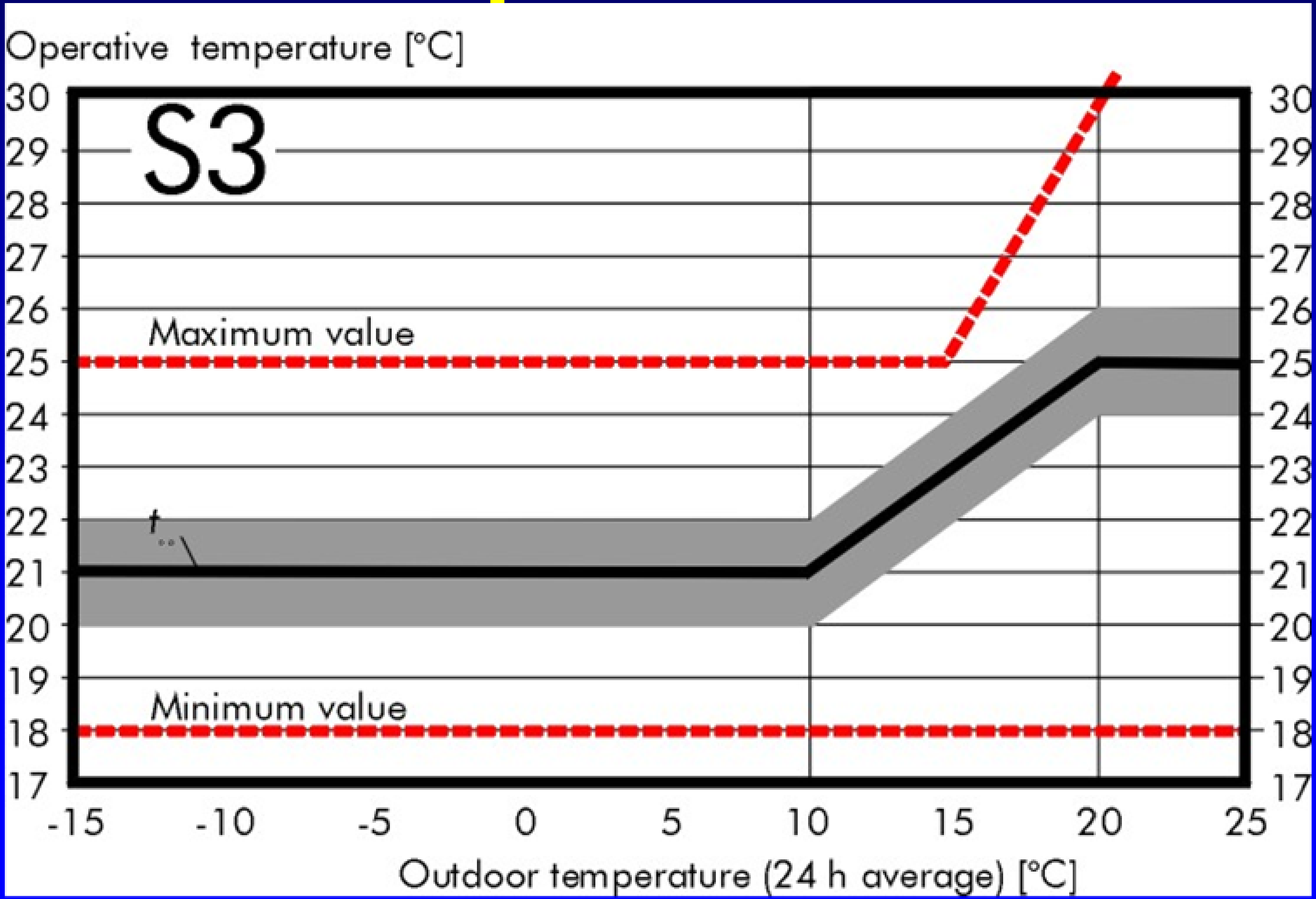
Target values for operative temperature



Target values for operative temperature



Target values for operative temperature



Construction practice

- All new office buildings are air conditioned – most common system: water based chilled beam or ceilings
- …also more common in residential buildings with reversible air source heat pumps
- Mechanical ventilation with heat recovery is compulsory for all buildings
- All working spaces, living rooms and bedrooms have to have window
- Direct evaporative cooling cannot be used due to health risks with contaminated water

European Insulation Manufacturers Association

THERMAL INSULATION

AND

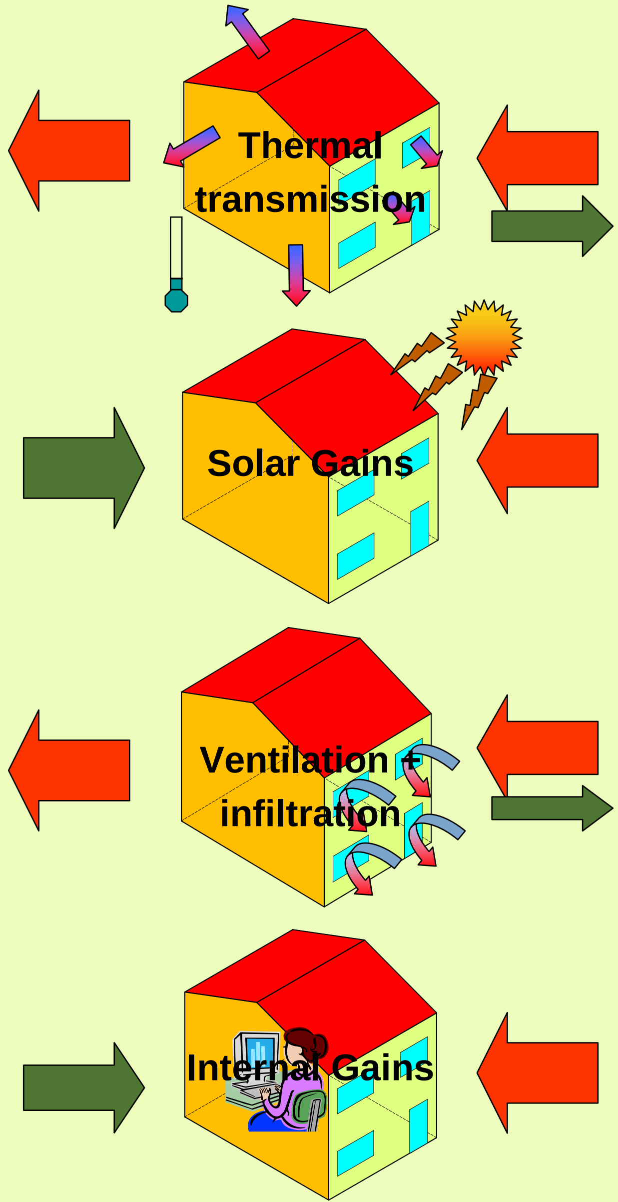
SUMMER COMFORT

March 09

EURIMA

- **EURIMA is the products insulation manufacturers association.**
- **EURIMA is active in all forums concerning thermal efficiency in buildings at European level.**
- **EURIMA has sponsored a some interesting rapports; many off then including summer comfort or cooling energy impact.**
    - **The contribution of Mineral wool and other thermal insulation materials to energy saving and climate protection in Europe (2002)**
    - **Mitigation of CO2 emissions from the building stock – Beyond the EU Directive on the Energy Performance of Buildings (2004)**
    - **Cost – Effective climate protection in the EU Building stock (2005)**
    - **Cost – Effective climate protection in the building stock of the new EU Member states (2005)**
    - **Sensitivity analysis of cost effective climate protection in the building stock (2006)**
    - **Better buildings through energy efficiency – A roadmap for Europe (2007)**
    - **U-values for better Energy performance of buildings (2007)**

ENERGY BALANCE (heat flows)



Winter season	**Summer season**
$T_{ext} < T_{set;heat}$	$T_{ext} > T_{set,cool}$
Insulation avoids loose energy	Insulation protects from overheating Poor Insulation can dissipate energy (only during some hours)
Solar gains must be maximisated	Solar radiation increases heat. Shading elements must be included
Air ventilation loose energy.	Air movement increases heat. Ventilation can dissipate heat (only during some hours).
Internal gains helps to heating	Internal gains increase overheating

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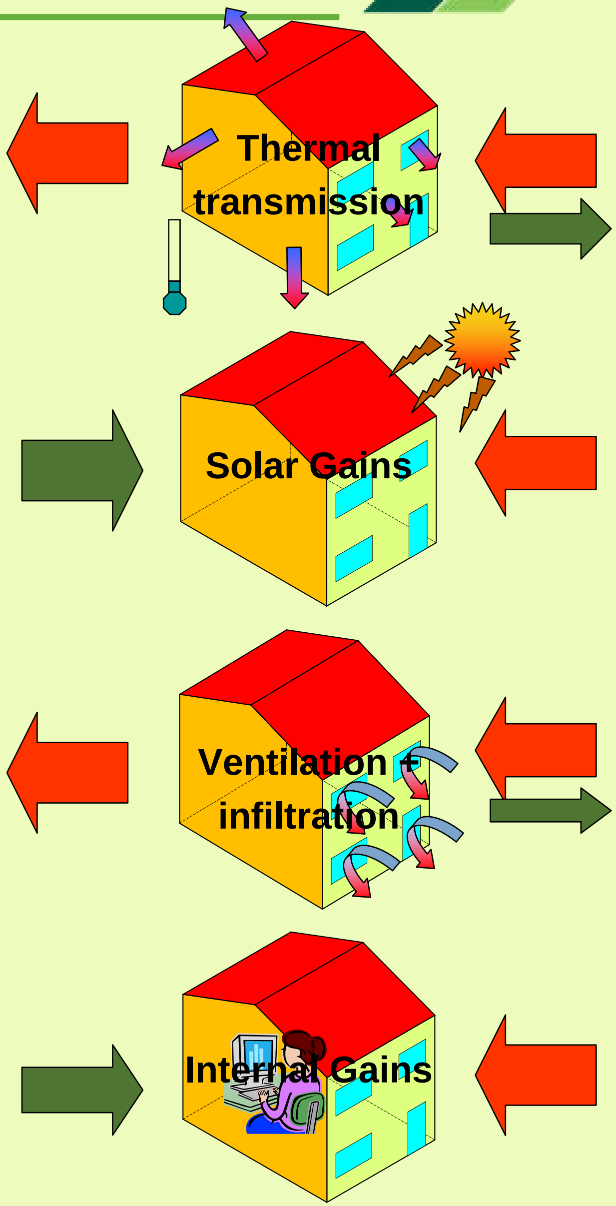
ENERGY BALANCE
Considerations

<u>Winter season:</u>

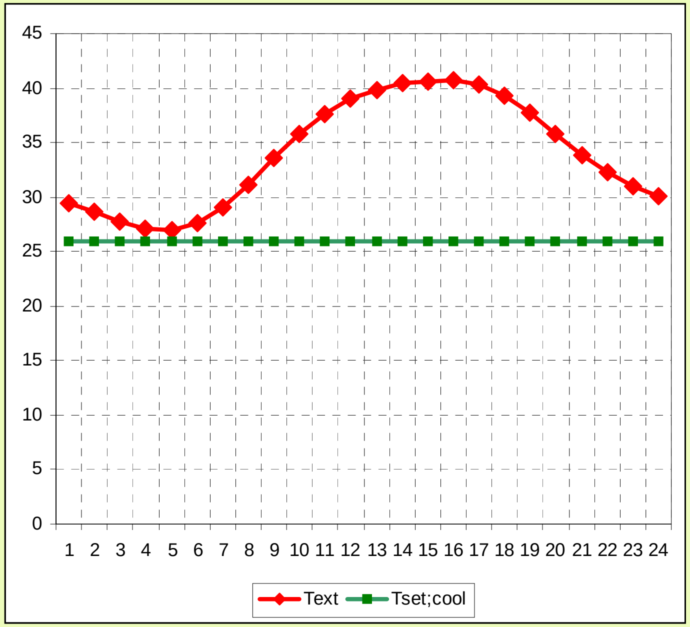
There are some input and output flows is possible to produce a real balance.

<u>Summer season:</u>

There is only very small possibilities to dissipate energy and some flows are unavoidable (internal or solar gains).



Summer comfort
Very Hot climates



During all day $T_{ext} > T_{set;cool}$

During all day heat flows go from outside to inside; there is no possibility at any time to dissipate heat.

Recommendations:

Thermal transmission → minimize → **maximum insulation**

Ventilation → minimize (maintain the minimum ventilation rate compatible with air quality).

Solar gains → minimize (maintain the minimum compatible with daylight availability)

Internal gains → reduce (no real possibility to act on this item)

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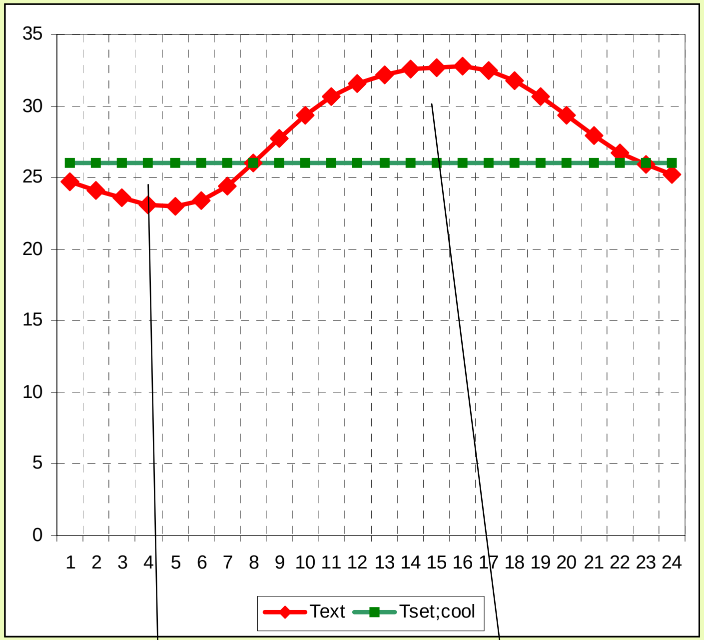
Summer comfort
Hot climates



Cooling availability

Overheating Risk

During some hours $T_{ext} > T_{set;cool}$ (similar to Very hot climates) but during some hours $T_{ext} < T_{set;cool}$

During hot hours heat flows go from outside to inside (overheating); there is no possibility to dissipate heat but during some hours it’s possible to dissipate heat by ventilation and thermal transmission.

¿is it a contradiction between insulation and ventilation?

¿is it a contradiction between insulation and solar shading?

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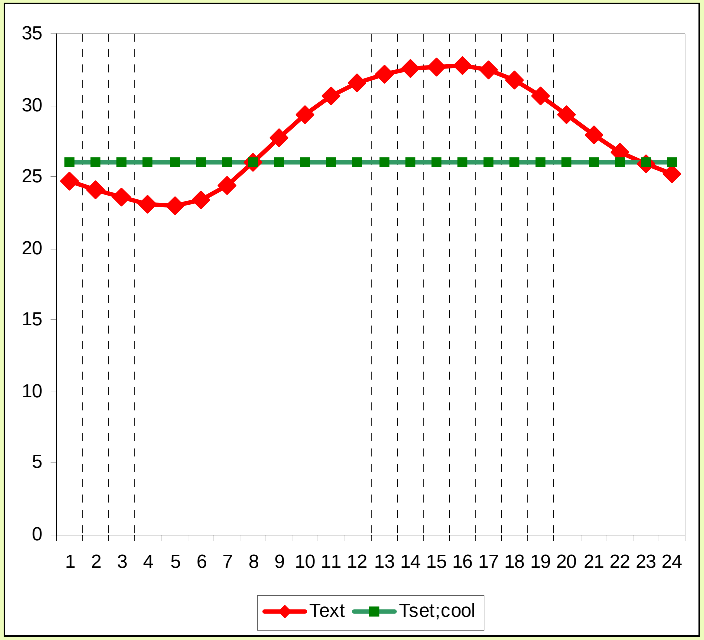
Insulation ←→Ventilation



Usually the cooling availability is much more lower than overheating risk, due to the lower ΔT and due to shorter time.

Thermal transmission

$Q_{thermal} = S \cdot U \cdot \Delta\ T \cdot t$

Thermal ventilation

$Q_{ventilation} = 0{,}34 \cdot V \cdot n \cdot \Delta T \cdot t$

It's not possible (easy) to change U from day to night but air ventilation rate can be easily modified during night (opening windows,....)

Insulation must be maintained as high as possible in order to protect building from overheating.

Ventilation must be maintained as low as possible during overheating hours and as high as possible during free cooling hours (night ventilation)

There is no contradiction between insulation and ventilation.

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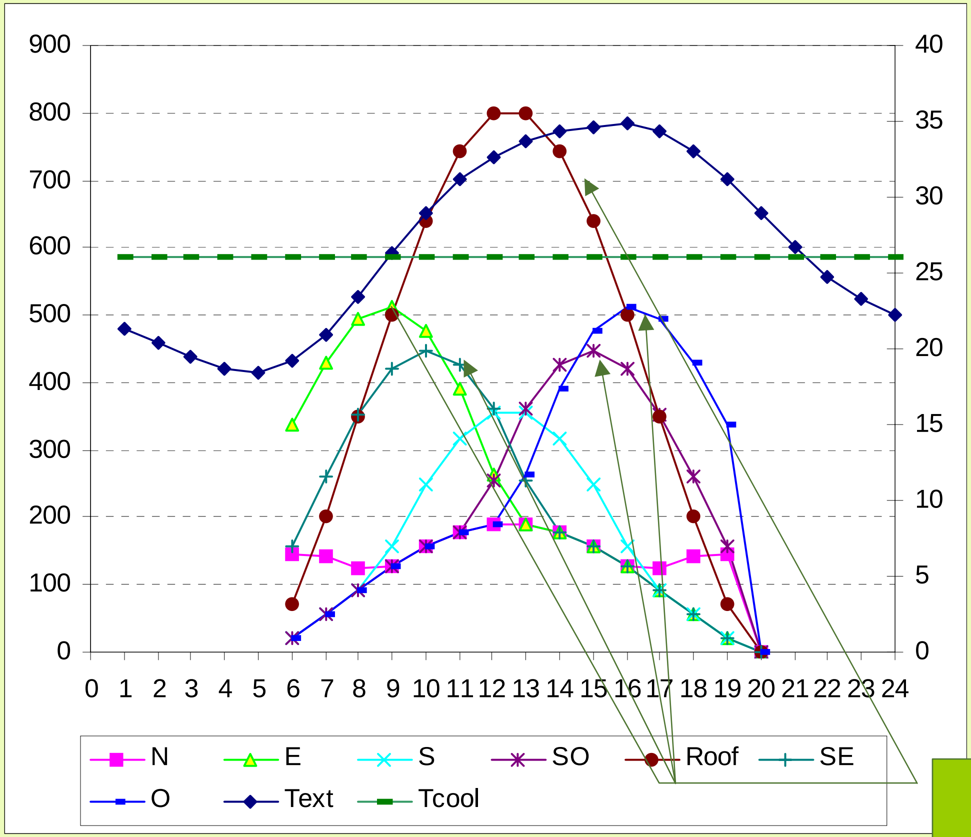
Insulation ←→Solar shadings



In hot climates Maximum solar irradiation coincides with maximum temperatures (mainly in SE; SO; O orientations).

During "overheating risk hours" thermal transmission must be reduced → insulation increased during these hours solar shadings must be included.

Maximum solar irradiation and maximum overheating risk

Solar shading must be used at the same time than insulation

There is no contradiction

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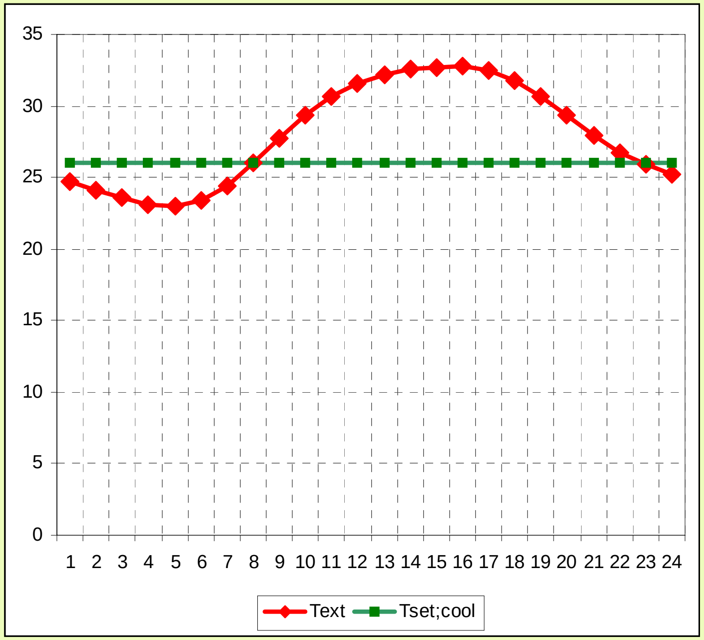
Summer comfort
Hot climates



Recommendations:

Thermal transmission → minimize → **maximum insulation**

Ventilation → minimize (maintain the minimum ventilation rate compatible with air quality) during day hours and → maximize during night.

Solar gains → minimize (maintain the minimum compatible with daylight availability)

Internal gains → reduce (no real possibility to act on this item)

Building codes recommendations

Winter + Summer conditions:

- Minimum U values according winter conditions and overheating risk
- Movable solar shadings performance according summer conditions and elimination during winter season.
- Variable ventilation rates according winter conditions and overheating risk and allowing night ventilation if cooling availability exists.

CONCLUSIONS

Is already well accepted:

Insulation is the best way (low cost) to reduce energy demand in winter season.

BUT:

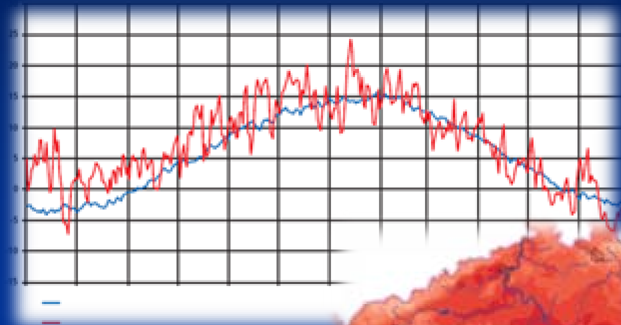
Insulation is also the west way to reduce overheating risk during summer season, other free cooling techniques (as night ventilation or solar shadings) are not in contradiction with insulation.

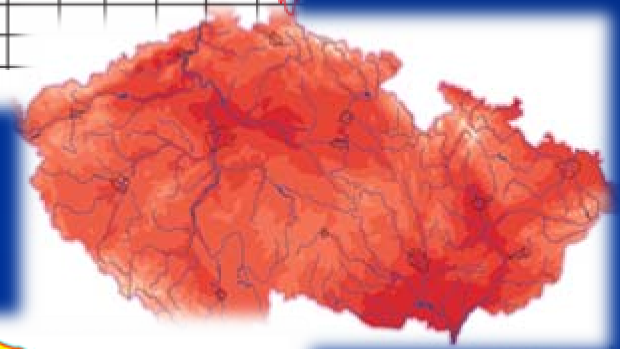
Czech Technical University in Prague
Faculty of Civil Engineering
Department of Microenvironmental and Building Services Engineering

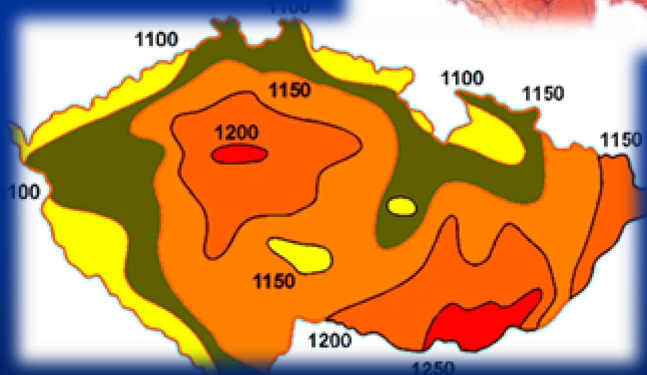
Summer comfort and cooling Situation in the Czech Republic

Karel Kabele

Czech climate







- Design temperatures:
  - Winter: -12 to -18°C
  - Summer: +32°C (cooling load design), 30°C (building structures)

CZ - Summer requirements

- Working x residential environment
  - Government regulation 361/2007 Col.
    - according to metabolic rate, clo, max acceptable operative temperature 26 to 28°C
  - ČSN ISO 7730 – Thermal comfort
  - ČSN EN ISO 15251 $\theta_{oi,max} = 25{,}5$ *to* $27°C$
  - ČSN 730540 Thermal protection of buildings
    - Summer stability - building without cooling

$\Delta\theta_{ai,max} = 5$ *to* $9{,}5\ K$ = *max amplitude of* θ_{ai}

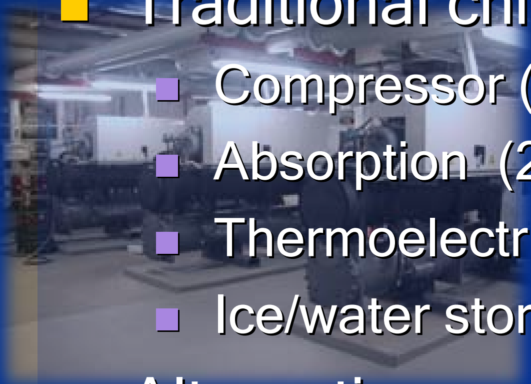
$\theta_{ai,max} = 27$ *to* $31{,}5°C$

§

Systems

Source

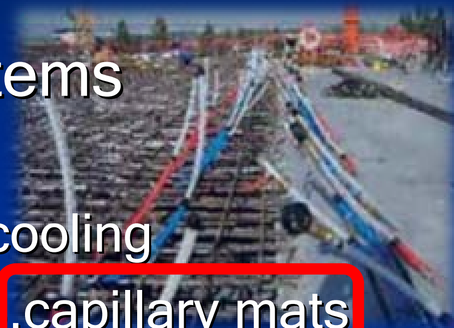
- Traditional chillers
  - Compressor (98%)
  - Absorption (2%)
  - Thermoelectric (<1%)
  - Ice/water storage



- Alternative
  - Night cooling
  - Solar cooling
  - Evaporative cooling
  - Earth heat exchanger
  - Underground water
  - Passive cooling

Distribution

- Water systems
  - FCU
  - Radiant cooling
    - TABS ,capillary mats



- Refrigerant systems
  - Split, Multisplit, VRV
- Air systems
  - Low / high pressure
  - Single duct, double duct
  - VaV

Case study

RADIANT COOLING AND HEATING IN CZECH CLIMATE CONDITIONS

PROBLEM DESCRIPTION

- The main purpose of this study was to investigate integrated heating/cooling system performance during typical Central Europe climate conditions with different operation load profile.
  - Is the integrated ceiling heating/cooling system able to secure compliance with comfort requirements during the whole year operation?
  - Are the existing design recommendations in terms of maximum heating/cooling output of the ceiling applicable particularly in climate conditions of Central Europe?

Integrated heating/cooling ceiling system with capillary mats

PROBLEM ANALYSIS

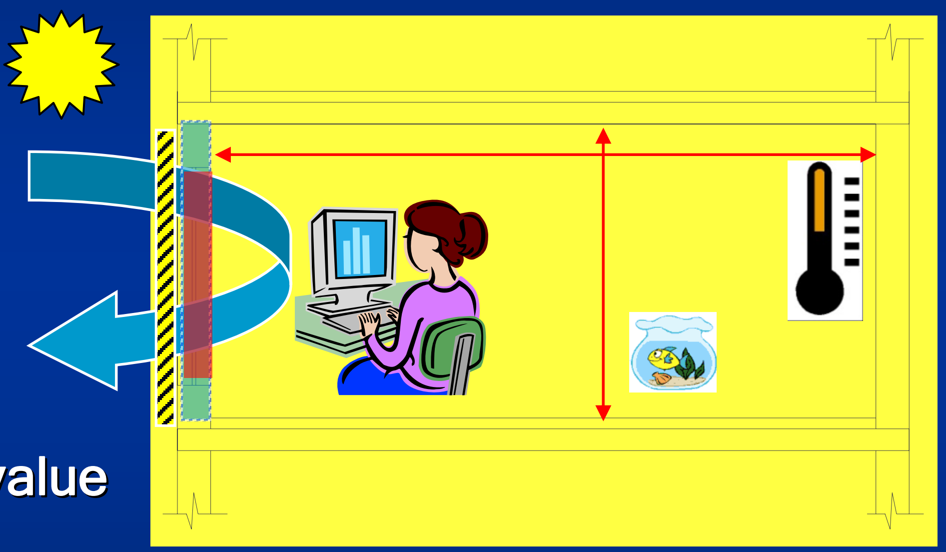
Study is focused on three types of the buildings, where integrated heating/cooling ceiling system has been used and problems appeared.

- residential building
- office building with small offices
- office building with open space offices

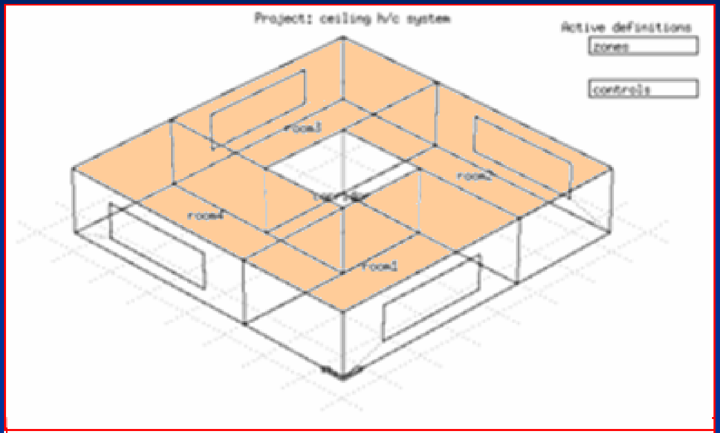
PROBLEM ANALYSIS

Parameters, that may have any influence on the possibility of the integrated ceiling heating/cooling system use:

- ✓ Internal sensible heat load
- ✓ Internal latent heat load
- ✓ Infiltration air rate
- ✓ Ventilation air rate
- ✓ Humidity control
- ✓Quality of the walls - U value
- ✓ Glazing ratio
- ✓ Quality of the windows – U,g value
- ✓ Active shading – blinds
- ✓ Ratio of hight to depth of the room
- ✓ Orientation
- ✓ Set point for heating
- ✓ Set point for cooling



METHOD

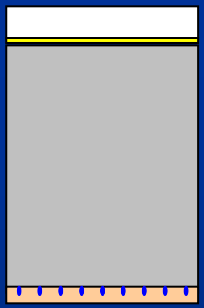


ESP-r model

A five - zone model in ESP-r
Glazing 3o% of one outside wall each zone
Medium-heavy constructions
external wall U = 0.24 W/m²K
internal wall U = 1.56 W/m²K
window U = 1.20 W/m²K, trn=0,76

ESP-r simulation of an annual building energy performance, 1 hour time step

Active Ceiling / Floor construction

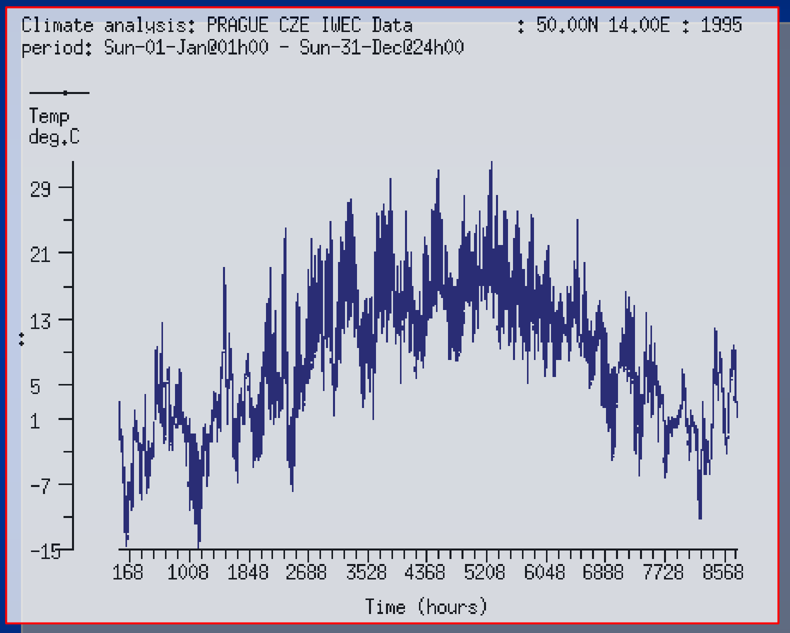


System is defined by heating capacity controlled according to established practice in a range of 0-130 W/m², cooling capacity 0-80 W/m² in each of the rooms. Set point for cooling is 26°C, for heating is 22°C.

Model operation profiles

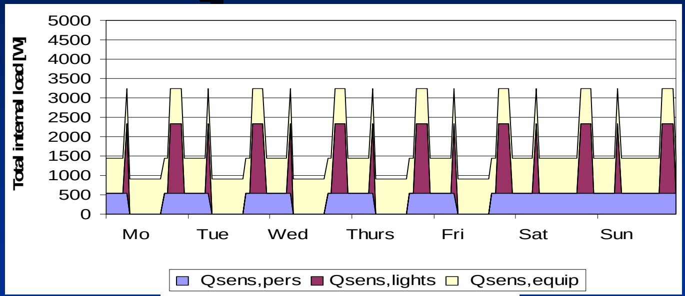
Model was loaded by

- Czech climate conditions (IWEC)

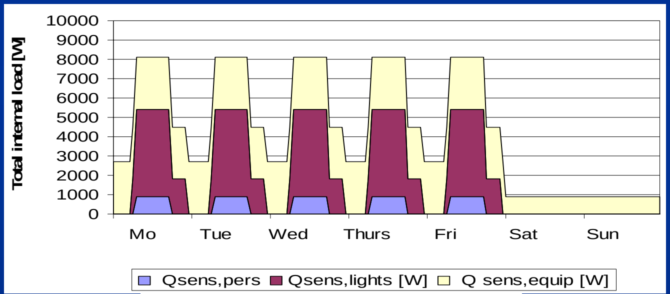


And 3 alternatives of operation schedules

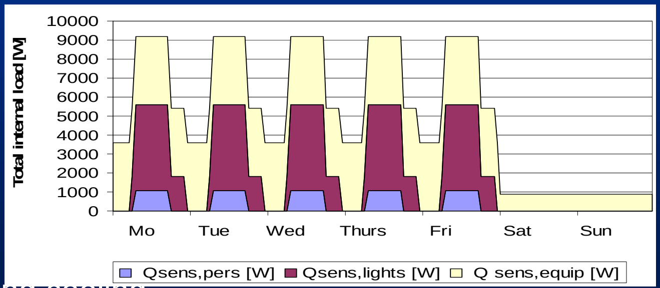
- occupants (sensible,latent load)
- lights
- equipment



Residential – B1



Small office – K1



Open space office – VK1

SIMULATION RESULTS

CRITERION

- annual heating/cooling energy use
- comfort expressed by resultant temperatures, PMV and PPD parameters
- the possibility of condensation on the ceiling surface during the cooling period

Alternative	Heating [kWh/m²/a]	Cooling [kWh/m²/a]
Residential	45.3	69.3
Office	7.4	228.4
Open-space office	7.2	264.9

SIMULATION RESULTS

CRITERION

- annual heating/cooling energy use
- comfort expressed by resultant temperatures, PMV and PPD parameters
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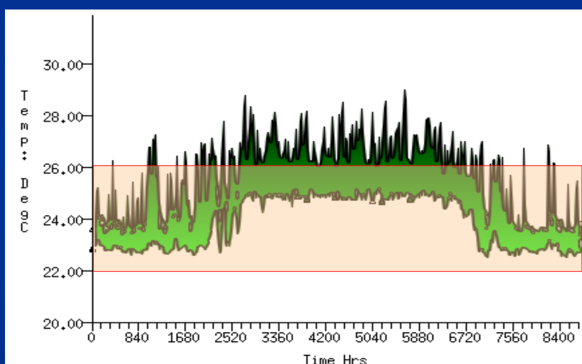

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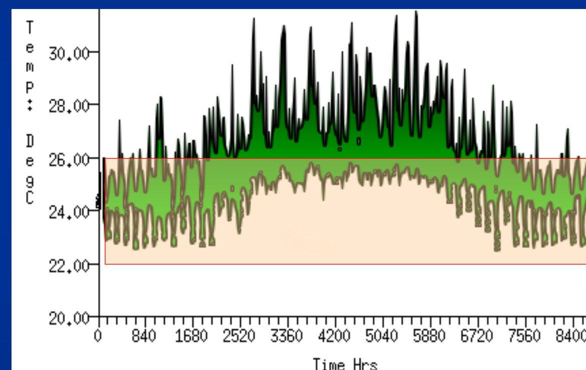
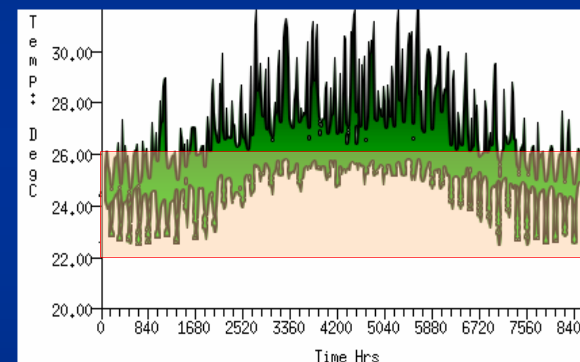


Small office – K1



Open space office – VK1

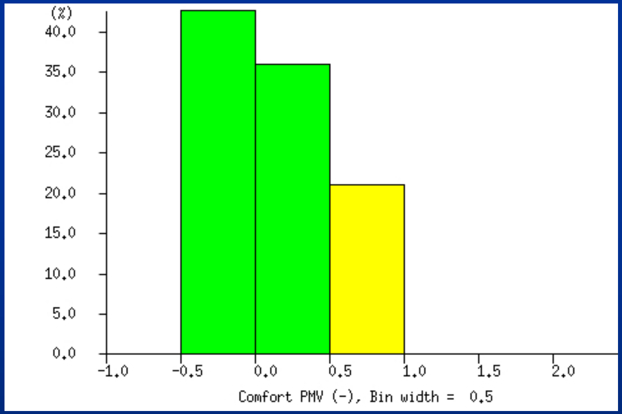
? Resultant temperature x db temperature

? Weekends - Peak values

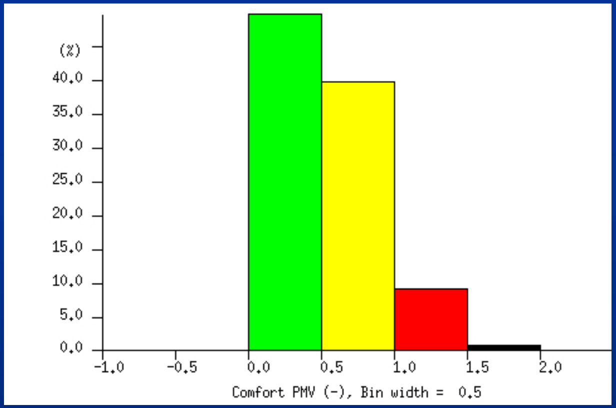
SIMULATION RESULTS

CRITERION

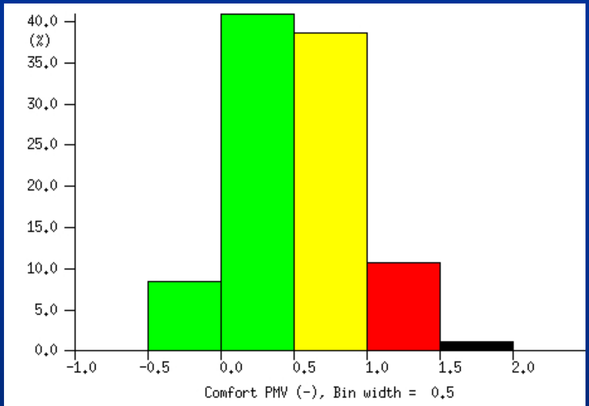
- annual heating/cooling energy use
- comfort expressed by resultant temperatures, PMV and PPD parameters
- the possibility of condensation on the ceiling surface during the cooling period



Residential – B1



Small office – K1

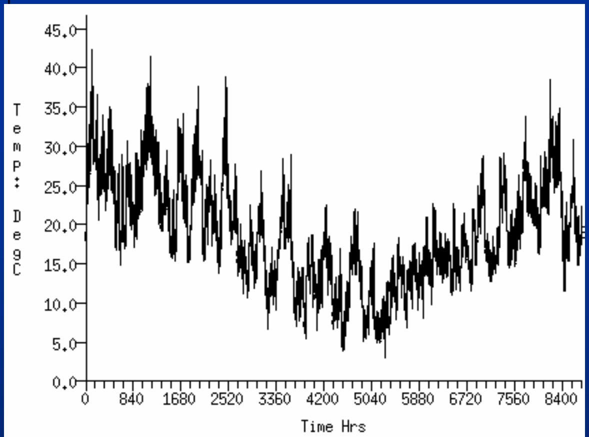


Open space office – VK1

SIMULATION RESULTS

CRITERION

- ➢annual heating/cooling energy use
- ➢ comfort expressed by resultant temperatures, PMV and PPD parameters
- ➢ the possibility of condensation on the ceiling surface during the cooling period



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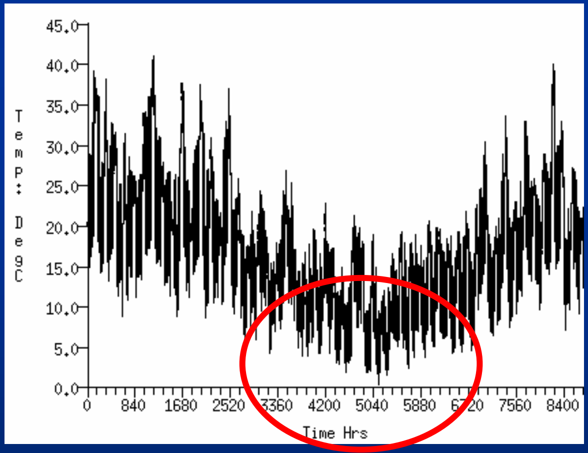
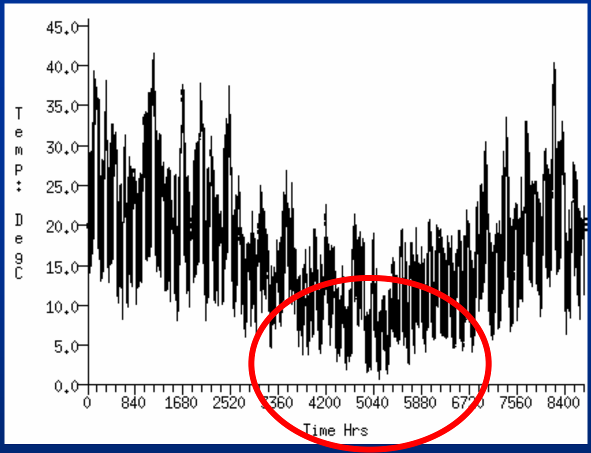


Small office – K1



Open space office – VK1

CONCLUSION

- The simulation shows that common design heating/cooling capacities (130 and 80 W/m^2) of the ceiling surface are appropriate for all three simulated cases.
- The system can reliably guarantee the required temperature during the whole year in the heating mode.
- Several problems are detected with the cooling, when the designed capacity cannot cover the temperature requirements and occasionally a short-term condensation can occur.
- The application of this integrated system is limited by its capacity. especially in the buildings with higher internal gains and connected cooling demand this application is disputable.

Thank you for your attention…

Karel Kabele

Energy Savings, Summer Comfort and Green Buildings in Israel

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Introduction

During the 90ies a trend of great increase in the use of air conditioning started in many Mediterranean countries, mainly due to the increase of family income. In the case of Israel, this was complemented by the increase in mall-type shopping centers which have replaced to a large extent the traditional downtown-based shops. It is estimated that three quarters of Israeli households have today some kind of air conditioning device (although in some places a primitive one, the "window air-conditioner").

Given the insular nature of the Israeli electrical grid – but also its dependence on a relatively small number of electricity producing units - mainly based on coal, ie with a large specific CO2 production – the need for energy savings in the air-conditioning sector becomes increasingly important and contradicts the existing trend in increase in energy consumption, due to a very large extent in increasing air-conditioning demand.

.This report aims to present the actual state of the art in the field of summer comfort and passive cooling of buildings in Israel. The first part of the paper discusses the actual penetration of air conditioning systems and problems resulting from using mechanical cooling. The second part presents the existing legislative frame concerning summer comfort and cooling, Following that the trends and perspectives on low energy cooling are presented, while the future legislative requirements are discussed.

1 Israel's Climate

Israel is a small country (apr. 20,000 sq.km) but being located in a transition region between the Mediterranean climate and the subtropical one, it is made up by four regions totally different from the climatic point of view: the Mediterranean coastal region, the mountain region, the Negev (mainly) desert region and the Arava-Eilat Region along the Syrian-African Rift. Climatic behaviour in each of these regions is often diametrically opposed from the other ones, but in most regions the summer problems are more important than the winter ones. Some basic data in these regions are summarized in Table I

2 Israel's Energy and Electricity Sector

Israel is characterized by an almost total dependence on imported energy sources – be it coal, oil or more recently natural gas. Israel's annual energy consumption is of the order of 23 MTOE every year. Israel's electricity sector is rather large in comparison to the similar ones in other western countries (approx. ratio of electricity to energy production : 50%) , with a peak demand of around 10 GW and an energy production of 53 Billion KWh, with a rate of increase of the order of 3-5% a year till 2007. In 2002, given that 70 % of the energy for electricity production is from (imported) coal and the rest (some 20%) from heavy fuel oil (mazut), a rather high specific production of CO2 per generated kWh resulted. Since then, an increasing part of electricity production (approx. 20 % in 2007, with an increasing trend) is based on natural gas, which is more environment-friendly, has a lower specific CO2 production and is partially a domestic source (today's estimate is 0.91 Ton CO2/MWh) Israel's total CO2 emissions are of the order of 70 MT/year (2003) or 0.7kg/95USD , 60 % from oil and 40 % from coal (since the time that the statistics refer to, natural gas has increased appreciably).

High penetration of air conditioning in the buildings sector increases the absolute energy consumption of the building sector – especially the residential part - and the corresponding carbon dioxide emissions, while increasing highly the peak electricity demand during the summer period. Air conditioning energy accounts approximately for 12% of the annual energy consumption (5 Billion kWh) and approximately 25% of peak morning electricity demand (2.5 GWe) – and this accounts for almost all the increase in the electricity demand. Out of those figures, 40% are due to the commercial and services sector, 30 % to the residential sector – the latter having a higher share of the increase in energy consumption. Positive steps taken by the Government Agencies and the Electrical Company of Israel include the time-dependent electricity charge (TAOZ) which is used for commercial and industrial consumers. There are 3 tariffs, peak, off-peak and regular – with times changing for summer (July-September), winter (December-March) and Spring/Fall. Typically, the peak tariff is 25 USD cents for peak (11:00-17:00 during summer weekdays and 17:00-22:00 during winter weekdays) while the off-peak tariff is 6 USD cents (24:00-6:00 on weekdays and longer during weekends).

Attempts to apply the TAOZ tariff to residential buildings on a voluntary basis have had limited success. The public sector electric company encourages the use of ice-based and water-based systems to reduce the peak demand and some twenty projects of the kind (in universities, courthouses, high-tech sector companies, the airport and hospitals). Note that although peak-shifting is connected to a small increase in electric-energy consumption, increased thermal efficiency during the base hours results in a decrease in primary energy use.

Israel is considered a vanguard in the field of solar energy: the solar water heaters industry is very developed and Israeli companies like Ormat and Solal have contributed to solar energy electricity generation. Like in other countries, the electric company encourages sales of electricity by other producers when it is based on alternative energy sources like wind energy, solar energy and photo-voltaics. Some plants based on absorption air-conditioning with solar energy source have been constructed too, as well as hygroscopic materials that reduce the latent load.

Israel ratified the Climate Change Convention in September 1996 and the Kyoto Protocol in March 2004. Israel is classified as a developing country under the Convention although its CO_2 emissions are comparable to those of developed countries. Israel submitted its First National Communication to the Conference of the Parties to the Climate Change Convention in 2000. The report includes Israel's national inventory of anthropogenic emissions and removals of greenhouse gases for the year 1996. A 2001 government decision calls for steps to limit/reduce greenhouse gas emissions on the basis of the findings and conclusions of the inter-ministerial committee on climate change.

In preparation for the post-Kyoto period, Israel has initiated a number of steps in the area of mitigation and adaptation to climate change.

3 Legislative Frame Concerning Summer Cooling

The first steps to check energy consumption in the building sector of Israel were made in the 70ies – at the wake of the 1973 energy crisis, when an Insulation Standard for Buildings (IS 1045) which in its first form was concerned with residential buildings. The standard was divided essentially into two parts – one concerned with a minimum value of the resistance of the external elements and one concerned with the maximum value of the volume related building loss coefficient (G-Value) for each dwelling unit. The insulation standard for residential buildings was totally revised in the mid-eighties. In the beginning of the 90ies it was extended to low-mass buildings with much more stringent requirements. It was subsequently extended to school buildings, office buildings, commercial buildings, hotels and hospitals. In the latter four categories, thermal energy performance during the summer considerations was the main focus and this is being expressed through requirements on the glazings, both from the point of view of the thermal resistance but also its radiative properties.

At a later stage, the Insulation Standard was complemented by a Green Building Standard (IS 5281), which is intended to give a Green Certificate to Buildings that are particularly environment friendly (IS 5281). The assessment of the building is based 30 % on the energy performance (evaluated according to IS 5282 – Energy Use in Buildings), land use maximization, water resources conservation, indoor air quality, environmentally sound site management during construction, reuse of waste from demolished buildings and other environmental considerations, with a certain latitude given to the assessor. On the basis of this standard, buildings can be classified as Green Buildings or Outstandingly Green Buildings. A Green Council has been formed – to issue the certificates of compliance to the Green Buildings Standards.

The Ministry of National Infrastructures is funding a project on a future Energy Code which will be used in the future to assess the energy performance of buildings – both during the summer and the winter. When this code is ready, it will be used in place of the simplified procedure of IS 5282.

Several other standards have been developed for building elements, including a new standard for window certification, standards for calculation or measurement the U-Value of building masonry blocks, which are a common building element in Israel.

Other measures that have been already implemented are Standards for Air Conditioning Units (Energy Efficiency, Energy Ratings and Energy Labels). Note that Israel's industries (mainly Tadiran and Electra) are producing 100s of thousands of air conditioning units, some of them being exported, but others being imported into Israel. Although in the past air-conditioning was considered a luxury, the attitude today is rather different – given that in most regions in Israel air-conditioners can be successfully used as heat pumps during the winter period, with the corresponding energy savings.

Administrative measures include a requirement that new public buildings should comply with the green standard.

4. Low Energy Cooling Technological Trends and Perspectives

There are several houses in Israel in which novel passive measures have been used for the purpose of obtaining summer comfort. The Institute Desert Research in Sde Boker has several model houses, one using the mobile Trombe wall , an administration building [1] combining underground and earth-integrated construction with a glazed patio for heating and a downdraft evaporative cooling tower, and a Solar Neighbourhood with several passive measures aimed mainly (but not exclusively) at summer comfort [2].

In other parts of Israel, Solar Absorption is used in the major Tel-Aviv area hospital of Tel-Hashomer, whereas a dessicant-cooling – essentially absorption-based) system is used in the Technion.

A Solar Kibbutz and a Solar Beduin village have been inaugurated during the last year.

In the Eilat, Arava and Negev regions, in which the relative humidity is low, some people prefer the use of desert coolers based on evaporative cooling to air-conditioners – which are inappropriate though for the coastal area where the majority of the population lives.

Recently in the Desert Research Institute a window system has been developed, whose radiation properties vary with the season. Other systems, in which those properties vary with the incidence angle, also exist.

5. References

1. Etzion Y. "A Desert Solar Neighbourhood in Sde-Boker, Israel". Architectural Science Review, Vol. 33, 105-11, 1990.

2. Etzion,Y., Pearlmutter D., Erell, E. and Meir I.A. "Adaptative Architecture: Integrating Low Energy Technologies for Climate Control in the Desert". Automation in Construction, Vol. 6, 417-425, 1997.

3. Hirsch M., Ailon O., Grossmann G., Schitzer A., Gumid H., Goren I., Avnimeleh Y. and Arnon Y. "Air Conditioning Survey in Israel: Potential Savings and Implementation Policy". Neeman Research Institute, Technion, 2004.

4. IS 1045 on Insulation of Buildings

5. IS 994 on Air Conditioners

6. IS 5281 on Green Buildings and IS 5282 on Green Buildings Energy Rating.

Table I

Climatic Zones Zones of Israel

Climatic Zone	Winter (January)			Summer(August)		
	Heating Degree Days	Av. Max. Temp,ºC	Av. Min. Temp,ºC	Av. Max. Temp,ºC	Av. Min. Temp,ºC	Rel. Hum at 14:00, %
Mediterranean Coast	800	17	8	30	20	60
Mountain Area	1200	12	6	28	20	40
Negev Desert	1000	17	5	33	19	35
Eilat and Jordan-Arava Valley	300	21	9	40	25	20

ENERGY & SUMMER COMFORT in ISRAEL

by

Samuel Hassid
Environmental & Civil Eng. Dept.
Technion – Israel Inst. of Techn.
Haifa 32000 Israel

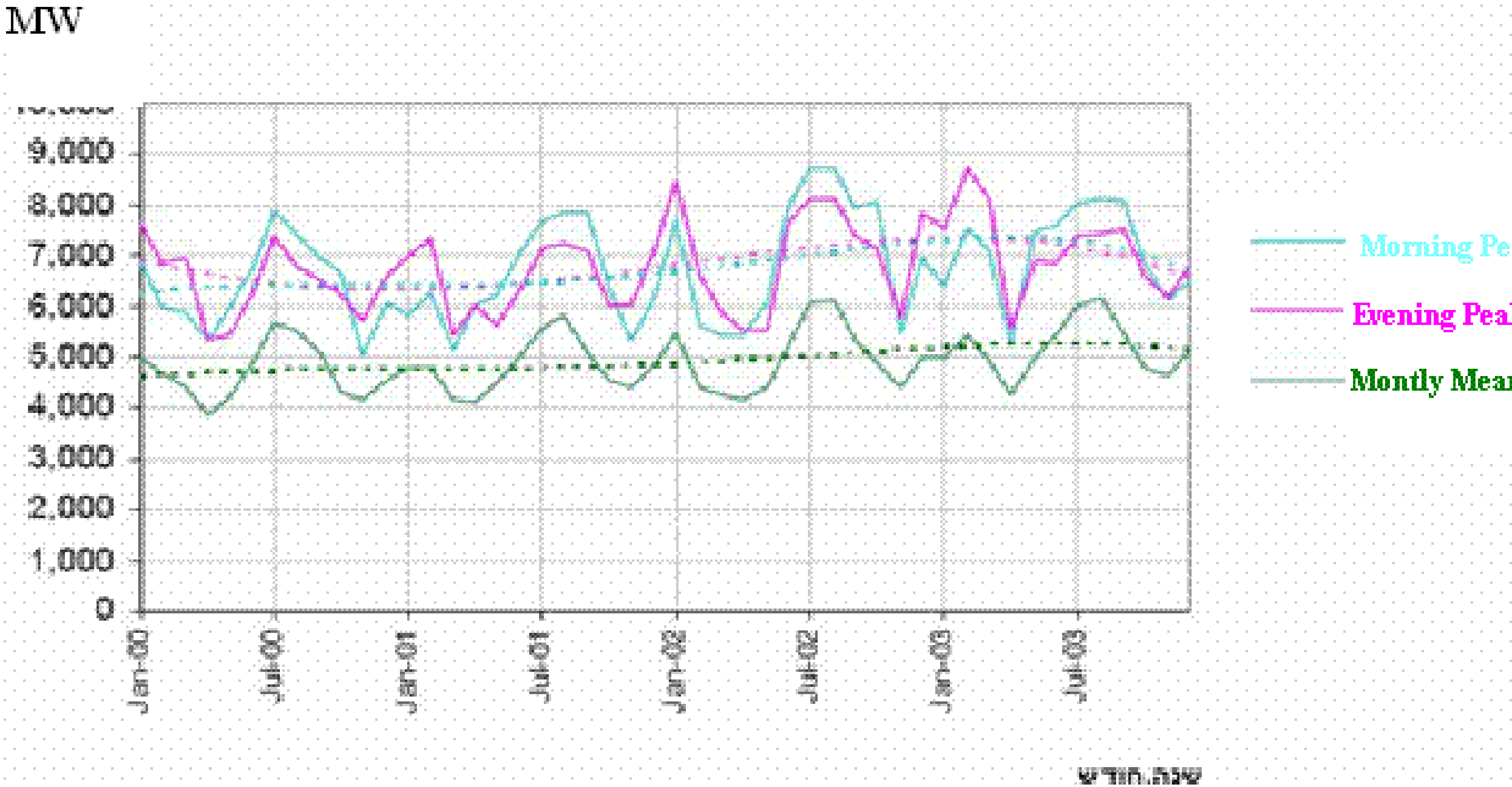
Climatic Zones in Israel

Climatic Zone	Winter (January)			Summer(August)		
	HDD	Max Av ºC	Min Av ºC	Max Av ºC	Min Av ºC	RH%, 14:00
Mediterranean Coast	800	17	8	30	20	60
Mountain Area	1200	12	6	28	20	40
Negev Desert	1000	17	5	33	19	35
Eilat and Jordan-Arava Valey	300	21	9	40	25	20

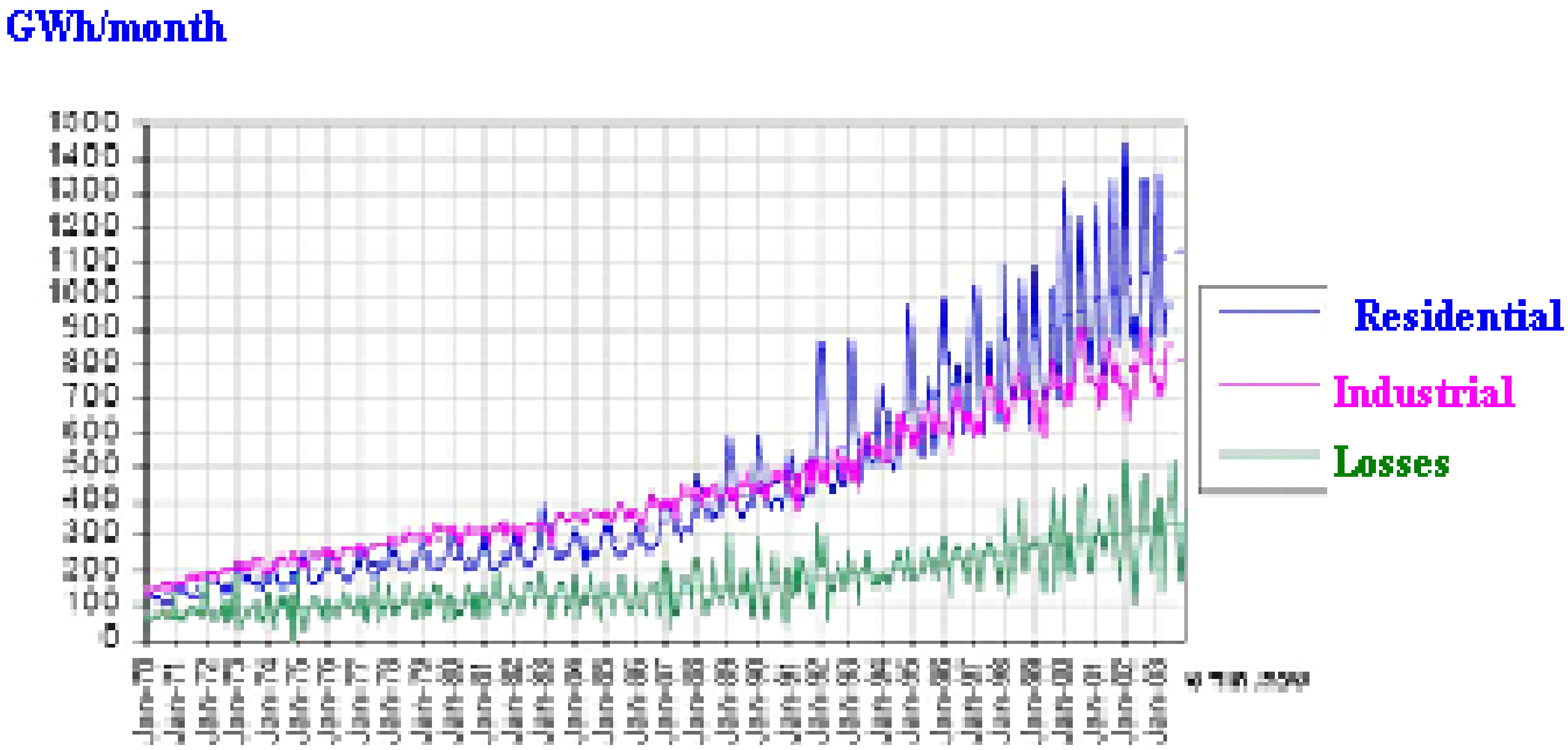
ENERGY SECTOR OF ISRAELI ECONOMY

- **2006 : Primary Energy 21.5 MTOE (3 TOE/person)**
  - **End USE 13.5 MTOE (1.9 TOE/person)**
- **Present : 40 % Coal – 40% Oil – 20 % Nat. Gas (incr)**
- **Electricity : Approx. 50 % of Energy (70% Coal, 10% Oil, 20 % Nat. Gas)**
- **CO2: 70 MTOE/year – or 0.6kg/95US$ (45% Coal)**
- **Change during the last year because of introduction of Natural Gas**
- **All the energy is imported**

Maximum Electrical Demand

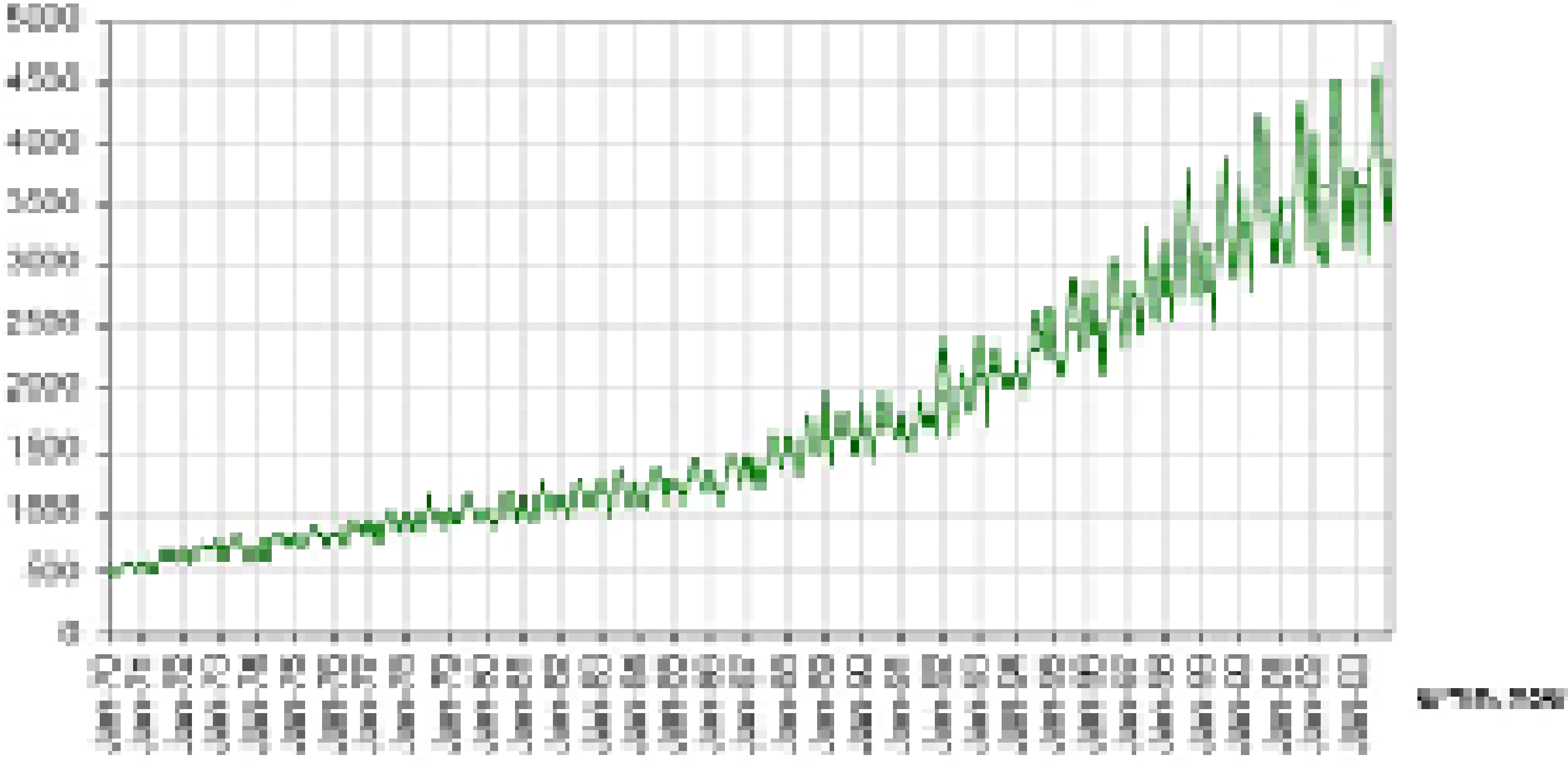


Monthly Electricity Consumption acc. to Tarif



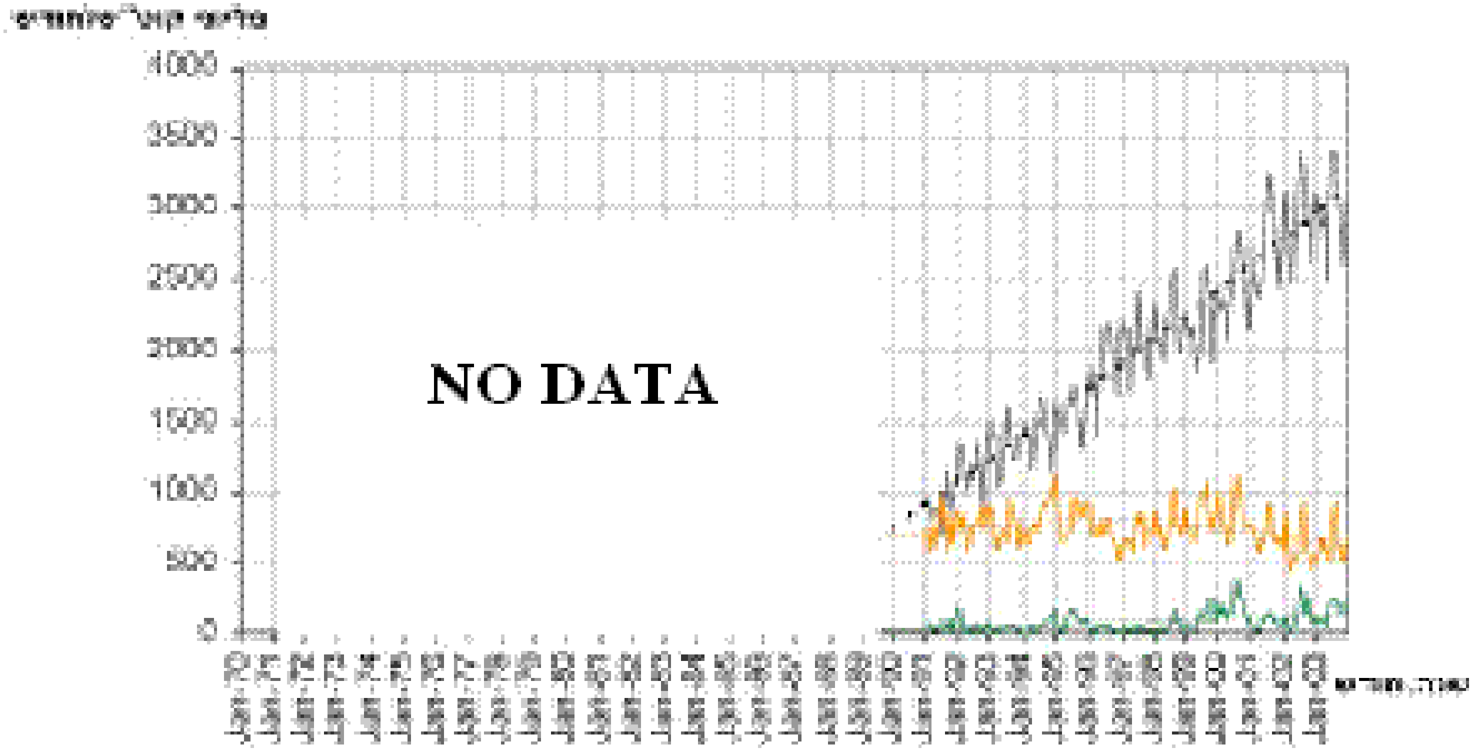
Total Electrical Production Per Month

GWh

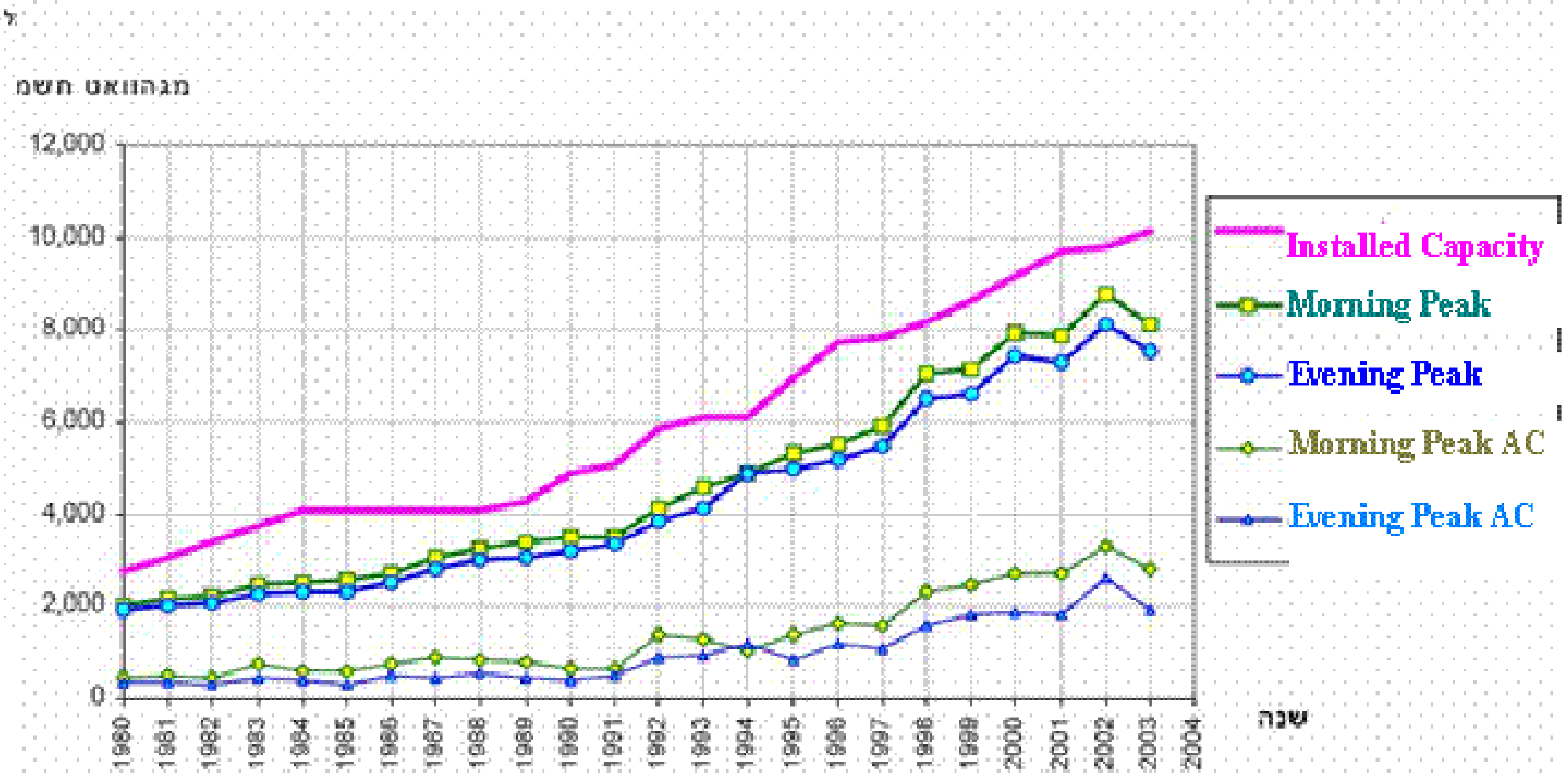


Electr. Production by fuel (Coal, Mazut, Fuel) GWh/month

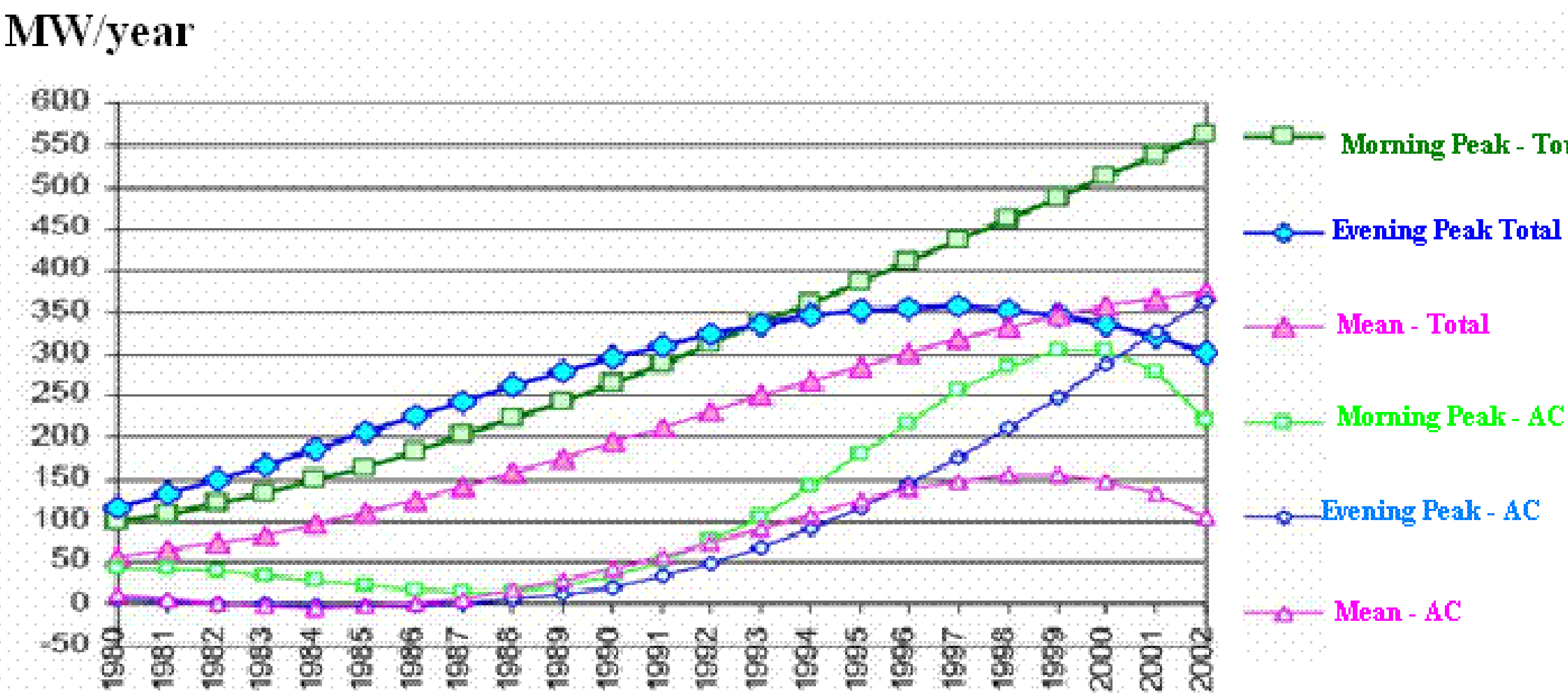
Note: During Last Year 20% Natural Gass (and increasing)



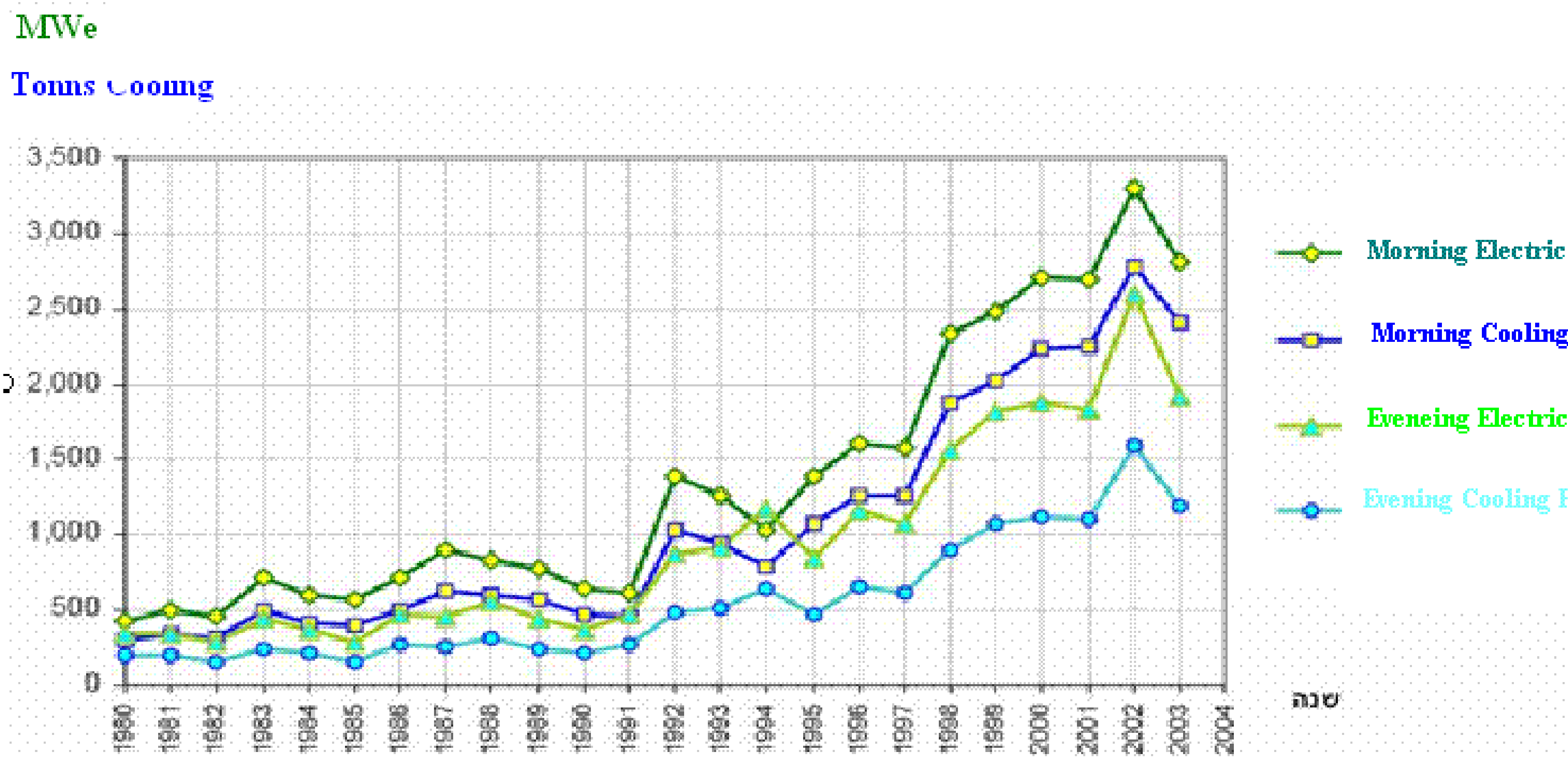
Nominal & Max. Power Demands – incl for AC (MWe)



Annual Increase in Peak Electrical Demand - Total and AC (MW/year)



Maximum Cooling Load (Tonns) and AC Electricity (MWe

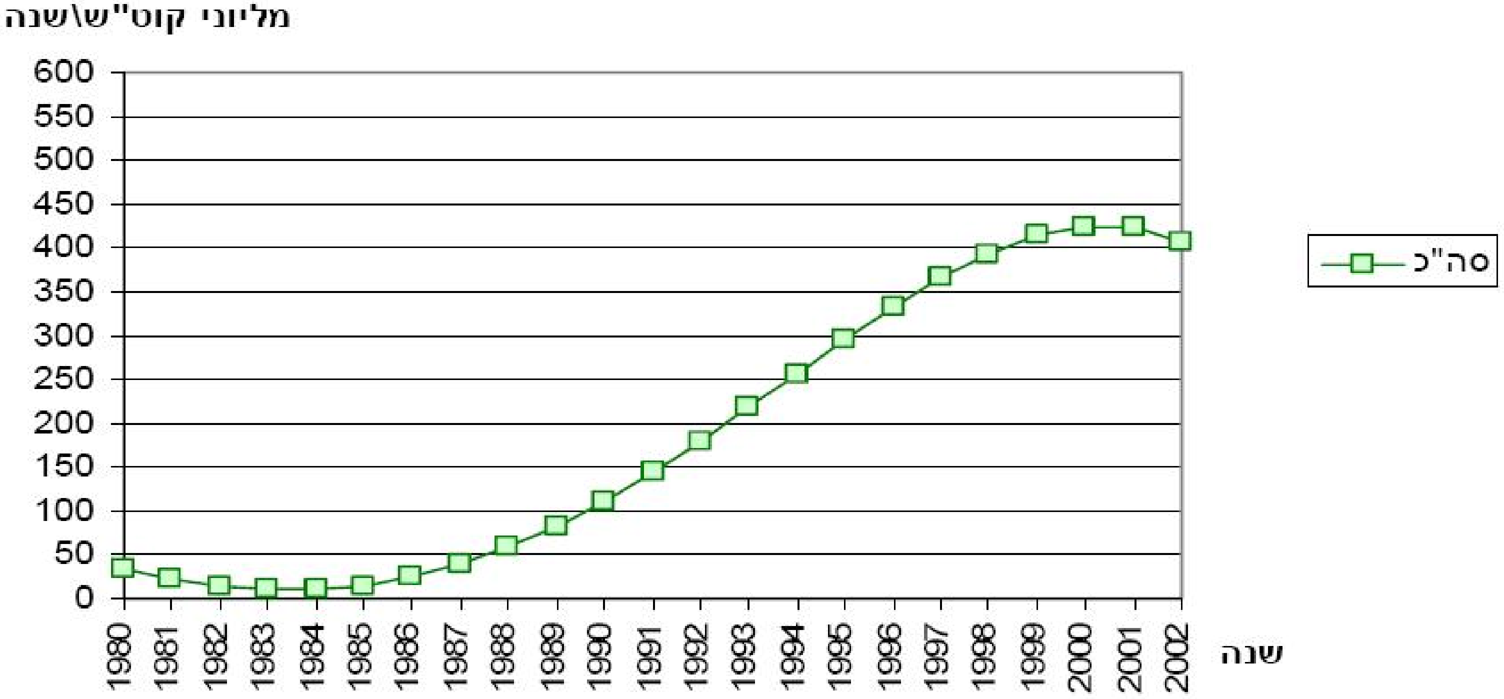


Annual Incr. in AC electrical demand, MWh/year

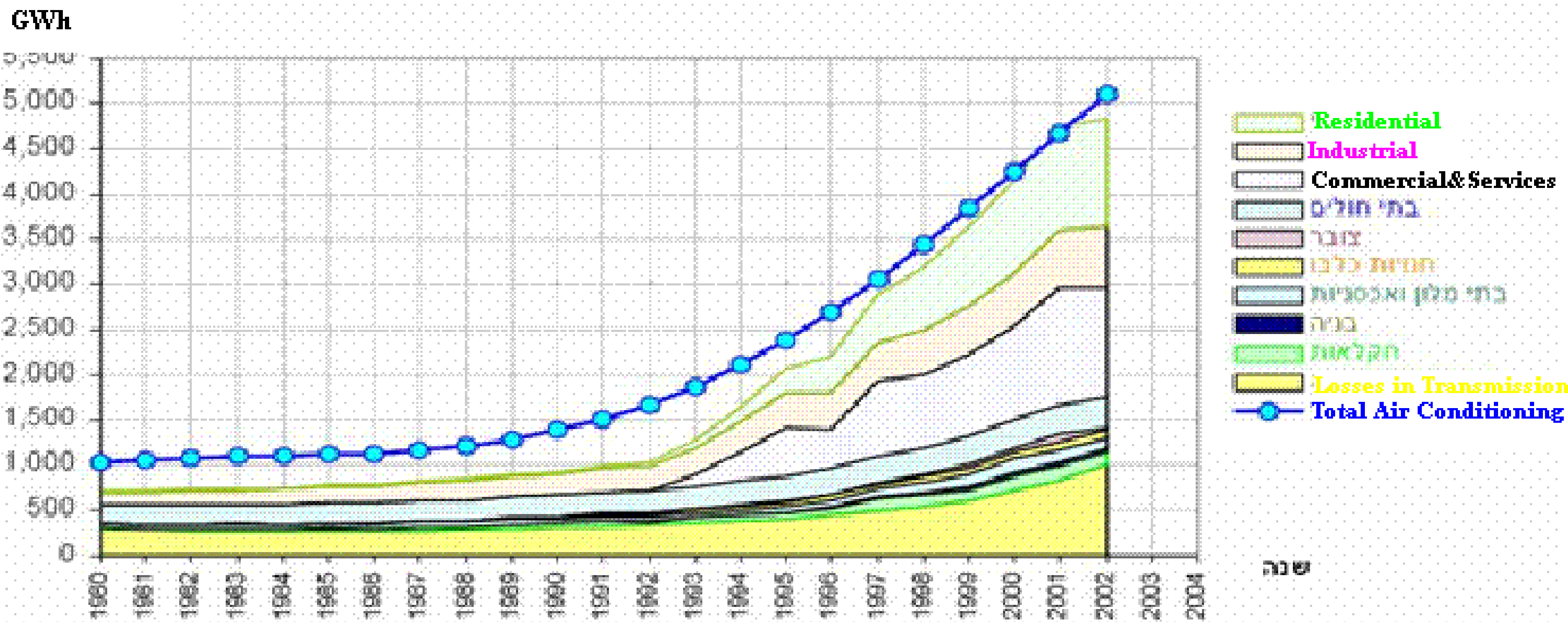
גידול שנתי בייצור אנרגיה חשמלית למיזוג אויר

(קווי מגמה בקירוב פולינומי)

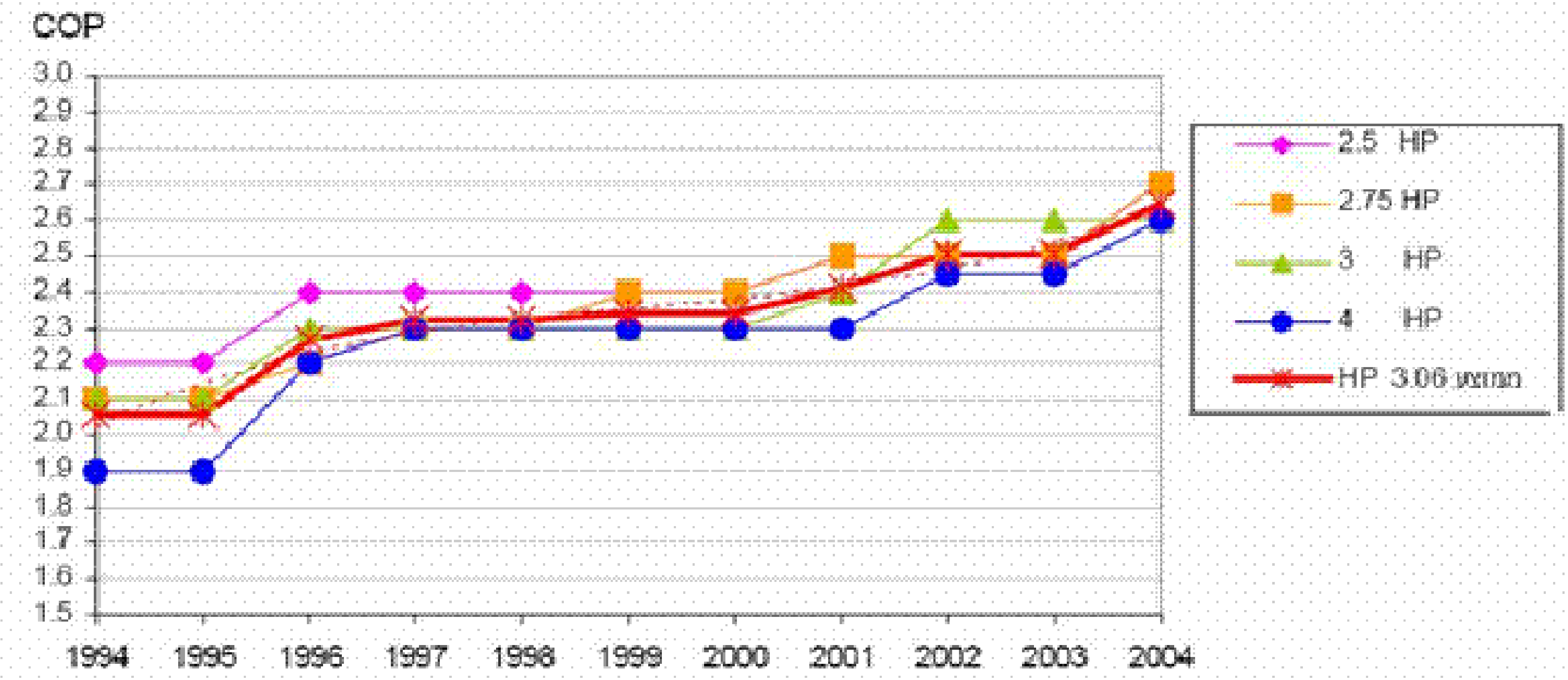
ייחוס בדו"ח: סעיף 2.2



AC Electric Energy by Use (GWh)

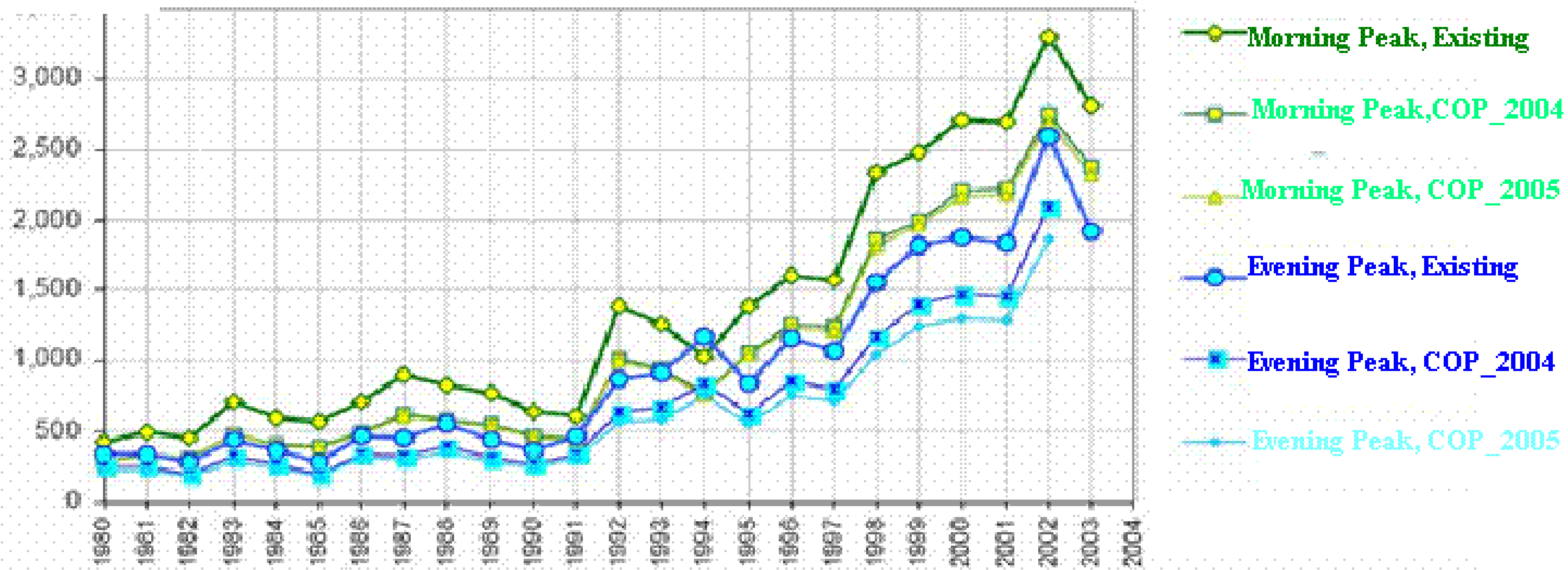


COP for different sized ACs



Peak AC Electrical Power for Different COP

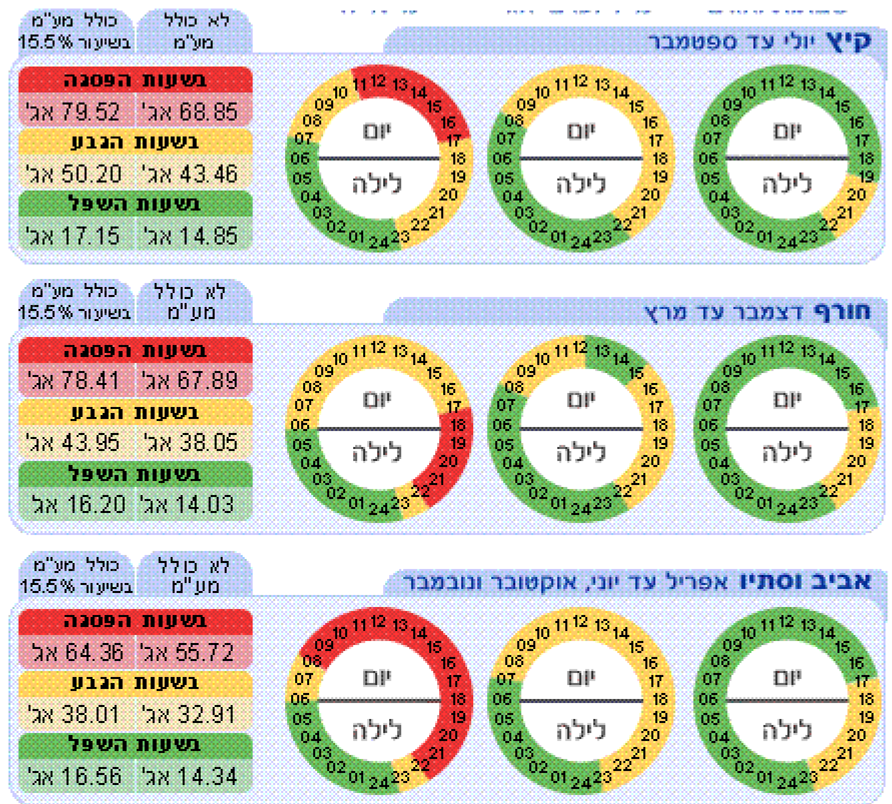
MWe



TAOZ TARIF (High Voltage)

RED:PEAK GREEN:OFF-PEAK YELLOW: REGULAR

	Sun-Thurs	Friday-Eve of Holiday	Saturday Holiday
SUMMER (Jul.-Sep.)			
WINTER(Dec-March)			
SPRING(Apr.-Jun), FALL(Oct.-Nov.)			



Promoting Ice storage

- **Israel considered a vanguard in the field of solar energy - mainly solar water heaters industry**
- **Israeli companies like Ormat and Solal have contributed to solar energy electricity generation**
- **Electric Company encourages sales of electricity by producers when based on alternative energy sources (wind, solar thermal and photo-voltaics)**
- **In Eilat, Arava and Negev regions, (low relative humidity), use of desert coolers based on evaporative cooling (inappropriate for the coastal area where majority of the population lives)**

- **Israel ratified the Climate Change Convention in September 1996 and the Kyoto Protocol in March 2004**
- **Classified as a developing country under the Convention, although CO_2 emissions comparable to developed countries**
- **Government decision calls for steps to limit/reduce greenhouse gas emissions on the basis of findings and conclusions of the Inter-Ministerial Committee on Climate Change.**

- **Legislative Frame Concerning Summer Cooling**
- **Insulation Standard for Buildings (IS 1045) first form was on residential buildings.**
- **The standard consists of two parts**
  - **minimum value of the resistance of the external elements**
  - **maximum value of the volume related building loss coefficient (G-Value) for dwelling unit**
- **Beginning of the 90ies - was extended to low-mass buildings with much more stringent requirements.**
- **Extended to school buildings, office buildings, commercial buildings, hotels and hospitals.**
- **Thermal energy performance during the summer considerations main focus for those buildings, expressed through requirements glazings, thermal resistance and radiative properties**

.

- **Green Building Standard (IS 5281), awarding Green Certificate to Buildings that are particularly environment friendly. Based :**
- **30 % on the energy performance (evaluated according to IS 5282 – Energy Use in Buildings)**
- **Land use maximization**
- **Water resources conservation**
- **Indoor air quality**
- **Site management during construction**
- **Reuse of waste from demolished buildings**
- **Other environmental considerations**
- **Certain latitude given to the assessor**

- **Buildings classified as Ordinary, Green Buildings or Outstandingly Green Buildings**
- **Green Council has been formed – issues the certificates of compliance to the Green Buildings Standards**
- **Ministry of National Infrastructures prepares a future Energy Code to assess the energy performance of buildings – both summer and winter. To replace of the simplified procedure of IS 5282.**

- **Several other standards include**
- **Window certification**
- **Calculation or measurement the U-Value of building masonry blocks (common building element in Israel)**
- **Air Conditioning Units (Energy Efficiency, Energy Ratings and Energy Labels).**

- **Administrative measures: requirement that new public buildings should comply with the green standard**

- **Ice Storage – to promote shifting to Off-Peak Hours**
- **Solar Absorption Systems (Tel-Hashomer Hospital) and Dessicant Systems (Technion)**
- **Low Energy Cooling Technological Models in Sde-Boker Campus:**
  - **Administration building combining underground and earth-integrated construction and glazed patio for heating and a downdraft evaporative cooling tower**
  - **Solar Neighbourhood with several passive solar features**
  - **window system with radiation properties varying with season**
- **Solar Kibbutz and a Solar Beduin village have inaugurated during the last year**

CONCLUSIONS

- Negative (but Unavoidable) : Increasing AC
- Positive
  – Introduction of Natural Gas
  - Green Building Getting Momentum
  - Various technological developments
  - Various Administrative Measures

Summer requirements in the energy performance regulations in The Netherlands

Barcelona , March 31- April 1, 2009

TNO

Wouter Borsboom
On behalf of Dick van Dijk

Email: Dick.vanDijk@tno.nl

Problems:

Overheating: High temperatures in the summer due to lot of glass

High energy use: Due to large single glass surfaces and poor insulation

Content

- History of EP regulations
- Expected near future change
- Summer requirements in EP regulations
- Calculation method

History of EP regulations

- **In The Netherlands:**
- **Overall energy performance regulations since 1995**
- **Calculation methods: national Dutch standards (NEN)**
- **Only for new buildings: to check against minimum EP requirements**
- **Similar methods derived in later years for existing buildings**

History of EP regulations

- Building types:
  - Residential NEN 5128
  - Non-residential NEN 2916
- Energy aspects:
  - Heating, **cooling**, ventilation and hot water (incl. system losses and renewables) and lighting

History of EP regulations

- Revisions each few years
  - Based on feed back, new developments
  - And due to tightened minimum levels each few years
- Consequence:
  - Increased number of techniques appreciated in the method
  - ➔ several new techniques penetrated in the market
  - But method remained basically the same

Expected near future changes

- **New national calculation procedures (NEN 7120) in preparation (draft: early 2009):**
  - Integrate method for residential and non-residential buildings
  - And for new and existing buildings
- **Major change on cooling/summer comfort:**
  - Introduction of **fictitious cooling**
  - Is already in use since several years for residential buildings
  - Now also for non-residential buildings

Expected near future changes

- **Until now, for non-residential buildings (NEN 2916):**
  - Calculation of energy use for cooling only if cooling system present
  - But: minimum requirements are the same for cooled and not-cooled buildings! ➔ Difficult to meet the minimum requirements in case of cooled building ➔ Attenuation factor introduced on the minimum requirements for buildings with mechanical cooling
  - Result: buildings with mechanical cooling are punished, but only a little

Legal boundary conditions

- **In Dutch building regulations: no requirements on thermal comfort → Not possible to set minimum requirements on summer comfort in the EP calculations**
  - → Buildings can still be designed with bad summer comfort
  - Use of mechanical cooling is discouraged but not severely

fictitious cooling approach (1)

- **Also in case of no mechanical cooling (in design stage):**
  - Energy need for cooling has to be calculated
  - A fictitious default cooling system is assumed, with low efficiency
  - The resulting cooling energy is part of the overall energy performance

fictitious cooling approach (2)

Pro:

- **This will punish design with bad summer comfort**
- **And** if **mechanical cooling is installed later on (due to bad summer comfort): it has already been taken into account**
- **The amount of calculated energy for cooling gives a rough indication for overheating risk (but: too rough?! Because the calculation is not done at individual room level….)**

Desired cooling approach (2)

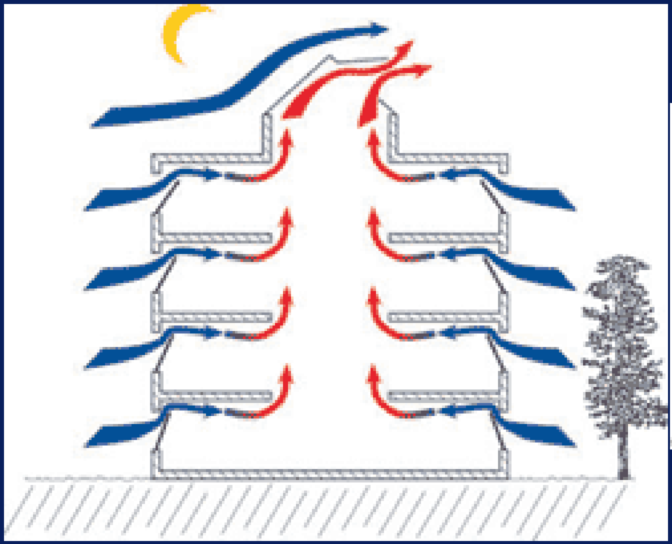
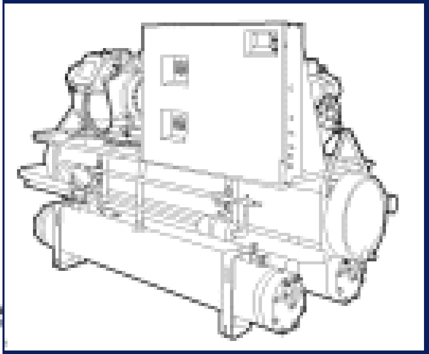
Con:

- **The designer may trade off by extra energy saving measures on heating and/or hot water and accept bad summer comfort…**
- **Because:**
  - The contribution of ‘bad summer comfort’ to the overall EP may be as low as a few percent (for an average winter…)
  - While thermal discomfort, if no measures are taken, may be large
- **Passive cooling options will not be taken into consideration because of a focus into mechanical ventilation**
  - Even for residential buildings..

Calculation method residential and non-residential buildings (NEN)

- **Monthly method to calculate the energy need for cooling**
  - Similar as for heating: monthly heat balance, with ‘utilization factor’
  - Already developed in 1995 (Eric van den Ham, CDC)
  - Now part of EN ISO13790:2008 “Calculation of energy use for heating and cooling”
    - Adopted by many Member States
- **Factors taken into account:**
  - Window solar gains, solar shading devices
  - System efficiencies (variety of HVAC system types)
  - Extra ventilation (passive cooling)
  - Energy annihilation due to combined heating and cooling
  - …

Our TNO building, Delft, Netherlands combine comfort and energy savings

- **Thanks for your attention**

EuroACE

The European Alliance of Companies for Energy Efficiency in Buildings

Note by Manuel F. Geremías

URSA Insulation S.A.

Objectives

Given that

- Technical information, standards and country status will be or have been presented...

... the objective of this note is to present EuroACE as way of representing a holistic approach to energy efficiency in buildings

What is EuroACE?

- Founded in **1998** by 20 of Europe's leading **companies** involved with the manufacture, distribution and installation of **energy saving goods and services**.

- In response to European Council of Ministers of proposals to **combat the threat of climate change** which completely ignored any potential for **reducing energy consumption in buildings**. Even though Europe's 160 million buildings are responsible for well over 40% of greenhouse gas emissions.

- **EuroACE works together with the European institutions** to help Europe achieve greater sustainable energy use in buildings and significant reductions in carbon dioxide emissions.

EuroACE

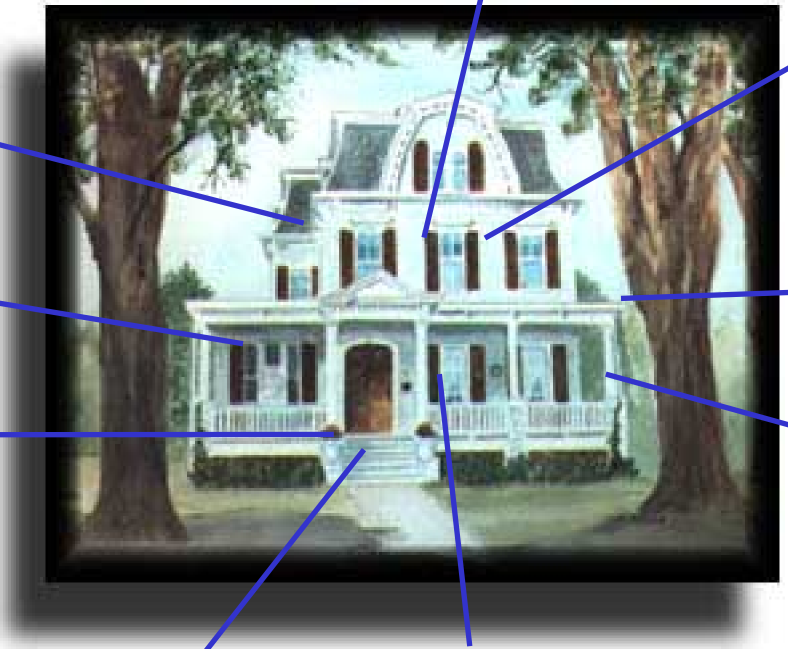
Who are Euroace Members?

- Acciona
- Aereco
- Armacell International
- BING
- CRH
- Danfoss
- Honeywell
- Hunter Douglas
- Huntsman Polyurethanes
- TREMCO illbruck
- Kingspan Insulated Panels
- Knauf Insulation
- Paroc
- Philips Lighting
- Pilkington
- Rockwool International
- Saint-Gobain Isover
- Skanska
- Somfy
- United Technologies
- URSA Insulation
- VELUX A/S

All sectors related to energy efficiency in buildings are represented within EuroACE

EuroACE

Cross-sector representation



EuroACE

What Euroace's contribution?

- Total turnover of EuroACE member companies:

  →140 billion euros

- Total employment of EuroACE member companies:

  →328,000 people

THE TIP OF THE JOBS ICEBERG!

EuroACE

Energy efficiency strategies in summer comfort and cooling

- Recent studies predict a dramatic increase of cooling energy demand in Europe (not only in the South), despite the available knowledge and technologies

- In several countries energy consumption for cooling in the summer is higher than consumption for heating in winter times

EuroACE

The challenge

A**ir-conditioning** is the most important reason for increasing **energy consumption** in non-residential buildings.

- In **North-West European** climate, electricity consumption due to **cooling** - and the accompanying installations such as humidification, ventilation systems, etc. - increases the electricity consumption in offices about 40 kWh electricity per m². This corresponds to 100kWh per m² (+ 32%) additional primary energy consumption.
- **In Southern-European countries**, the energy consumption generated by air-conditioning is even **higher**.

Two aspects of the approach:

- The building envelope
- The active cooling (and heating) system of a building

The Envelope

- Heating, **cooling** and lighting systems have major impacts on the **energy consumption** in non-residential buildings.

- The **envelope system** strongly affects the energy demand of active systems, since it regulates heating and cooling loads and daylight availability.

- With **renovation and refurbishment** of the building envelope major energy savings can be achieved

- In some cases high-performing envelope systems can completely avoid the use of active systems. Depending on existing performance of the envelope in non-residential buildings, energy savings up to 50% may be achieved by means of an overall retrofit action.

The best way of **reducing energy** for air-conditioning is the choice for **passive techniques** such as solar protection and high thermal mass.

EuroACE

The active systems

How to **reduce energy consumption for cooling?**

- Use the most efficient systems
- Install programmable thermostats
- Maintain HVAC systems regularly
- Seal and insulate ducts
- Use shading systems

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info@euroace.org

EuroACE

Acciona

- Spanish company
- ACCIONA develops and manages energies, infrastructures and services
- Created in 1997 as a result of the merger between Entrecanales & Tavora and Cubiertas & MZOV, ACCIONA
- Group revenues amounted to 7,953 billion euros in 2007

http://www.acciona.com/

Aereco

- Situated in France in Marne-la-Vallee, Aereco is present in Western and Eastern European countries, in China, Japan and in other Asian and American countries.
- Business field: ventilation components
- Aereco stands for "AERation ECOnomique" (economical ventilation)
- Founded in 1984

http://www.aereco.com/

Armacell International

- As global leader in engineered foams, Armacell provides insulation, specialty foam and rubber solutions for a wide range of industries.
- developed Armaflex®, the world's foremost trademark in flexible foam insulation
- 20 manufacturing facilities in 13 countries

armacell engineered foams THE MAKERS OF Armaflex®

BING

- Federation of rigid polyurethane foam associations
- 1981: foundation
- Brussels

CRH

- The international building materials group
- The Group was formed in 1970.
- Headquartered in Ireland, CRH operates in 35 countries, employing approximately 93,500 people, focusing on three closely related core businesses:
  - Primary materials
  - Value-added building products
  - Specialist building materials distribution

http://www.crh.ie/

Danfoss

- The Danfoss Group is a leader in development and production of mechanical and electronic products and controls.
  - Refrigeration, conditioning, heating, Industrial automation, water controls, solar energy etc.
- Family-owned, global company (privately held)
- Employees more than more than 23,000 globally
- Dates to 1933 >> Mads Clausen establishes the company, Dansk Køleautomatik- og Apparat-Fabrik

http://www.danfoss.com/

Honeywell

Honeywell

- Serving customers worldwide with
  - aerospace products and services
  - control technologies for buildings, homes and industry
  - automotive products
  - Turbochargers
  - specialty materials.

- With roots tracing back to 1885, Honeywell employs more than 128,000 people in 100 countries

- Located in US

http://www.honeywell.com/

Hunter Douglas

HunterDouglas

- Hunter Douglas is the world market leader in window coverings and a major manufacturer of architectural products
- Rotterdam / The Netherlands
- five geographic markets: Europe, North America, Latin America, Asia and Australia.

http://www.hunterdouglas.com/

Huntsman Polyurethanes

HUNTSMAN
Enriching lives through innovation

- Huntsman Polyurethanes is a global leader in providing MDI based polyurethanes solutions
- Huntsman is a global manufacturer and marketer of differentiated chemicals.
- Its operating companies manufacture products for
  - chemicals, plastics, automotive, aviation, textiles, footwear, paints and coatings, construction, technology, agriculture, health care, detergent, personal care, furniture, appliances and packaging.
- As of December 31, 2008, Huntsman had approximately 12,600 employees and operates from multiple locations worldwide.
- The Company had 2008 revenues of approximately $10 billion.

http://www.huntsman.com/pu/

TREMCO illbruck

- Business fields:
  - Sealants, glazing, waterproofing, roofing, flooring and passive fire protection markets
  - throughout Europe, Africa and the Middle East.
- created from the merger of Tremco's European Sealant/Weatherproofing Division with illbruck Sealant Systems in September 2005.
- Tremco illbruck is part of Tremco Inc., an RPM company. It employs more than 1.000 people in 17 countries.

http://www.tremco-illbruck.com/

Kingspan Insulated Panels

- Kingspan Insulated Panels, part of the Kingspan Group Plc,
  - high quality Insulated Roof, Wall and Façade Systems for the construction industry.
- Ireland
- Group businesses
  - Insulated Roof Wall and Facade Panel Systems, Controlled Environments. Insulations Boards for Roofs Wall and Floor, Architectural Facade System, Timber Frame Systems Structural Insulated Panel Systems (SIPs), Steel Frame Systems, Structural System, Access Floor Systems, Solar Thermal Systems Solar Photovoltaics, Environmental Solutions

http://www.kingspanpanels.com/

Knauf Insulation

- Meeting insulation needs for new and existing buildings, industrial applications (power and chemical plants, refineries and HVAC) as well as OEM products for other specific applications

- Knauf Insulation has around 5000 employees active in more than 50 countries around the world with 30 manufacturing sites for the production of glass wool, stone wool, wood wool, extruded polystyrene (XPS) and expanded polystyrene (EPS).

http://www.knaufinsulation.com

Paroc

- Headquarters - Findland
- The PAROC® product range includes building insulation, technical insulation, marine insulation, structural stone wool sandwich panels and acoustics products.
- The company operates in 13 countries across Europe, with production facilities in Finland, Sweden, Lithuania and Poland.
- Paroc Group is owned by Arcapita Bank B.S.C.(c) and its co-investors, with a minority shareholding owned by Paroc's employees.
- Net sales in 2007 amounted to EUR 462 million and personnel in average 2 282 persons.

http://www.paroc.com/channels/com/

Philips Lighting

PHILIPS
sense and simplicity

- Royal Philips Electronics of the Netherlands is a diversified Health and Well-being company
- As a world leader in healthcare, lifestyle and lighting, Philips integrates technologies and design into people-centric solutions

www.lighting.philips.com

Pilkington

- Founded in 1826 and a member of NSG group from June 2006, Pilkington is a leader in the global Flat Glass industry
- NSG Group reported sales of Euros €5.4 billion (fiscal year ended 31 March 2008).
- Worldwide, the NSG Group operates or has interest in, 51 float plants.
- Widened Automotive customer base
- 32,500 employees worldwide (fiscal year ended 31 March 2008).
- Manufacturing operations in 29 countries on four continents.
- Sales in more than 130 countries.

http://www.pilkington.com

Rockwool International

- Insulation business: The Rockwool Group is the world's leading producer of stone wool
- Founded in 1909. At present, the Group employs more than 8,500 highly skilled persons. The Rockwool Group operates 23 factories in three continents
- Net sales in DKK million in 2008: 13,700
- Group headquarters and the R&D and environmental departments are based in Hedehusene, near Copenhagen.

Saint-Gobain Isover

- Saint-Gobain Isover is the INSULATION activity of the “Construction Products” division of the Saint-Gobain group, a manufacturer, processor and distributor of materials (glass, ceramics, plastics, cast iron, etc)
- 11,000 employees worldwide
- Net sales 2008: € 2.7 billion (75% mineral wool, 15% polystyrene, 10% miscellaneous)
- 62 industrial and 3 R&D sites

http://www.isover.com/

Skanska

SKANSKA

- Skanska is one of the world's leading construction groups with expertise in construction, development of commercial and residential projects and public-private partnerships
- Founded in 1887. First international operations already in 1897.
- Today, 60,000 employees are active in selected home markets in Europe, the US and Latin America.
- Skanska is headquartered in Stockholm, Sweden and listed on the OMX Nordic Exchange Stockholm
- Revenue >> SEK 139 billion

http://www.skanska.com/

Somfy

- Automatic control of openings and closures in homes and buildings
- The Group is present in 53 countries, 8 production sites
- Sales in € million FY 2008 : 749,4

United Technologies

- United Technologies Corporation (UTC) is a diversified company whose products include
  - Carrier heating and air conditioning
  - Hamilton Sundstrand aerospace systems and industrial products
  - Otis elevators and escalators
  - Pratt & Whitney aircraft engines
  - Sikorsky helicopters
  - UTC Fire & Security systems
  - UTC Power fuel cells.

- 17th largest U.S. manufacturer (2008 list, Industry Week) / 223,100 employees (2008) / $58.7 billion (2008) revenues

http://www.utc.com

URSA Insulation

- URSA is Europe’s third biggest manufacturer of insulation materials and, in terms of sales, the largest business unit of Uralita, a foremost and tradition-steeped European construction industry player.

- With 16 production sites and a closely-knit distribution network, URSA is present throughout the countries of Europe as well as Russia where the company commands a leading position in the two core product segments of glass wool and extruded polystyrene (XPS). In 2007, URSA’s more than 2,000-strong workforce generated sales in excess of € 540 million.

- As a leading supplier of insulation and various insulating systems, URSA has succeeded to fully address user requirements relating to thermal and acoustic insulation. Quality products for every application and top-caliber customer support constitute the cornerstones of the corporate culture.

http://www.ursa-online.com

VELUX A/S

- Denmark – Copenhagen
- Roof windows
- VELUX >> manufacturing companies in 11 countries and sales companies in 40 countries
- about 10,000 employees
- The VELUX Group is owned by VKR Holding A/S.
- VELUX Group's financial results are incorporated into VKR Holding's consolidated accounts. In 2008, VKR Holding's turnover amounted to Euro 2.3 billion

http://www.velux.com/


The Cool Roofs Project
Mat Santamouris

We face an important change of the climate.

Ambient temperatures increase.

Heat waves are more frequent.

Hot spells have a longer duration.

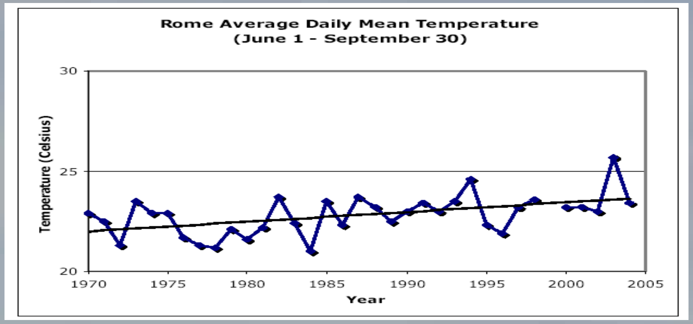
Poor design and uncontrolled development of urban areas increase the heat island intensity.

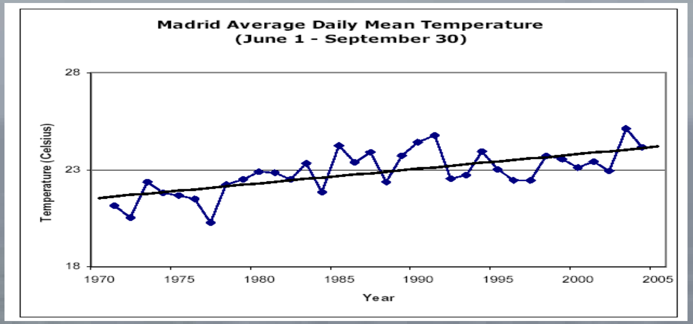
Human beings are more vulnerable and have to respond.

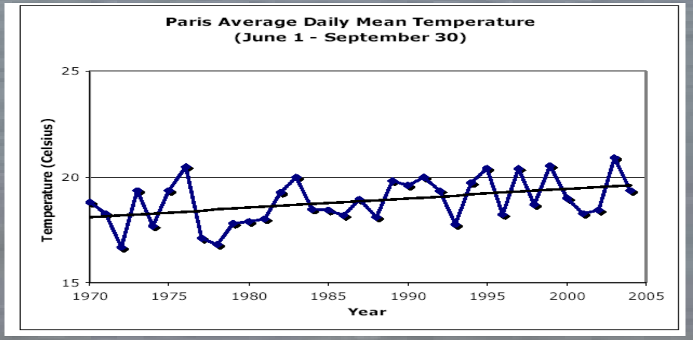
The Proof

Many climatological studies have shown an important increase of the average mean daily ambient temperature in most southern European cities, like Paris, Madrid, Rome and Lisbon.

Temperature increase is between 2-3 Degrees. Also, an important increase of the cooling degree days has been recorded.



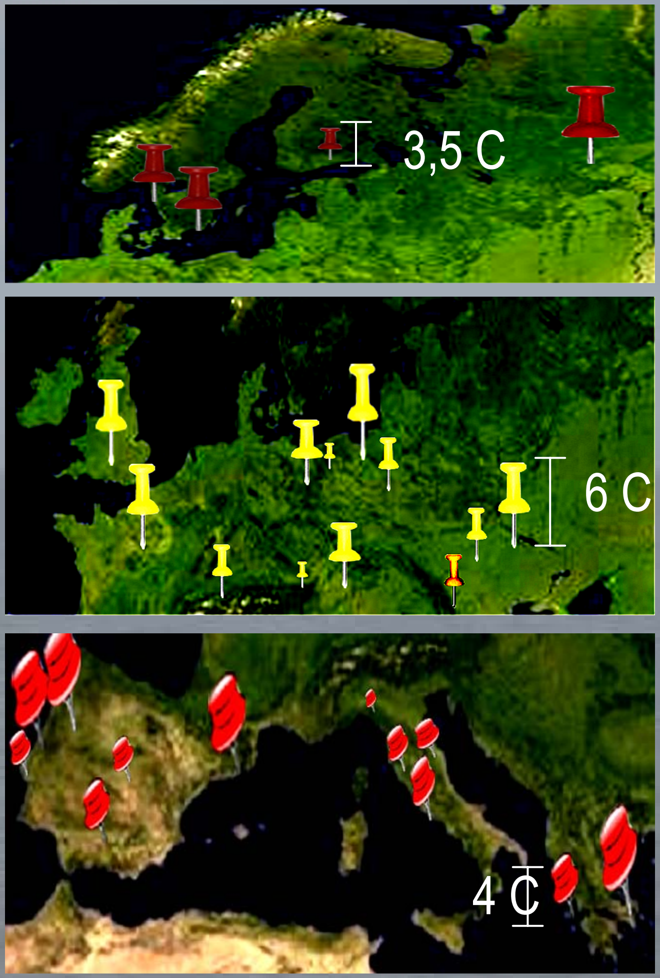


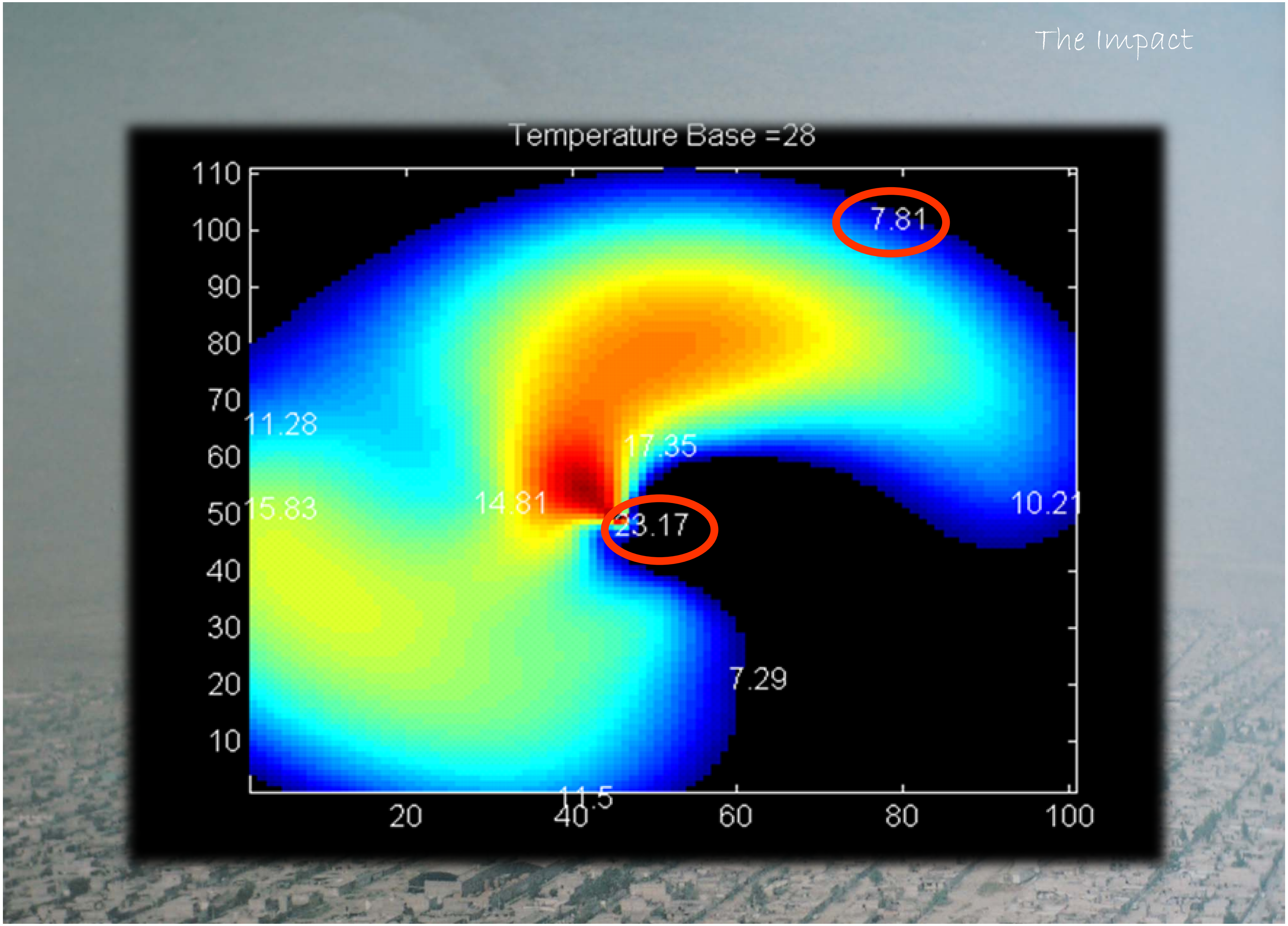


Heat Waves in Europe are more frequent. High temperatures increase the vulnerability of citizens and in particular of low income people. Studies in Europe, have shown that the greatest excess in mortality was registered in those with low socioeconomic status leaving in buildings with improper heat protection and ventilation.

The Proof

Heat Island intensity ranges between 1-10 C.
Heat Island is present in low, mid and high latitude locations.
It is observed during the day and the night period.
Especially in the south , heat island is very important during the day period contributing to a high increase of discomfort hours, increase of the cooling load of buildings and a very high increase of the peak electricity demand.

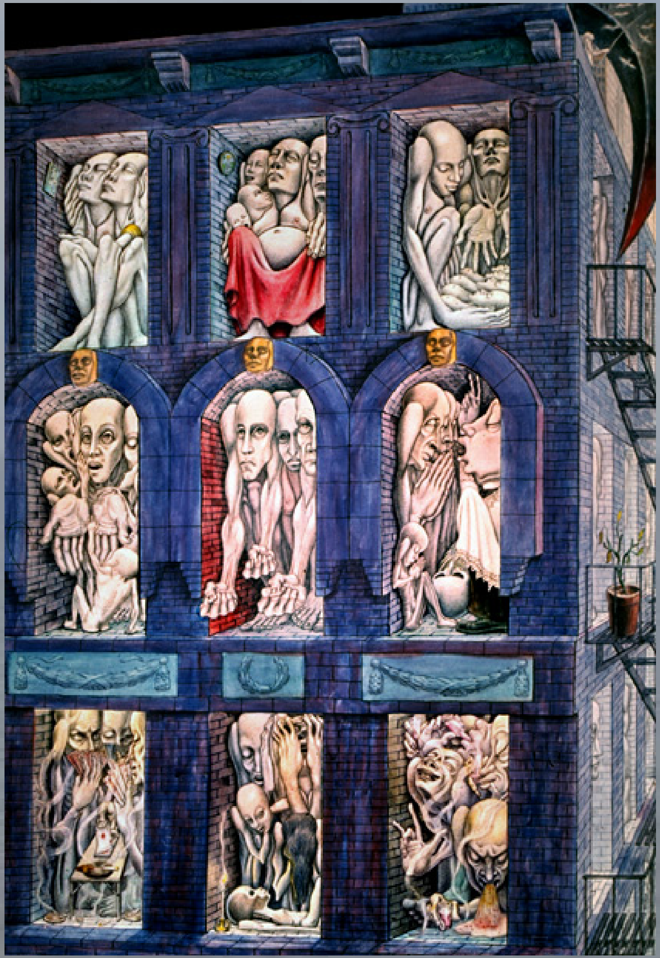




The Impact
Temperature Base =28
110
100
90
80
70
60
50
40
30
20
10
20
40
60
80
100
7.81
11.28
17.35
15.83
14.81
23.17
10.21
7.29
11.5

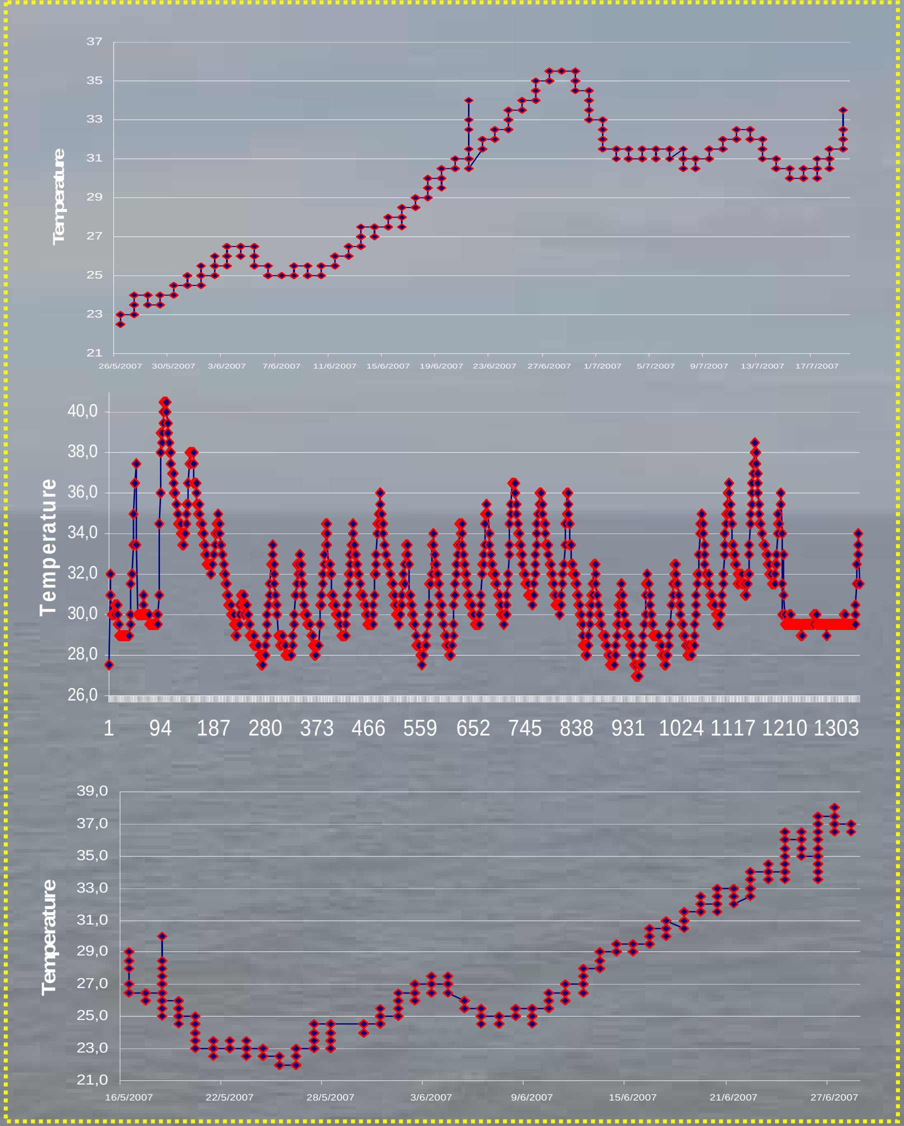
Low income population in both the developed and under development world is living in non appropriate shelters and is vulnerable to high ambient temperatures and extreme heat phenomena.

According to the United Nations more than one billion of urban citizens, live in non appropriate houses while in most cities of less developed countries, about one to two thirds of the population live in poor quality and overcrowded housing, without electricity and energy networks and are under the risk of environmental phenomena



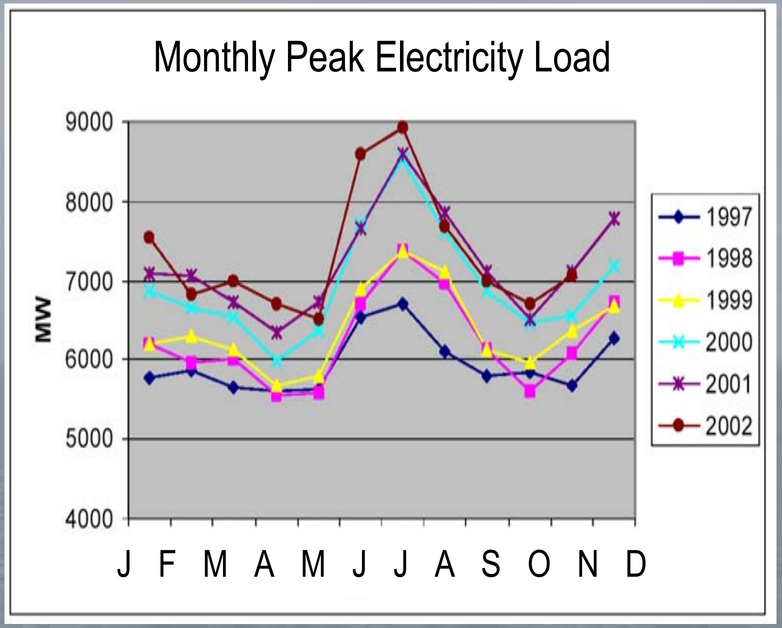
The Impact

Measurements of indoor temperatures in almost 60 low income houses without air conditioning, insulation and double glazing, have been performed in Athens, during the whole summer of 2007. For almost 50 % of the measurement period, indoor temperatures where higher than 34 C, presenting maximum close to 40 C. Hot spells of more than 38 hours above 30 C have been recorded.

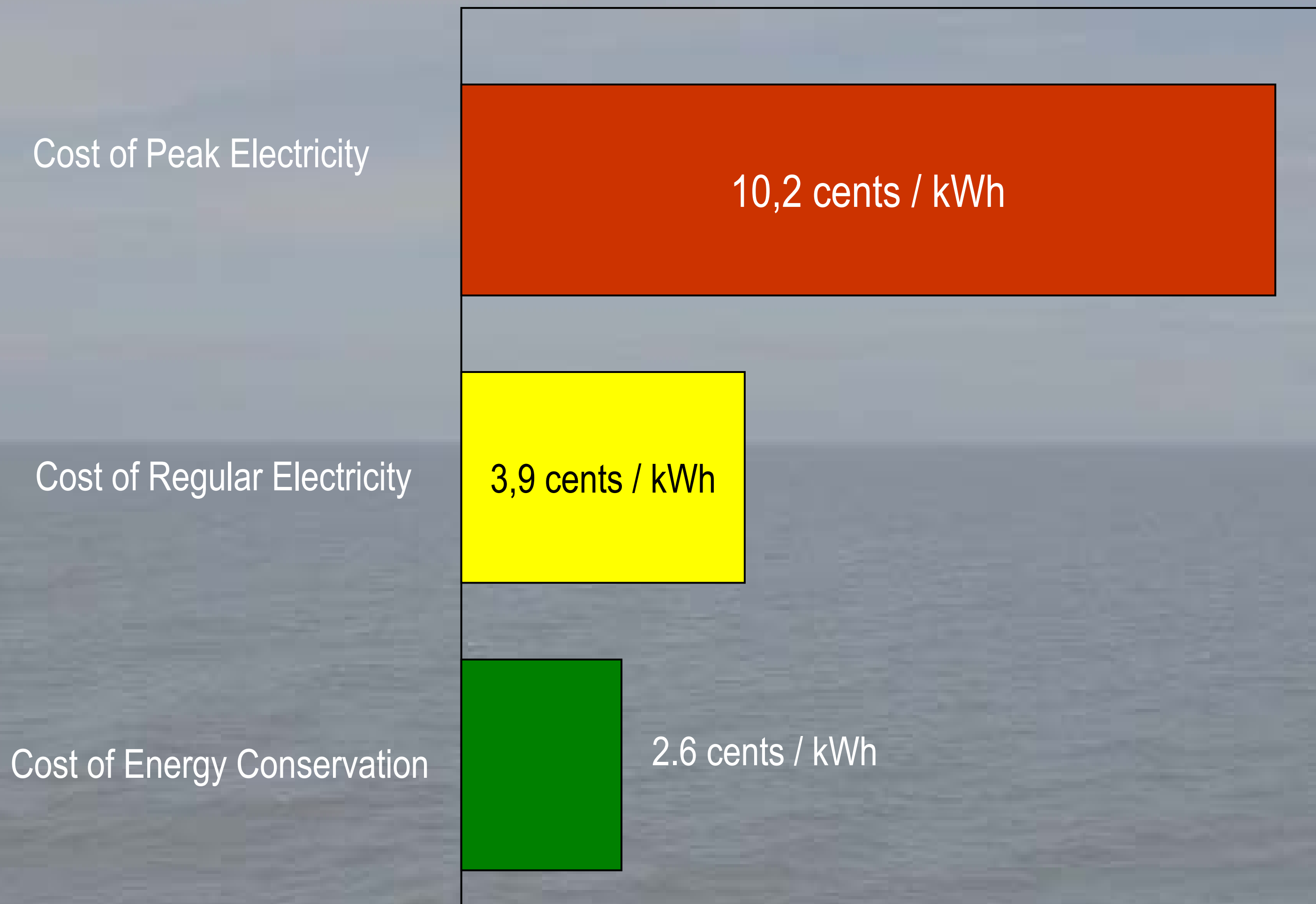


The use of air conditioning increases the peak electricity demand in most of the Southern European countries. In parallel, this is the main reason of blackouts and electricity shortages.

Such a huge increase of the peak electricity demand oblige utilities to built additional power plants operating under a low utilisability factor, and thus, increase the cost of electricity



The Impact


Cost of Peak Electricity
10,2 cents / kWh
Cost of Regular Electricity
3,9 cents / kWh
Cost of Energy Conservation
2.6 cents / kWh

The Impact

Huge Increase of CO2 because of A/C

Unit: tonnes CO2	1990	1996	2010	2020
Austria	157	1 603	15 748	31 467
France	26 860	87 377	285 231	468 957
Germany	7 845	25 615	139 241	265 983
Greece	99 235	959 939	2 387 187	3 737 087
Italy	182 591	2 247 038	2 923 568	3 623 486
Portugal	147 358	358 099	1 038 841	1 519 546
Spain	n.a. (around 90 000)	1 124 255	4 381 826	7 130 489
UK	47 710	219 640	704 204	1 165 583
Other E.U	4 694	15 369	83 545	159 590
Total E.U	516 451 (606 451)	5 038 935	11 959 391	18 102 187

Addressing successful solutions to reduce energy and environmental effects of air conditioning is a strong requirement for the future.

Possible solutions include:

1. Improvement of the urban microclimate to fight the effect of heat island and temperature rise and the corresponding increase of the cooling demand in buildings
2. Use of appropriate technology to improve indoor comfort conditions and reduce cooling needs

Techniques to Improve the Urban Microclimate and Heat Island Mitigation strategies concentrate on :

- the increased use of green areas,

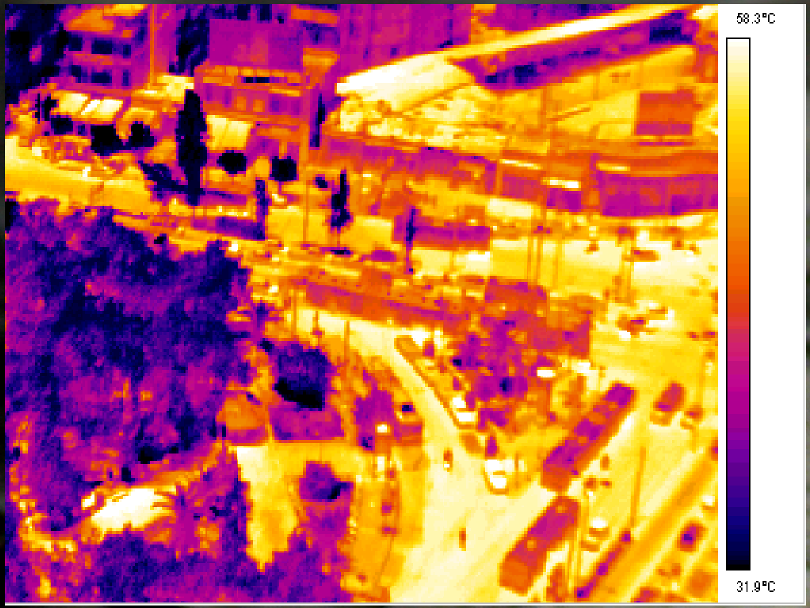
-the use of appropriate materials, in particular of white and colored high reflective coatings,

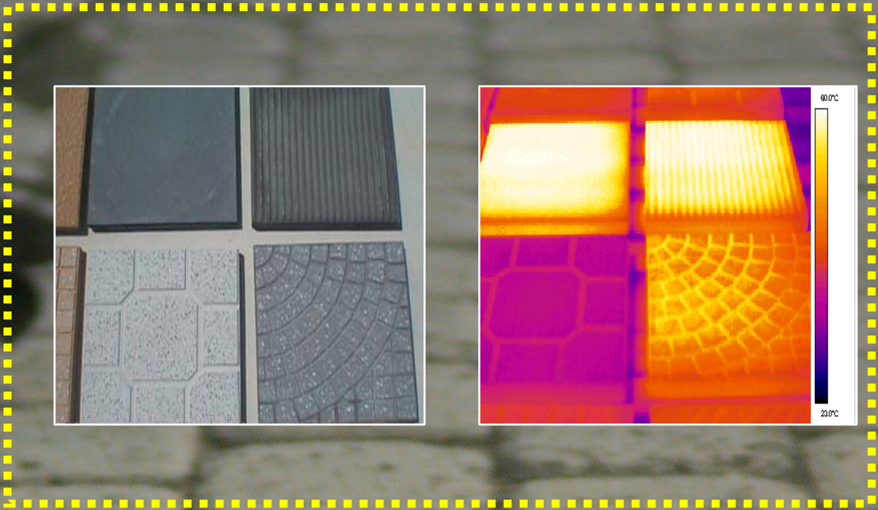
- decrease of anthropogenic heat

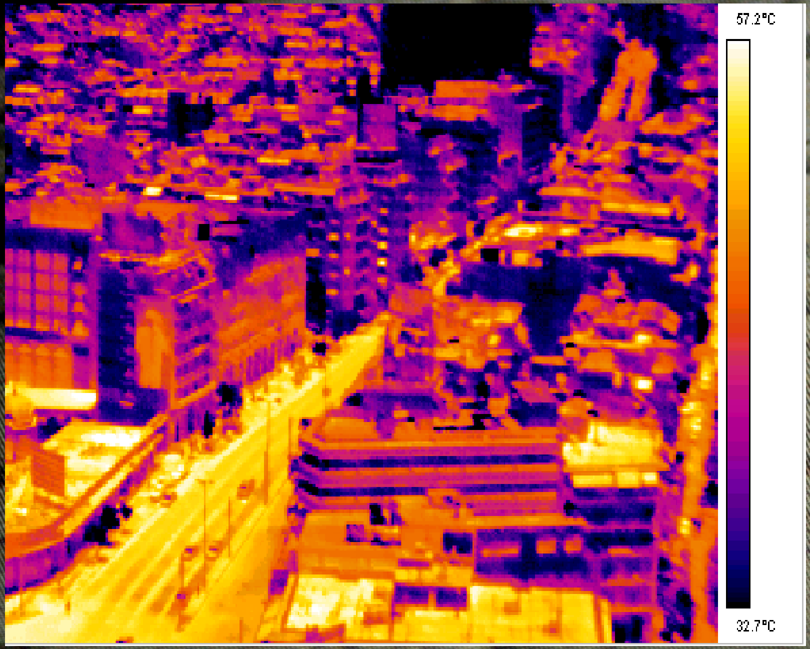
- use of cool sinks for heat dissipation,

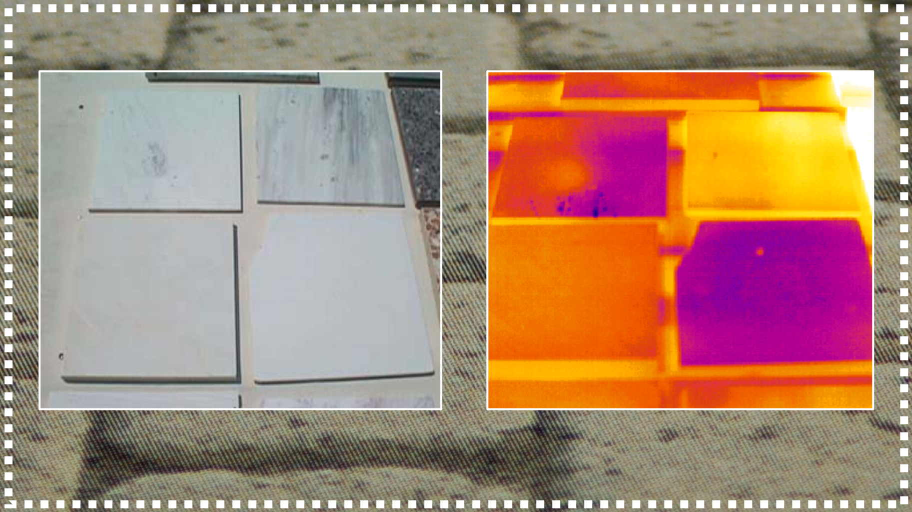
- appropriate layout of urban canopies involving the use of solar control, techniques to enhance air flow, etc.

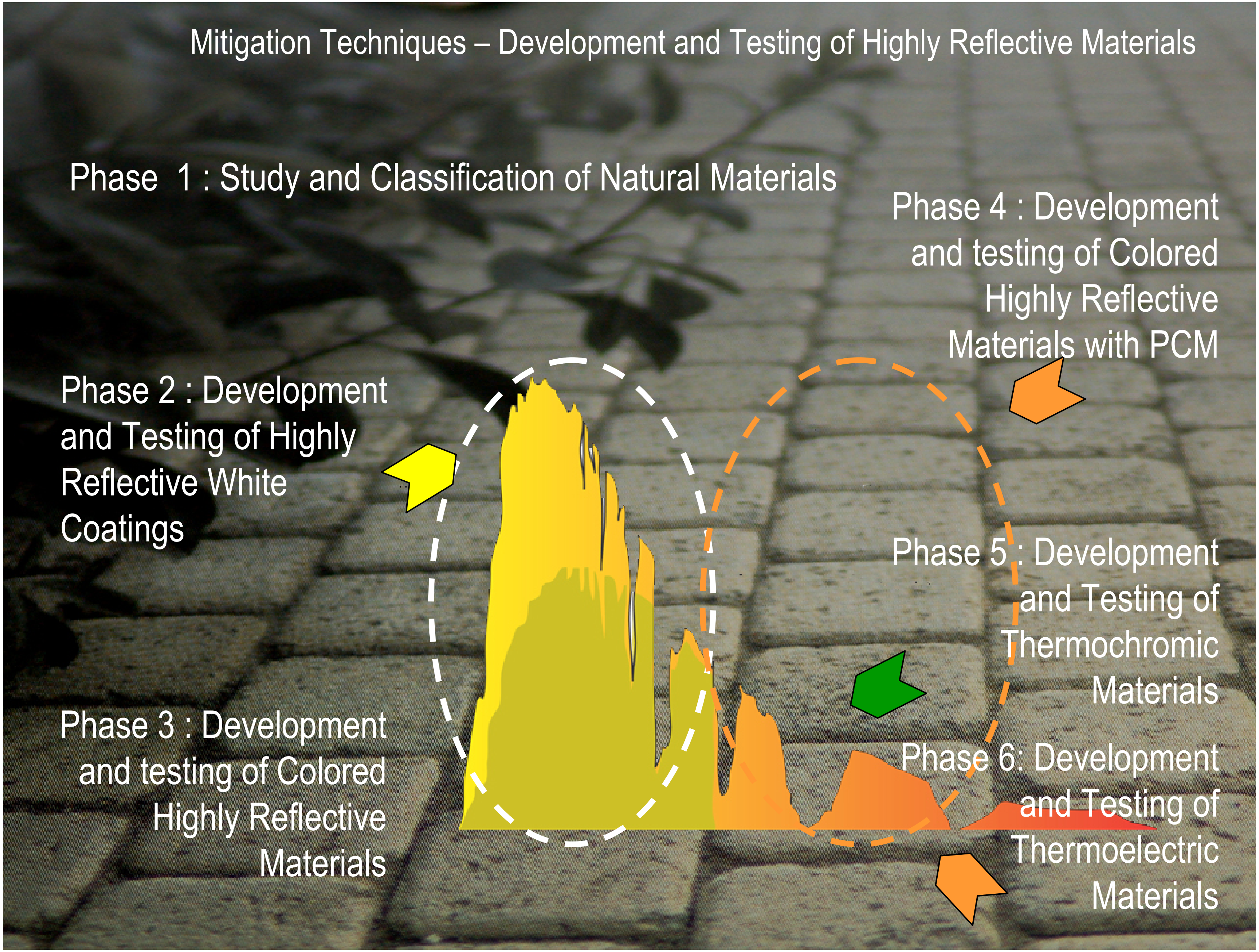
The Role of Materials







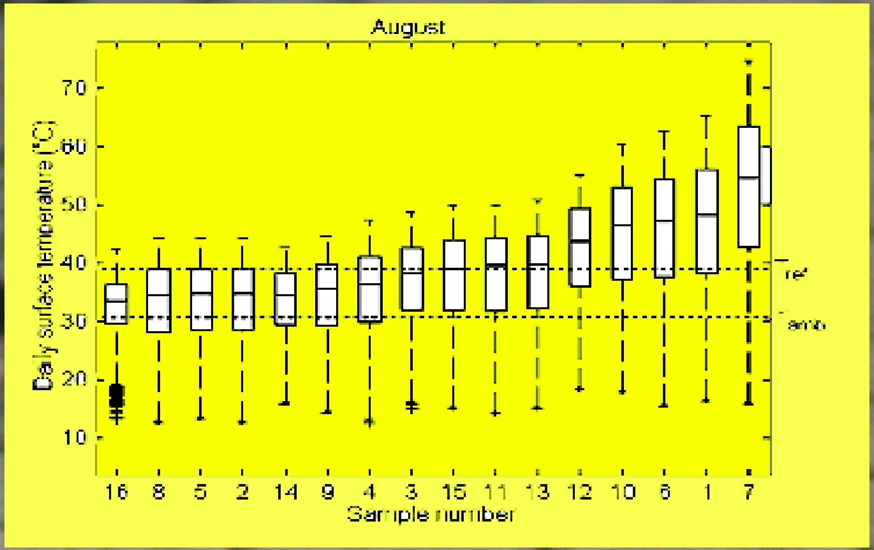


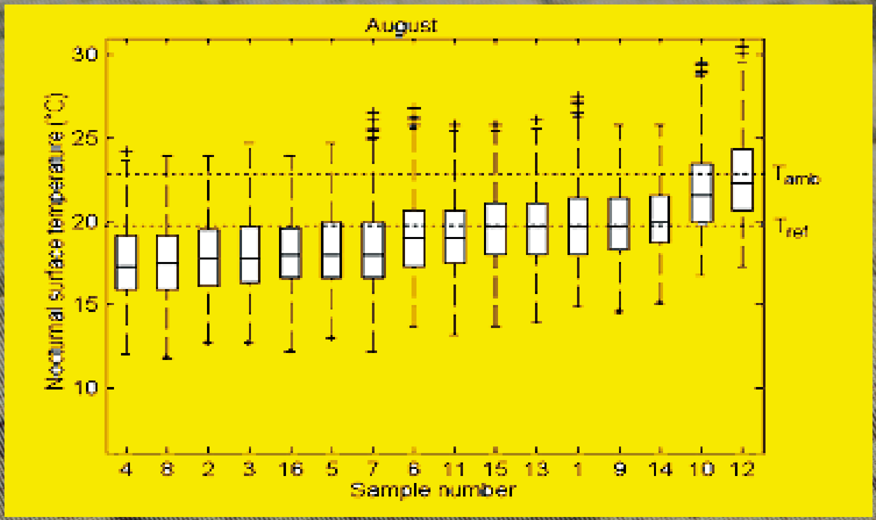

Mitigation Techniques – Development and Testing of Highly Reflective Materials
Phase 1 : Study and Classification of Natural Materials
Phase 2 : Development and Testing of Highly Reflective White Coatings
Phase 3 : Development and testing of Colored Highly Reflective Materials
Phase 4 : Development and testing of Colored Highly Reflective Materials with PCM
Phase 5 : Development and Testing of Thermochromic Materials
Phase 6: Development and Testing of Thermoelectric Materials

DEVELOPMENT AND TESTING OF HIGHLY REFLECTIVE WHITE MATERIALS

During the day period, maximum temperature difference between the white tiles was around 5 C as a function of their reflectivity. The difference between the white and aluminum tiles was up to 11 C.

During the night period maximum temperature difference between the white paints was around 2 C, while the maximum temperature difference between the white and the aluminum base paints was around to 5 C. In this case, the role of the emissivity is dominant.





A. Synnefa, M. Santamouris, I. Livada: A study of the thermal performance of reflective coatings for the urban environment, Solar Energy, Volume 80, Issue 8, August 2006, p.p. 968-981

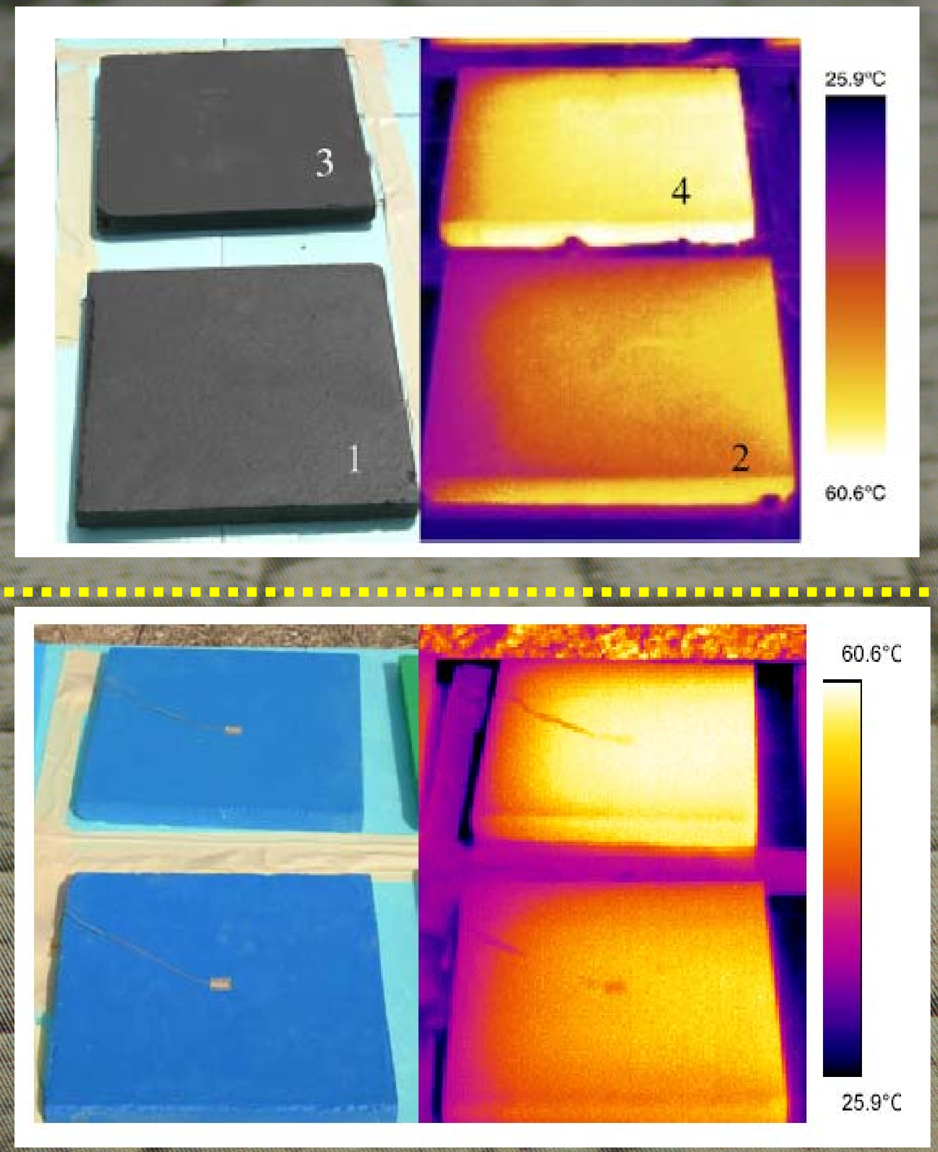
DEVELOPMENT AND TESTING OF HIGHLY REFLECTIVE COLORED MATERIALS

The optical properties and the thermal performance of 10 prototype cool colored coatings, prepared at the University of Athens using near-infrared reflective color pigments are tested in comparison to color- matched , conventionally pigmented coatings. The spectral reflectance was measured and the solar reflectance of the samples was calculated. The infrared emittance of the samples was also measured. The surface temperature of the coatings applied to concrete tiles was monitored on a 24 h basis from August to December 2005 in an effort to investigate the ability of the cool colored coatings to maintain lower surface temperatures than conventionally pigmented color-matched coatings under sunlight and during the night during both summer and winter.

A. Synnefa, M. Santamouris and K. Apostolakis : On the development, optical properties and thermal performance of cool colored coatings for the urban environment, Solar Energy 81 (2007) 488–497

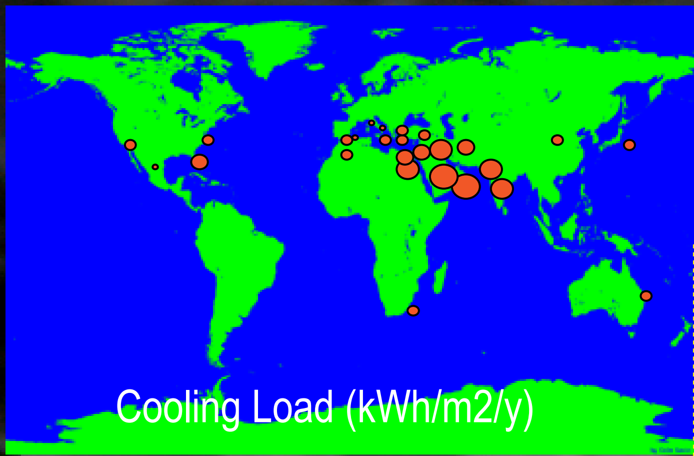
DEVELOPMENT AND TESTING OF HIGHLY REFLECTIVE COLORED MATERIALS

During the day, all the cool colored coatings had surface temperatures lower than the colored-matched standard coatings . The best performing cool coatings were black, chocolate brown, blue and anthracite, which maintained differences in mean daily surface temperature from their respective standard color-matched coatings by 5.2, 4.7, 4.7 and 2.8 C, during the month of August. The highest temperature difference was observed between cool and standard black and was equal to 10.2 C, corresponding to a difference in their solar reflectance of 22. The lowest temperature difference was observed between cool and standard green and was equal to 1.6 C (for August) corresponding to a difference in their solar reflectance of 7.

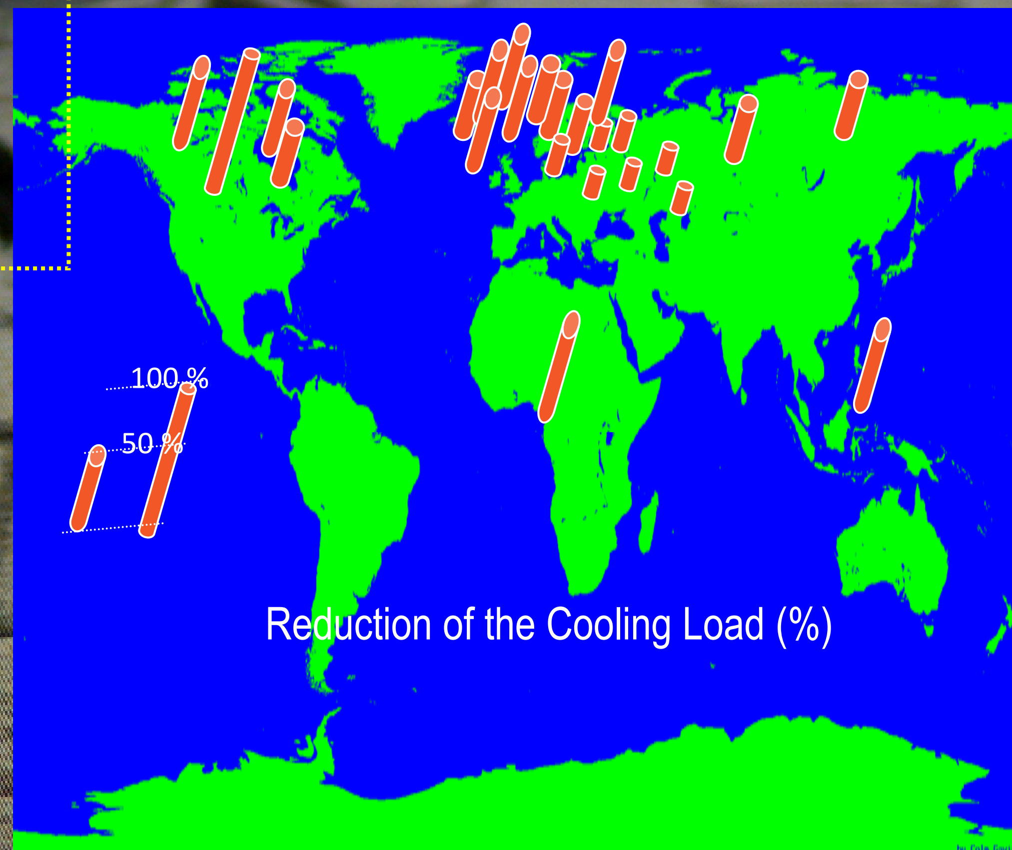


A. Synnefa, M. Santamouris and K. Apostolakis : On the development, optical properties and thermal performance of cool colored coatings for the urban environment, Solar Energy 81 (2007) 488–497

IMPACT OF REFLECTIVE COATINGS

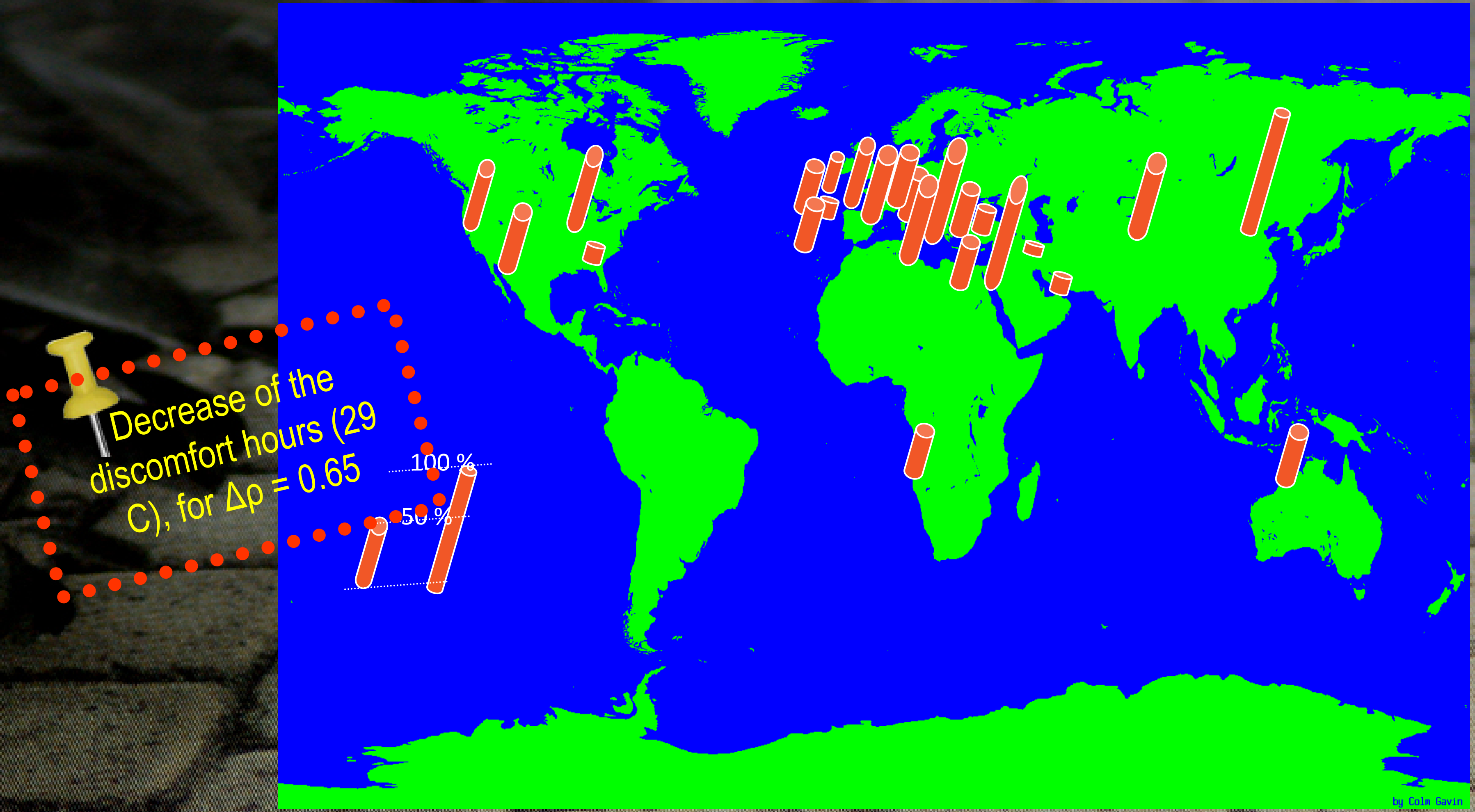


Increase of the albedo
from 0.2 to 0.85



A. Synnefa, M. Santamouris and H.Akbari: Estimating the effect of using cool coatings on energy loads and thermal comfort in residential buildings in various climatic conditions, Energy and Buildings, 39,11, 1167-1174, 2007

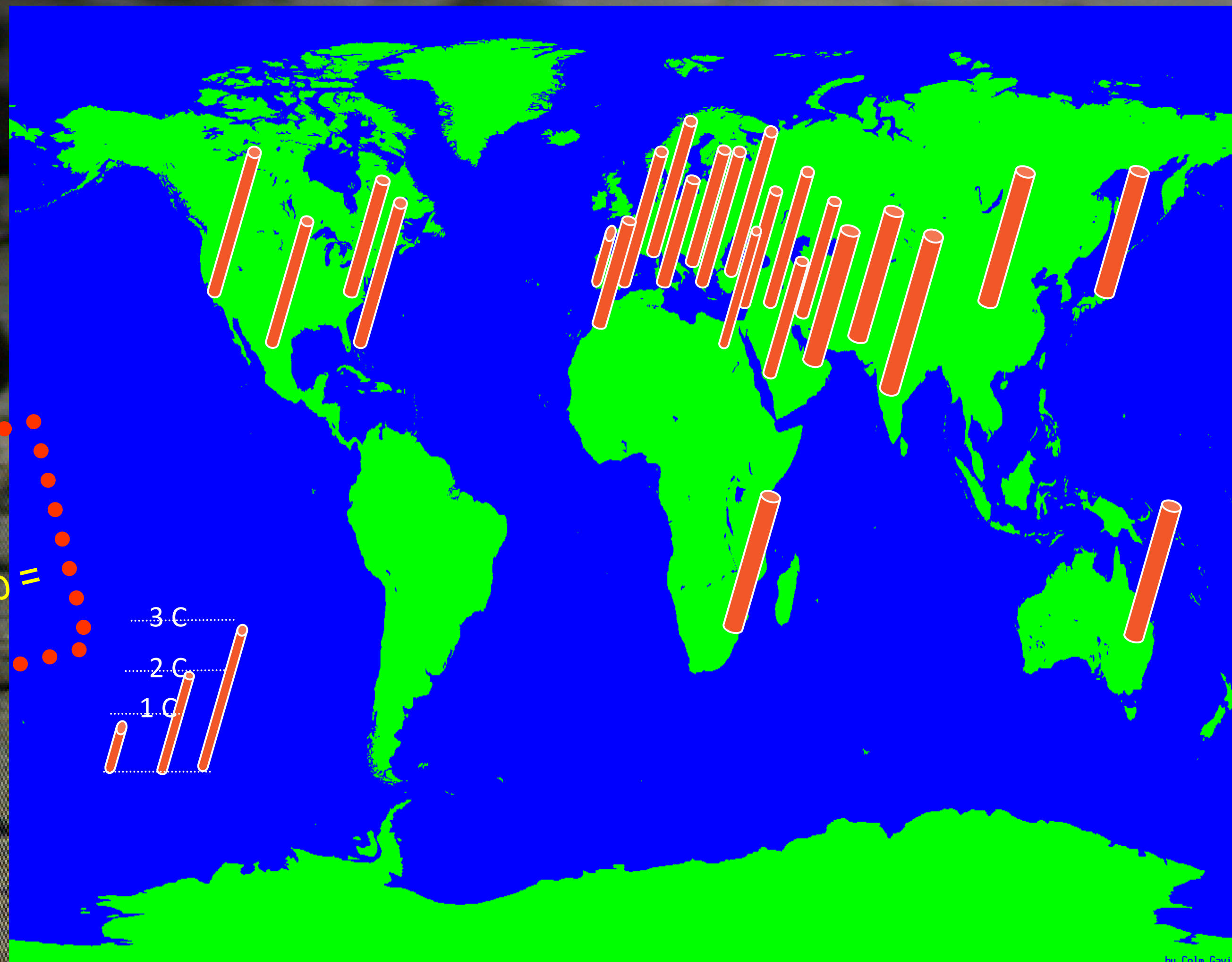
ENERGY IMPACT OF REFLECTIVE COATINGS



A. Synnefa, M. Santamouris and H.Akbari: Estimating the effect of using cool coatings on energy loads and thermal comfort in residential buildings in various climatic conditions, Energy and Buildings, 39,11, 1167-1174, 2007

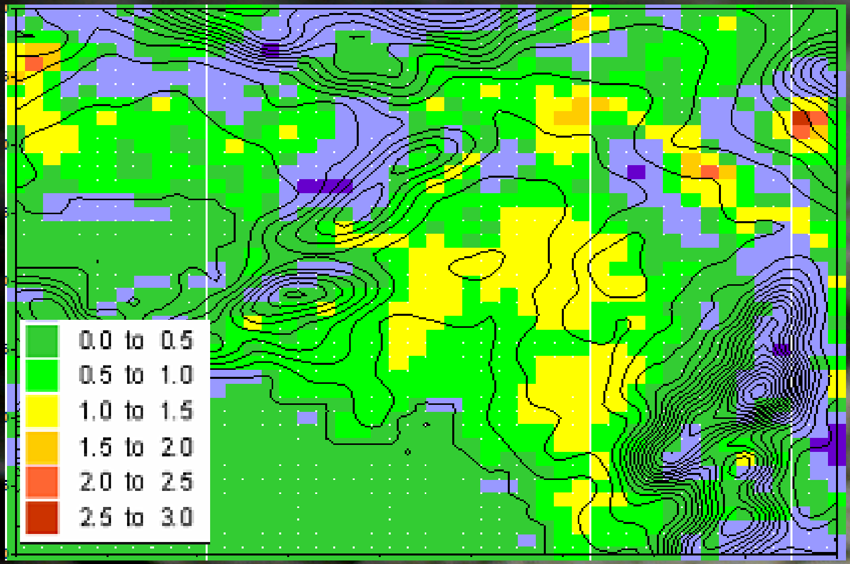
ENERGY IMPACT OF REFLECTIVE COATINGS

Decrease of the maximum indoor temperature, for Δρ = 0.65

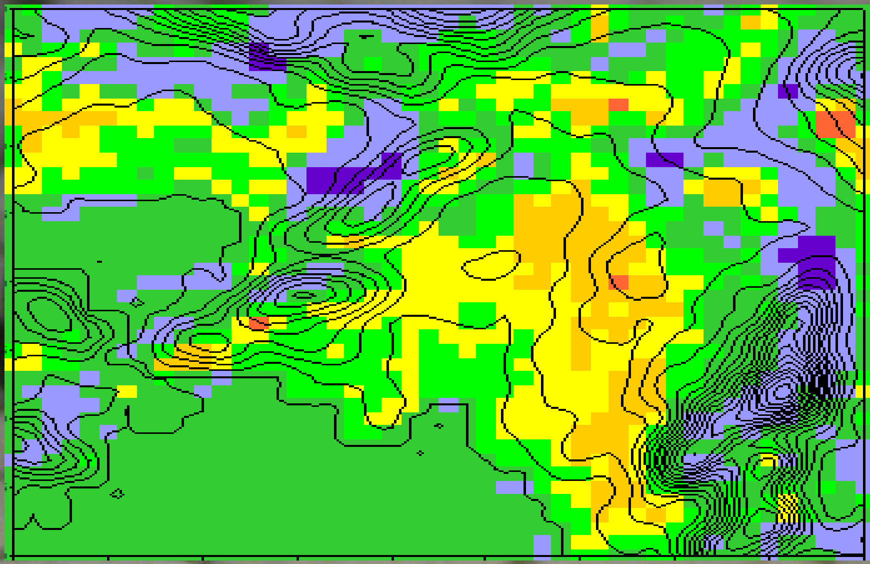


A. Synnefa, M. Santamouris and H.Akbari: Estimating the effect of using cool coatings on energy loads and thermal comfort in residential buildings in various climatic conditions, Energy and Buildings, 39,11, 1167-1174, 2007

IMPACT OF REFLECTIVE COATINGS



Air temperature differences (at 2 m) between the base case and the moderate increase in albedo scenario at 14:00 LST, on the 15th of August, 2005

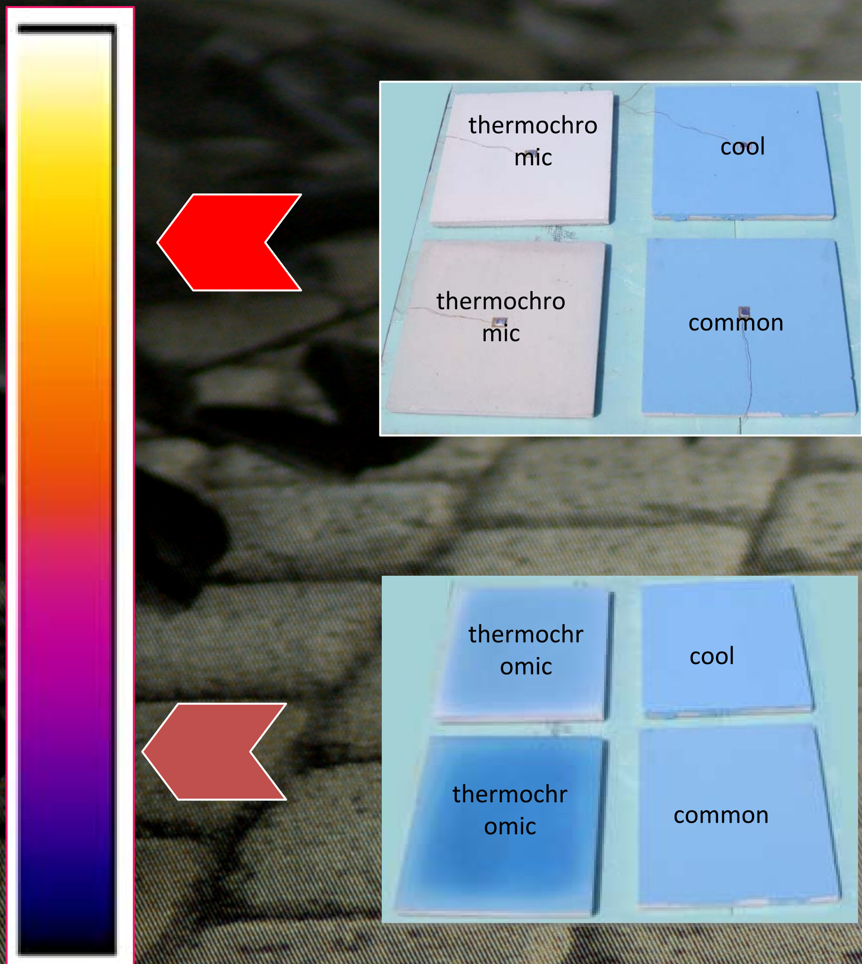


Air temperature differences between the base case and the high increase in albedo scenario at 14:00 LST, on the 15th of August, 2005

The impact of albedo changes on temperature is quite significant. The spatial distribution of temperature change correlates to the level of surface modifications in the modifiable areas. The simulations suggest that the urban areas (as well as other suburban and rural areas) are generally cooler than in the base case. The impact of albedo increase is higher at 12p.m. to 3p.m. More specifically, for the moderate increase in albedo case, the temperature depression at 12p.m. varies between 0.5 and 1.5°C. If the albedo is further increased then the temperature difference from the base case varies between 1-2 °C, with individual depressions as high as 2.2°C.

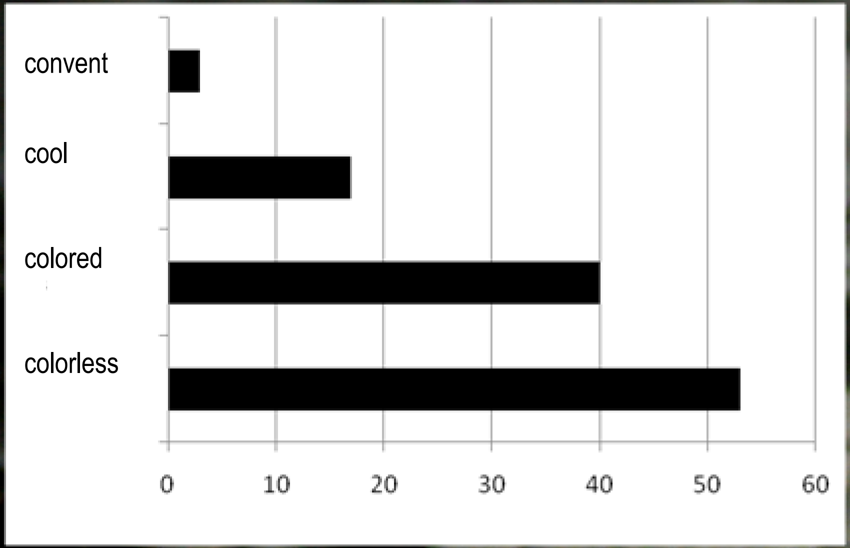
A. Synnefa, A. Dandou, M. Santamouris, M. Tombrou, N. Soulakellis : Large Scale Albedo Changes using cool materials to Mitigate Heat Island in Athens. J. Applied Met, 2008

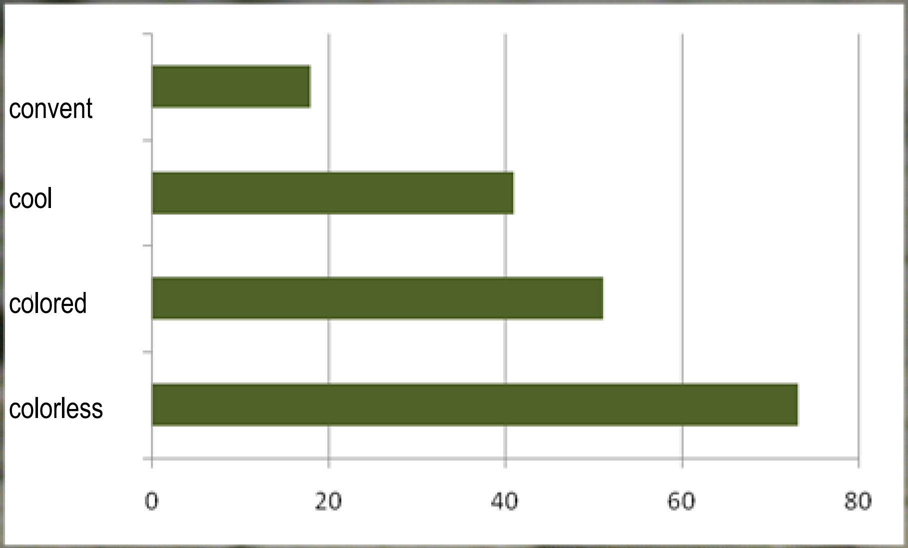
DEVELOPEMENT OF THERMOCHROMIC COATINGS

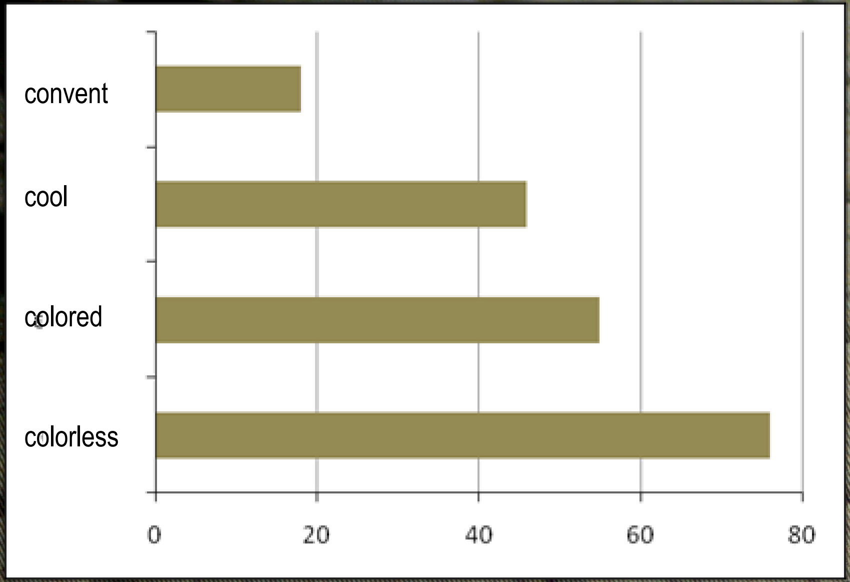


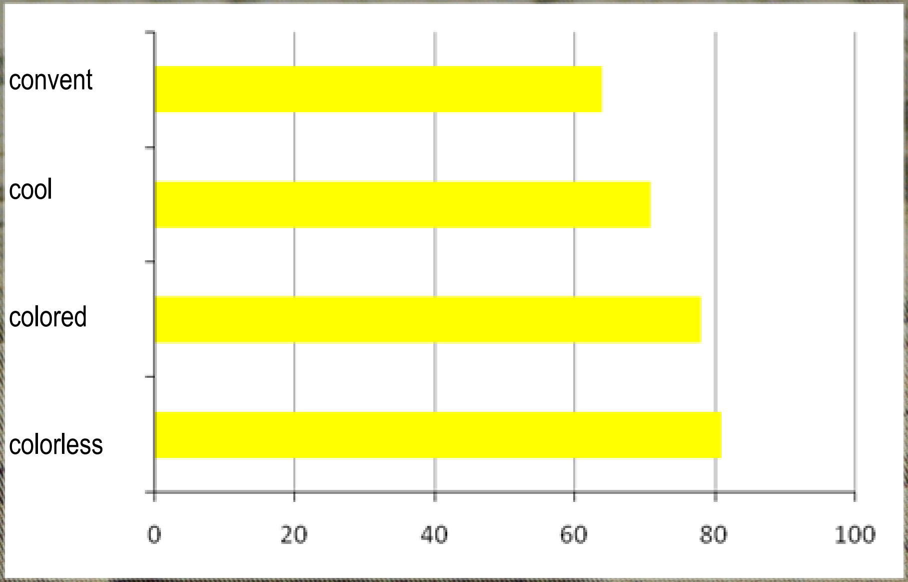
Thermochromic coatings change color as a function of the ambient temperature.
For low outdoor temperatures, winter, the coatings may be dark presenting a high absorptivity.
For higher ambient temperatures, summer, the coating becomes white presenting a high reflectivity.
Thus, when applied on roofs or walls it may present the best performance all year round.

DEVELOPEMENT OF THERMOCHROMIC COATINGS



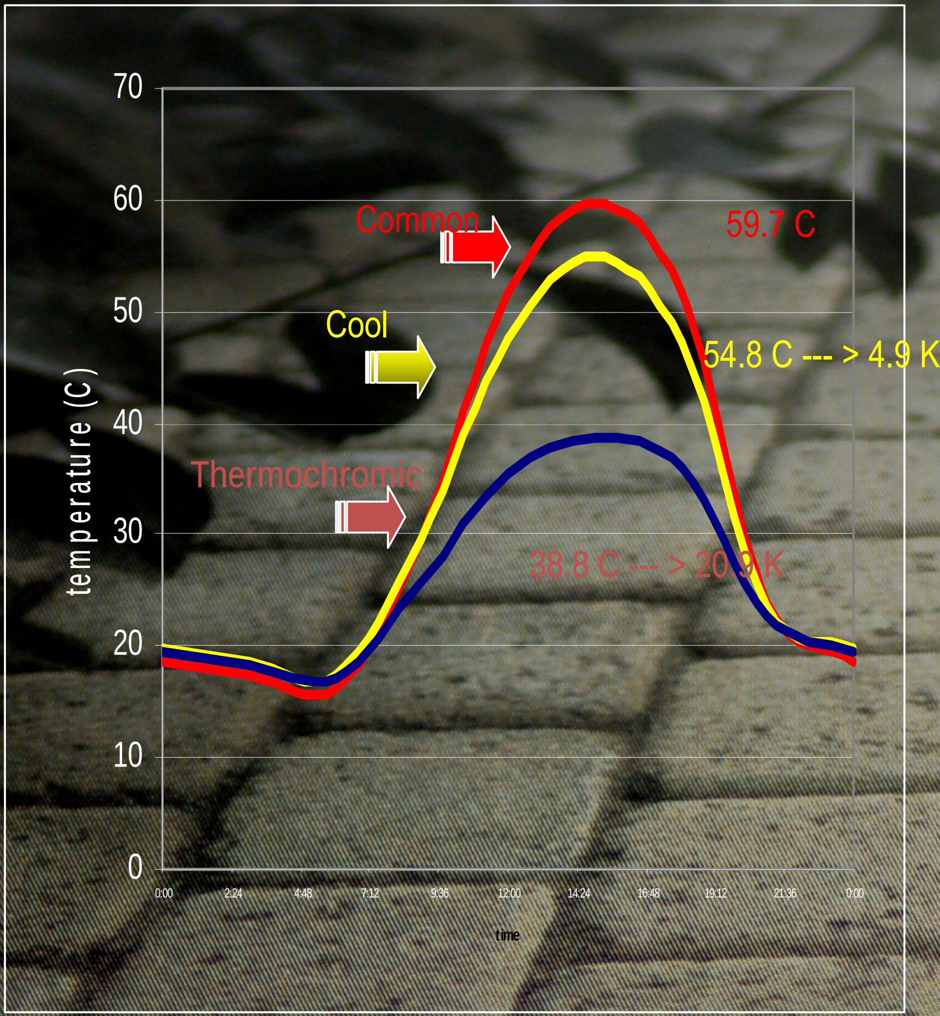


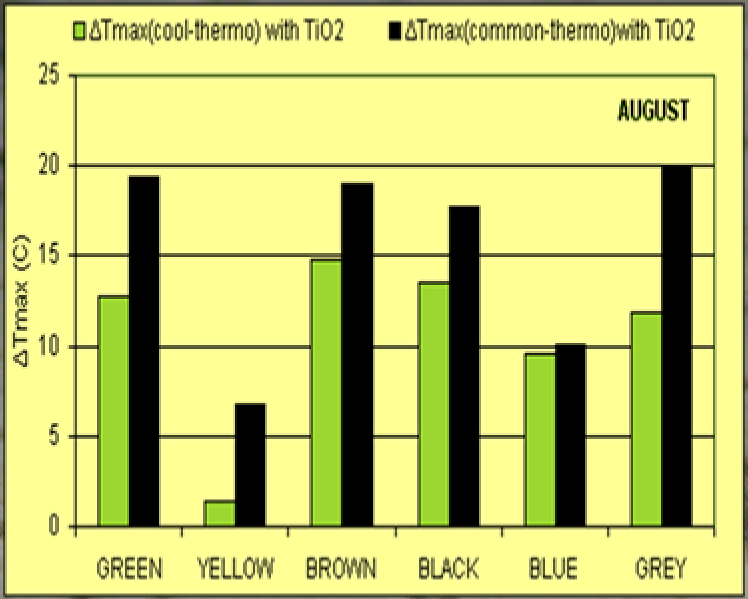


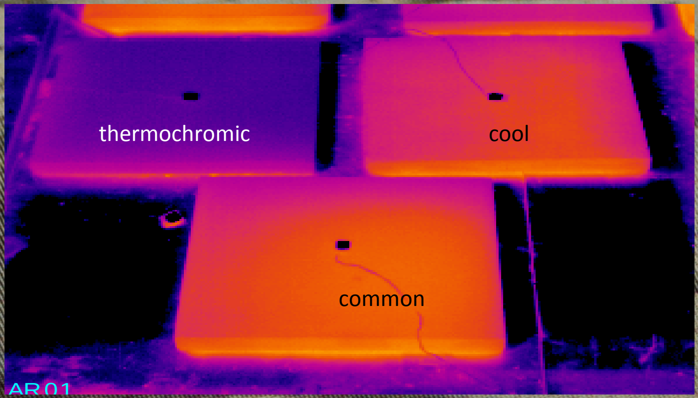


T. Karlessi, M. Santamouris, K. Apostolakis, A.Synnefa I. Livada : Development and Testing of Thermochromic coatings for Buildings and Urban Structures, Solar Energy, 2008

DEVELOPEMENT OF THERMOCHROMIC COATINGS







T. Karlessi, M. Santamouris, K. Apostolakis, A.Synnefa I. Livada : Development and Testing of Thermochromic coatings for Buildings and Urban Structures, Solar Energy, 2008

Target of the COOL ROOF project:

Creation and implementation of an Action Plan for the promotion, market transformation and changing behavior towards cool roofs technology in the European Union

Cool Roofs is an EACI Project

NATIONAL AND KAPODESTRIAN UNIVERSITY OF ATHENS	NKUA	GR
Technological Educational Institute of Crete	TEIC	GR
PERDIKIS BROS CO.	ABOLIN	GR
Municipality of Kessariani	MoK	GR
Brunel University	UBRUN	UK
Greater London Authority	GLA	UK
University of la Rochelle	University of la Rochelle	FR
SIPEA HABITAT	SIPEA-Habitat	FR
Italian National Agency for New Technologies, Energy and the Environment	ENEA	IT
Regional Province of Trapani - Sector for Land Environment Natural Resources	Provincia di Trapani	IT
ECOBIOS	ECOBIOS	IT
Federation of European heating and air-conditioning associations (REHVA)	REHVA	NL
ACG Consulting Group	ACG	BE

COOL ROOFS PROJECT - OBJECTIVES

- Support policy development by transferring experience and improving understanding of the actual and potential contributions by cool roofs to heating and cooling consumption in the EU.

- Remove market barriers and simplify the procedures for cool roofs integration in construction and building's stock.

- Change the behavior of decision-makers and stakeholders so to improve acceptability of the cool roofs.

- To disseminate and promote the development of innovative legislation, codes, permits and standards, including application procedures, construction and planning permits concerning cool roofs.

COOL ROOFS PROJECT - OBJECTIVES

- Creation of a methodology for rating cool roofs products in EU market following the project's results.
- Incorporation of higher albedo surface materials in CEN technical standards for EPBD.
- Expansion of the new Agreement between EU and USA to continue the ENERGY STAR programme for office equipment to ENERGY STAR Reflective Roof Products.
- Expansion of the EU-CRC to incorporate other urban heat island mitigation techniques and experts.
- Multiplying implementation of cool roofs in EU buildings.
- Involvement of manufacturers and end users targeting to EU market transformation

COOL ROOFS PROJECT – MAIN RESULTS

<u>Technical Axis:</u>

1. Database of cool roofs available materials
2. Manufacturing procedures
3. At least five EU Cool Roofs case studies
4. Comparison of the cool roofs performance with other urban heat island mitigation strategies

<u>Market Axis:</u>

1. List of manufacturers and their available products. Analysis of the market trends for the last 10 years in comparison with US figures.
2. Strategic plan and for overcoming the already known market barriers
3. Market research with questionnaires and interviews to interested parties.
4. Pricing policies through product’s benchmarking and analysis of the competitive market.

Policy Axis:

1. Analysis of the existing EU policies and legislative frameworks that can integrate cool roofs' incentives and measures.
2. Analysis of existing policies and legislative framework in the participating countries.
3. Analysis of the local incentives, rebates and funding schemes that can be utilised for the promotion of cool roofs.
4. Formulation of concrete and clear proposals to the local stakeholders via the EU-CRC network for the benefits of providing incentives for cool roofs as well as promotion of "cool roofs local programmes" via the creation of the shinning examples with documented analysis of the benefits, following the US examples.

End Users Axis (disseminaiton and promotion):

1. Workshops and seminars in local level.
2. Creation of brochures and dissemination material.
3. Creation of marketing spots.
4. Organising visits to the shinning examples
5. Participation to an International Conference and
6. Web Portal.

Summer comfort and Cooling:
UK Regulation and Policy

Roger Hitchin

Contents

- UK Regulations
- Air conditioning markets
- Building measures
- System measures
- Comparison

UK Regulation

Regulatory Objectives

- 1. Reducing carbon emissions and energy use
- 2. Avoiding overheating

- The UK has focused on regulating for carbon reduction
  - Air-conditioning is not the biggest contributor to the environmental impact of buildings
  - But use is growing (as in Europe and elsewhere)
  - Carbon implications are therefore of concern

Regulations on Cooling Energy

- Minimum performance requirements for newly-installed equipment
  - Whether in new buildings of refurbished ones
  - Chiller EER, room air conditioner EER, specific fan power
- Limit on carbon emissions from all fixed services
  - For new and refurbished buildings, if actual building has air-conditioning, so does reference building
    - *In effect, imposes requirements on system efficiency*
  - For EPCs, reference building is always mixed mode
    - *Provides incentive to avoid air-conditioning*

bre

Regulations on Overheating Risk

- Housing
  - Show that glazing area, shading, ventilation avoids risk

- Non-housing: several options
  - Solar plus incidental gains in July (averaged between 6:30 and 16:30 on a sunny day) do not exceed 35W/m2
  - Explicit calculation of hours above thresh-hold
    - *1% of occupied hours over 28C for offices*
  - Specific requirements for schools

- Future?
  - Move towards regulating solar gains only
  - (Comfort criteria seen as a designer/client issue rather than regulatory)

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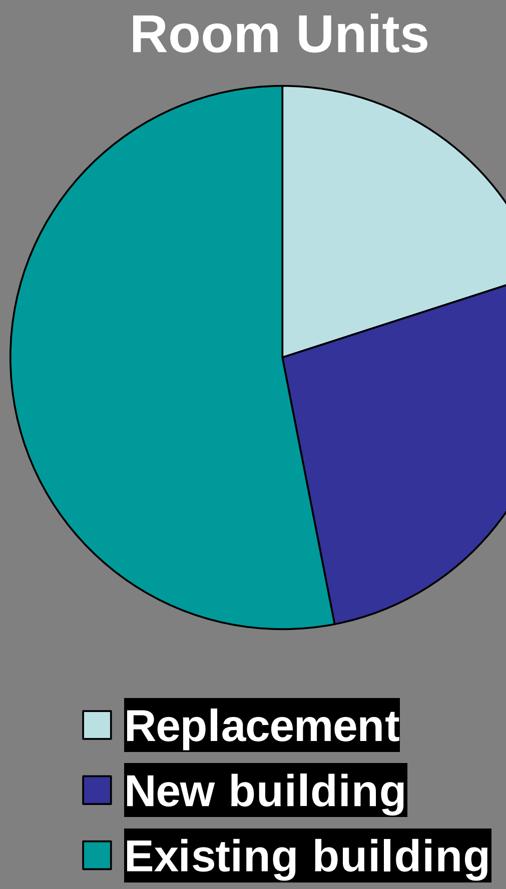
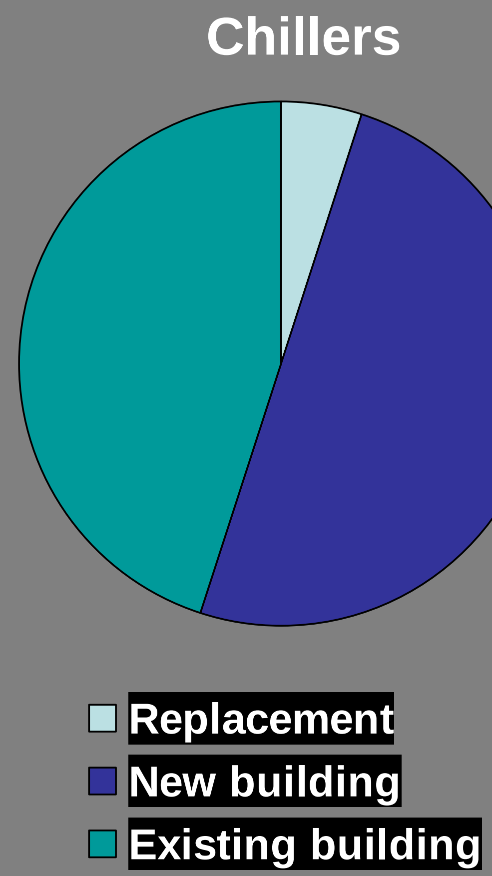
Air Conditioning Markets

A/C Market Dynamics

- No significant market until GDP per head passes threshold
  - All EU countries are above this
- Above a second threshold, growth accelerates
  - Most EU countries are in this growth phase
  - Most sales are into existing buildings
- Ultimate saturation ownership is climate dependent
  - No EU country is near saturation compared with US or Japan
  - Could building design reduce saturation level??

European Market is Immature – few sales are replacements





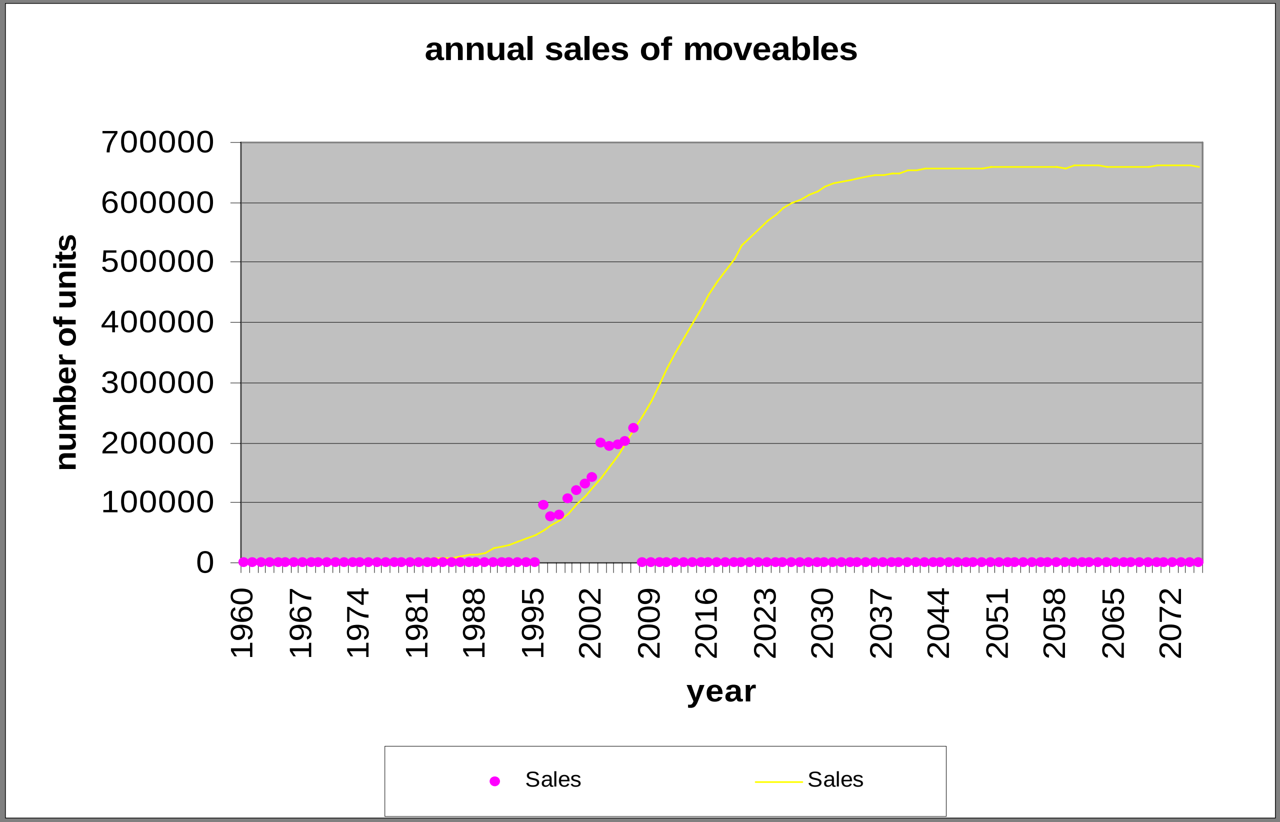
A/C Market Drivers

- Rate of take-up seems to be largely driven by consumer behaviour.

- For dwellings:
  - Affordability
  - Propensity to innovate (early adopters)
  - Propensity to copy others

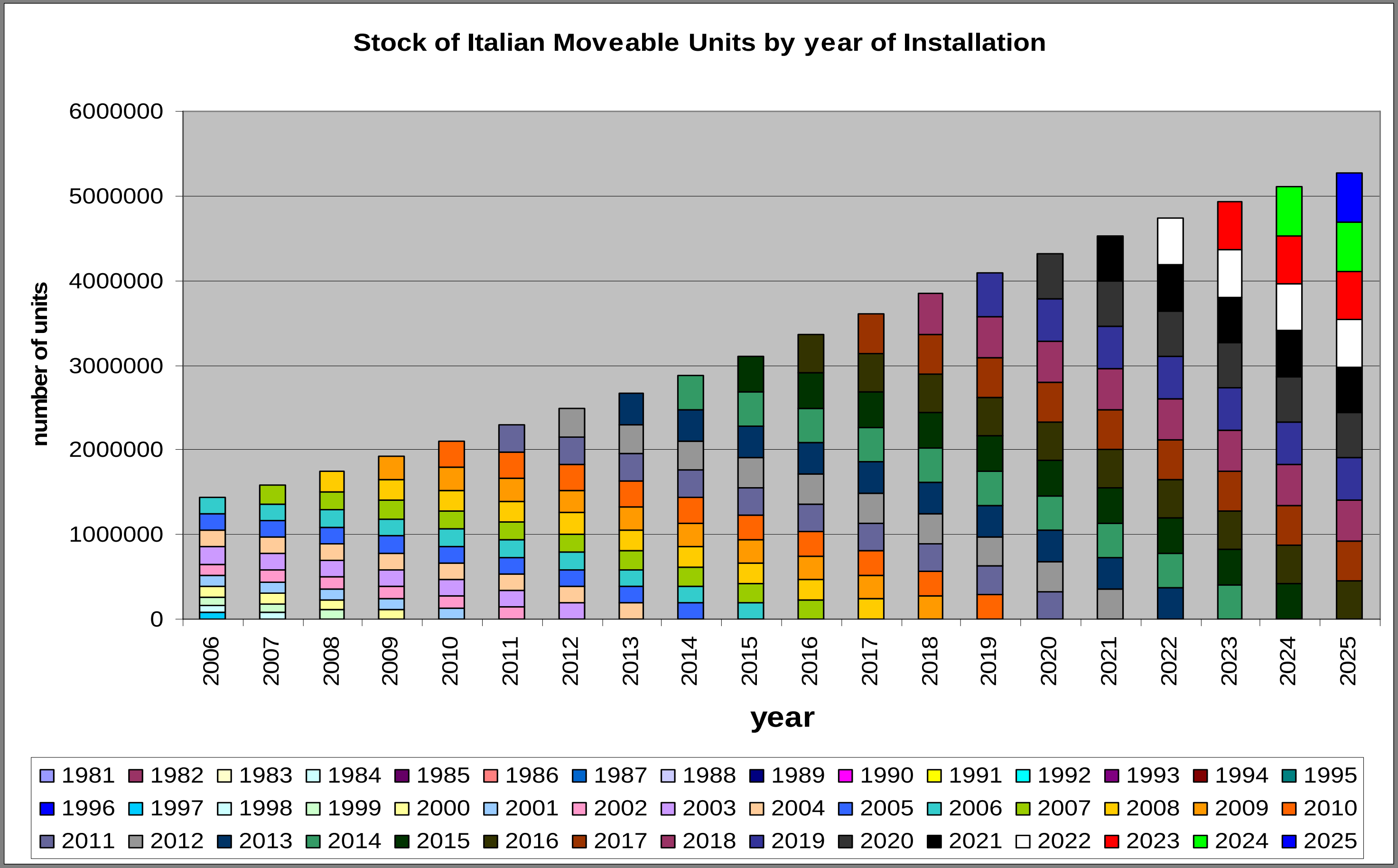
- For Offices:
  - Rental values

Market penetration curve - example



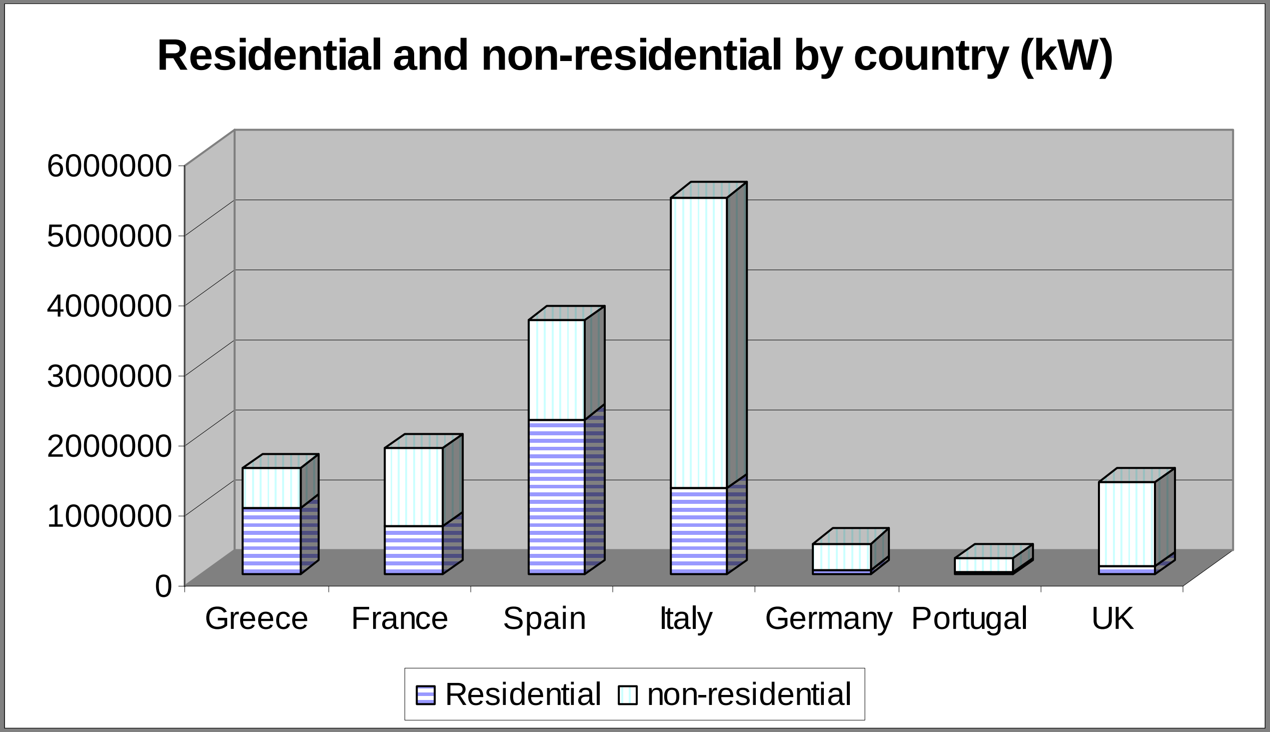
- Diffusion curve fitted to past sales figures and estimated saturation level

Projected room air conditioner stock in Europe



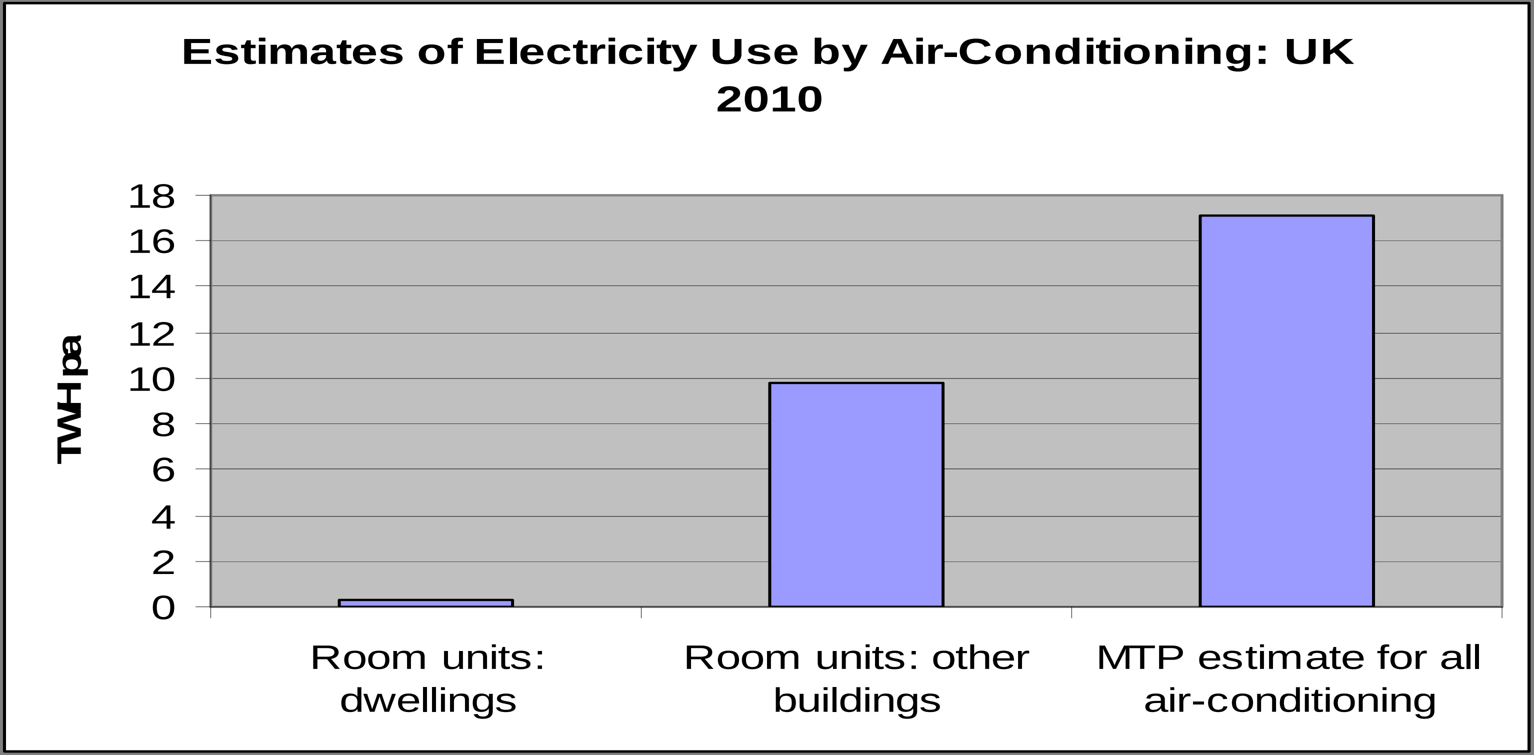
- Based on diffusion curve and assumed product life

Existing Market: housing versus the rest



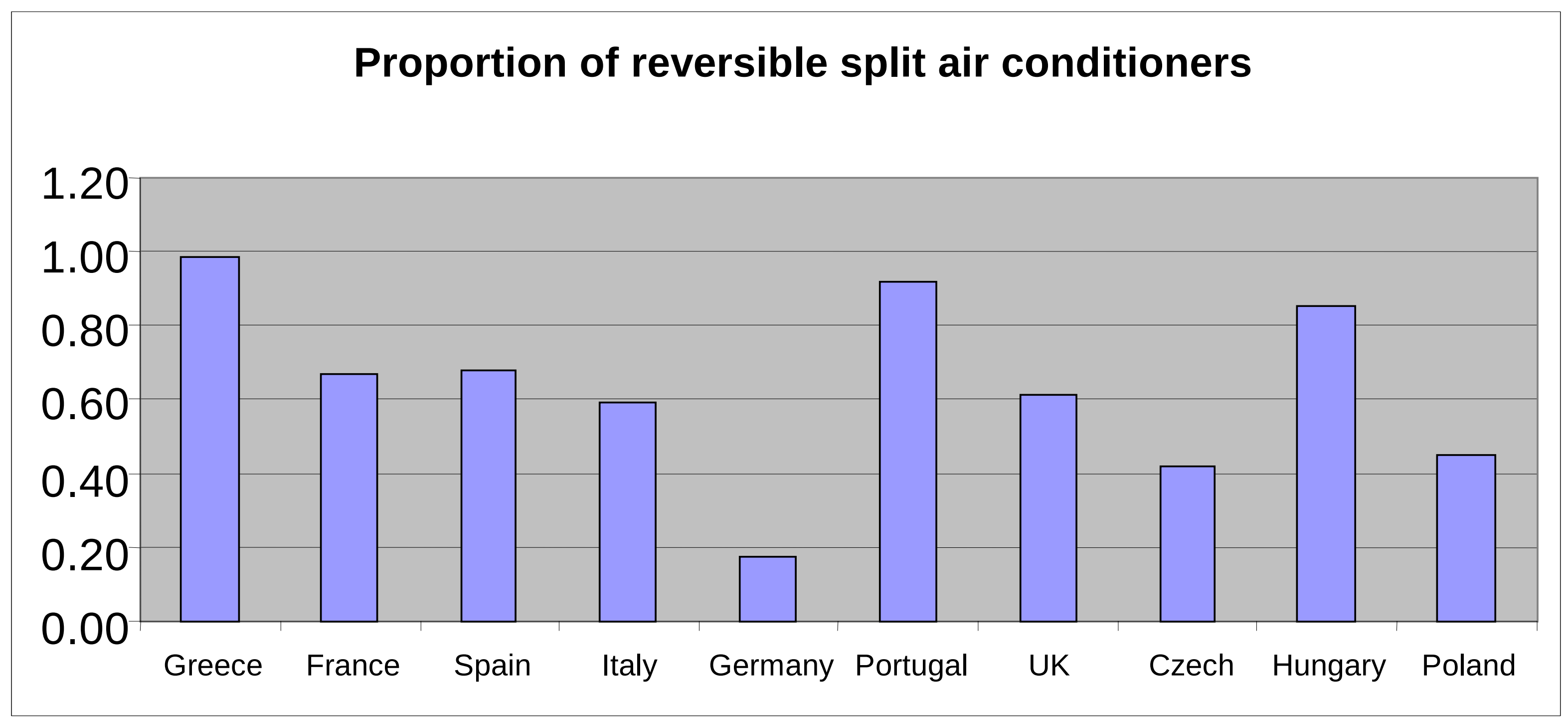
- Proportion of sales into housing is very variable
  - Overall about 36% (by cooling capacity) into housing

Relative importance in the UK



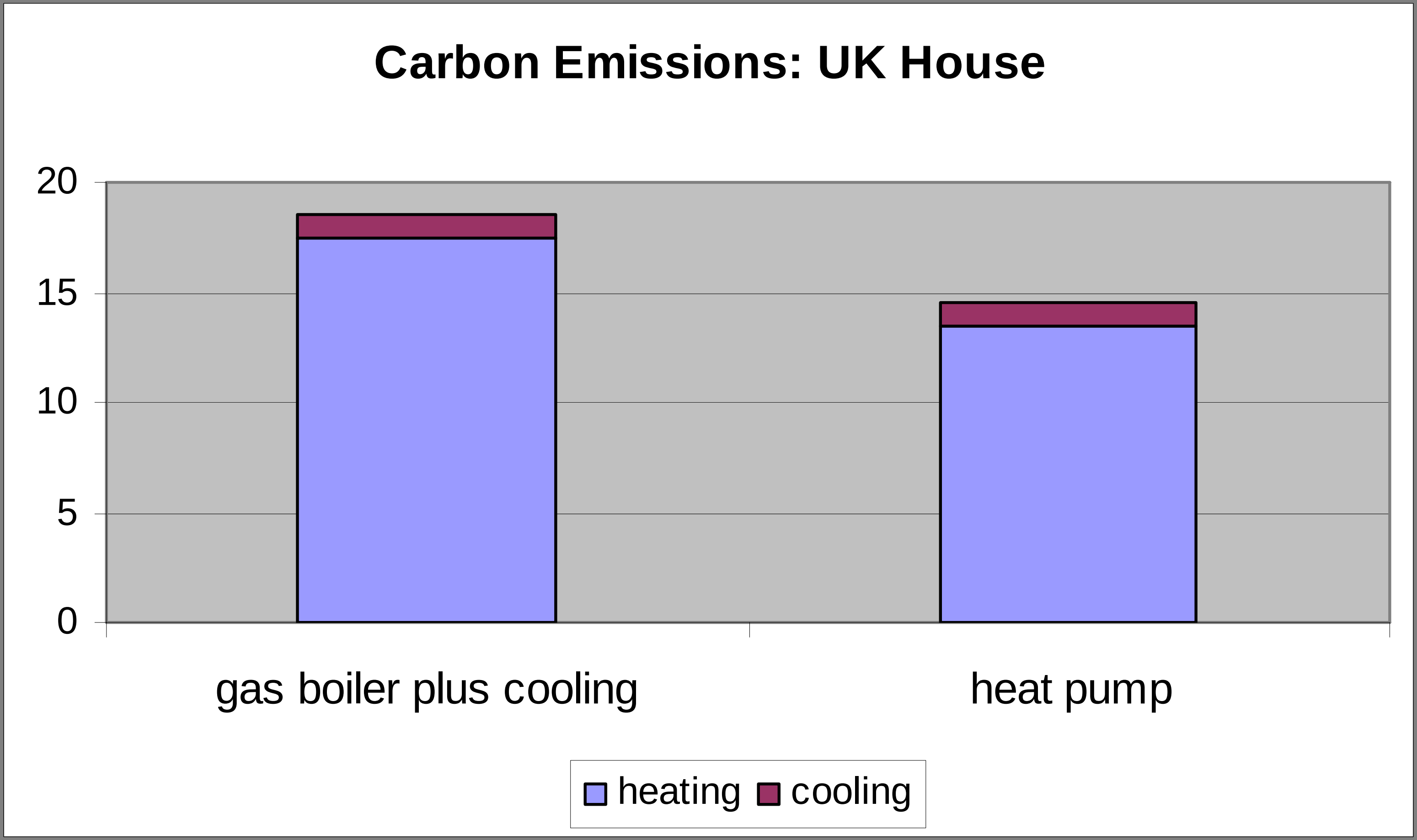
- Room units a substantial element
- Use in housing very low
  - even with high growth rate unlikely to match other buildings

Use for heating: reversible units



- Proportion of split units that are reversible is increasing in most countries

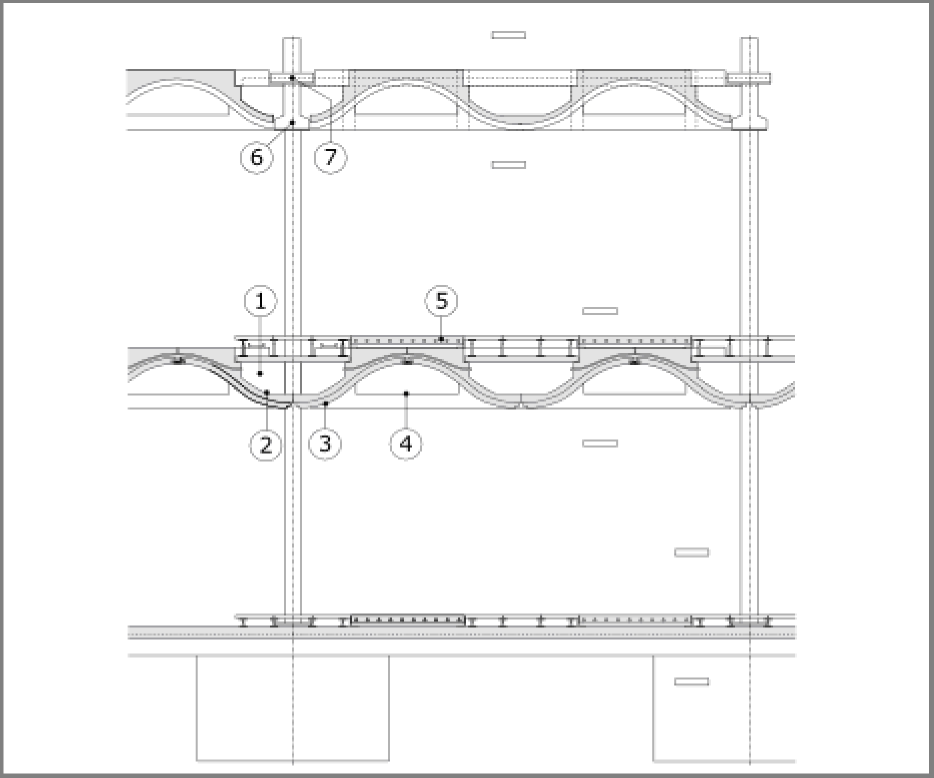
Carbon implications of reversibility



Building Measures

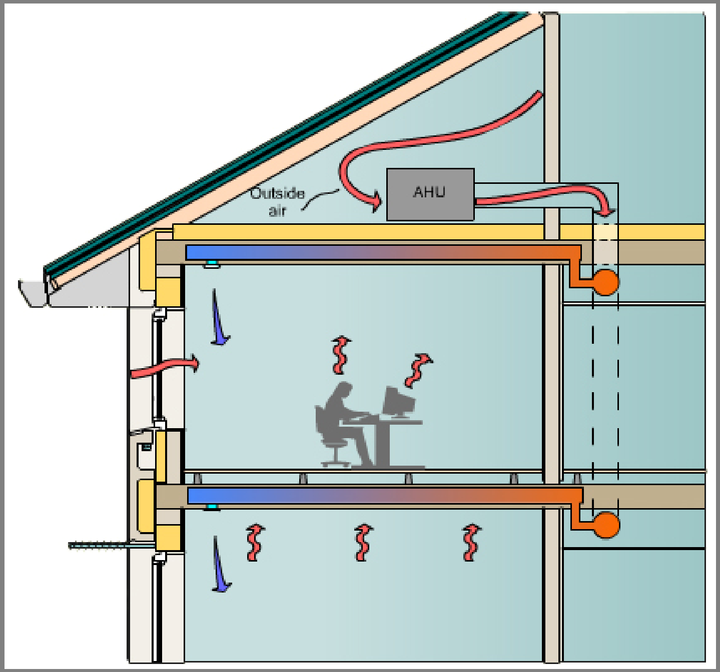
Passive Design is Established: Natural Ventilation

BRE Building

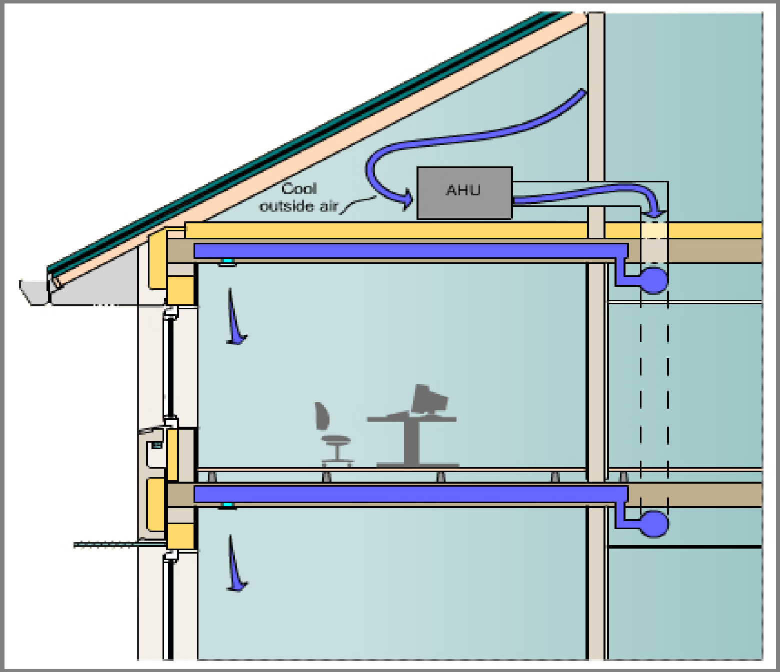


bre

Mechanical Night Ventilation - Termodeck



Summer day



Summer night

Lessons from Reported Case Studies

- Mostly offices or educational buildings
  - Educational buildings are rarely air-conditioned
- Generally seem to work reasonably well
  - Sometimes very well
- Some generic difficulties (but not universal)
  - Top floors more likely to overheat
  - Ventilation controls (for windows etc) not robust
  - Building use changes unhelpfully
  - Poor interface of specialist controls with BMS

bre

Existing Buildings

- Hardly any reported retrofit applications
- One example (Stevenage)
  - Used innovative product (Cooldeck)
  - Apparently successful but not fully reported
- Simplified theoretical assessment of offices showed that
  - Passive “intermediate level” retrofit improved comfort in naturally ventilated non-air conditioned buildings
  - “Acceptable” levels of overheating possible in air-conditioned buildings by retrofitting with mechanical ventilation solutions

Carbon Savings from Building Measures

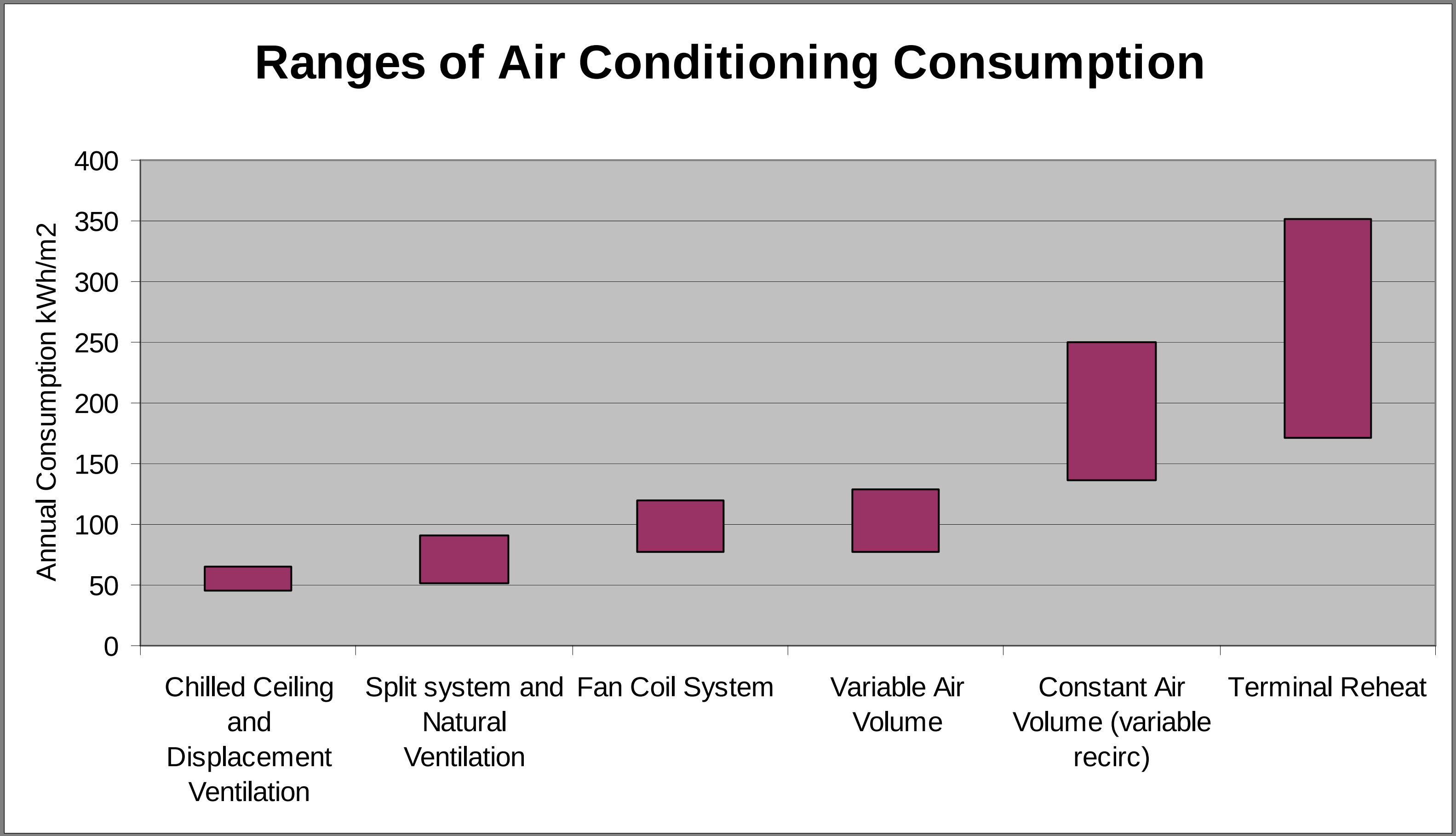
- Air conditioning is mostly in offices and retail premises
  - But also concern about housing

- Offices:
  - Typically of “massive” construction
  - Savings of the order of 2 kgC/m2 pa
    - *(higher if mechanical ventilation can be avoided)*

- Retail:
  - Supermarkets are often lightweight construction
  - Savings perhaps 2 kgC/m2 pa (might be more)

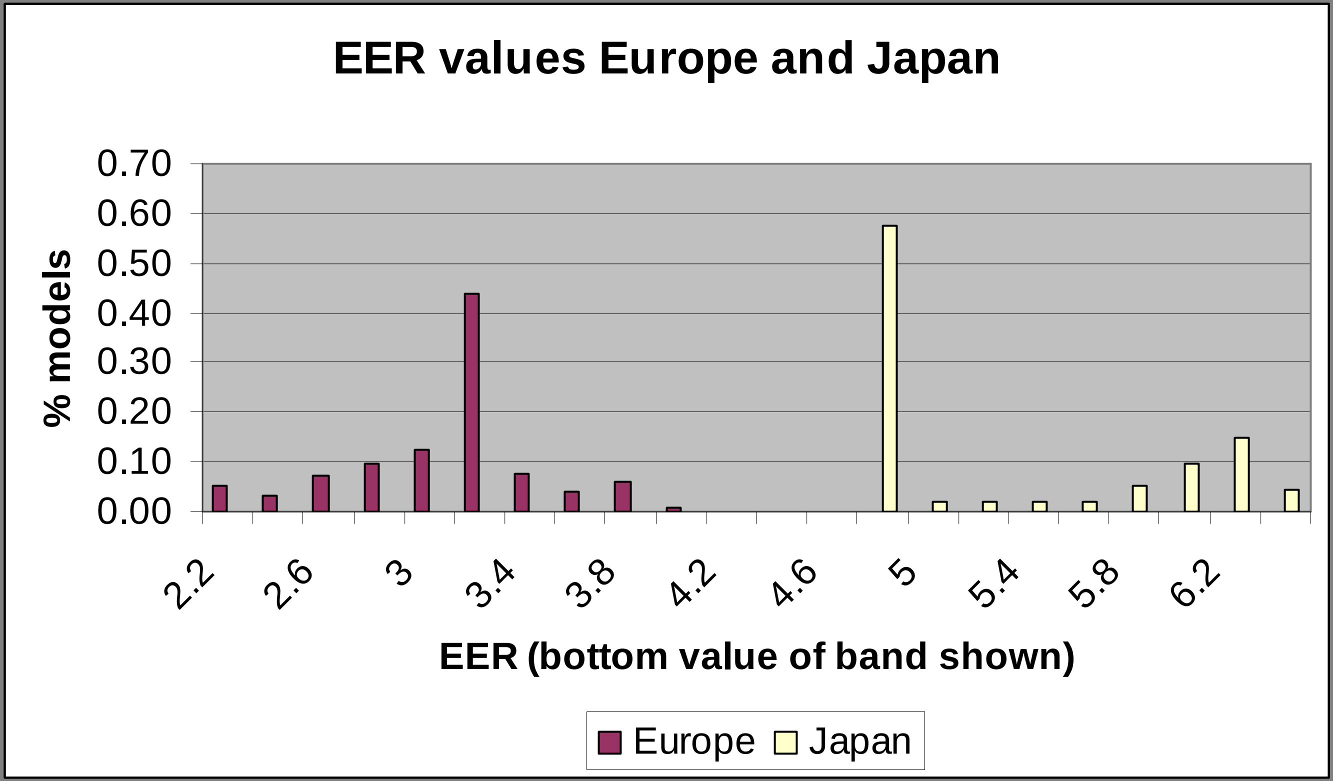
Equipment Measures

Variation of Consumption: Central Systems



- **Type of system is important: so are component choices: duct size, duct leakage, chiller. Typically 40% to 50% is fan energy**

Variation of Efficiency: Room Air Conditioners



- Products on Japanese market significantly more efficient than those in Europe
  - but costs are higher

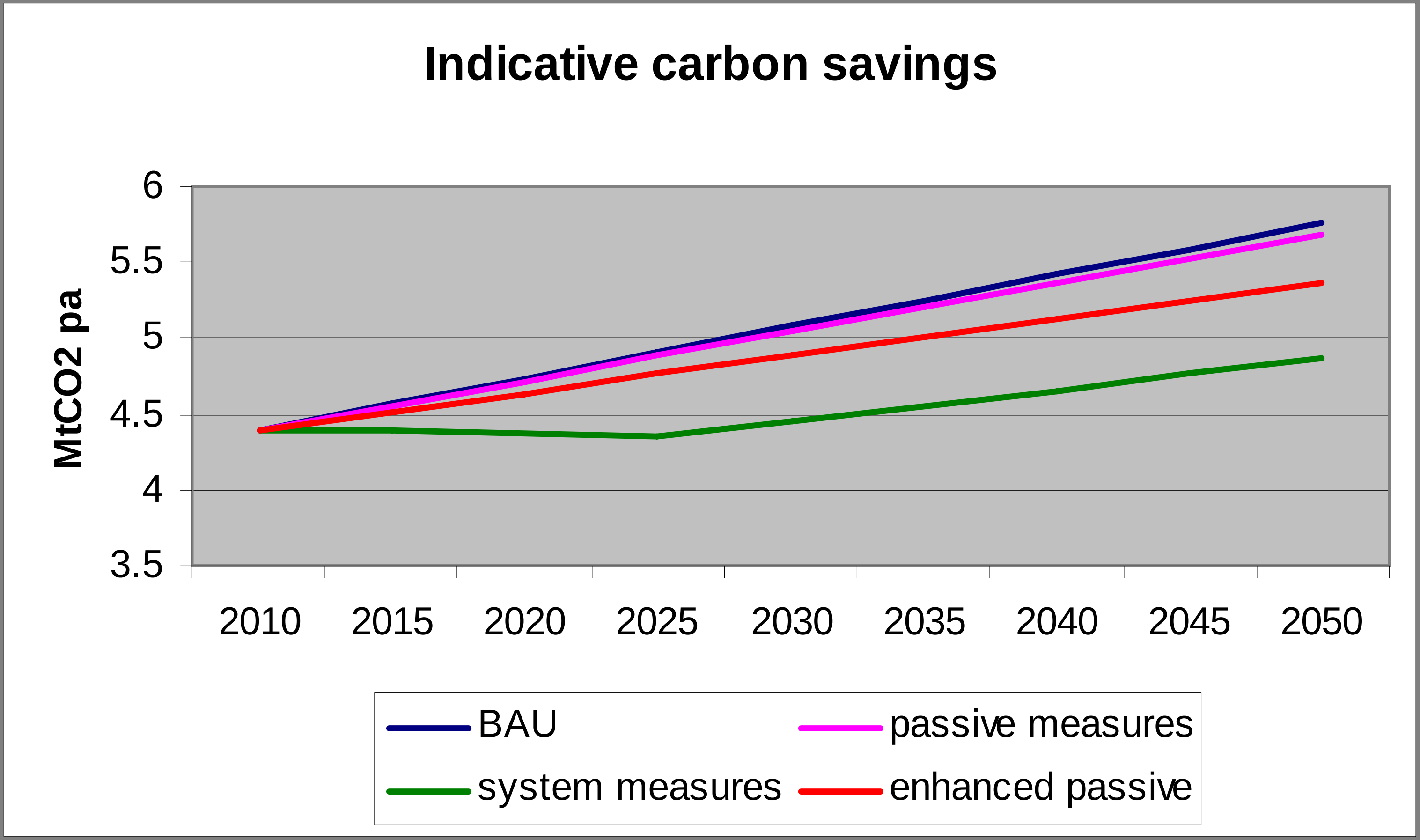
bre

Comparison of Impacts

Scale and timing of impacts

- Air conditioning currently accounts for about 4.4 $MtCO_2$pa
  - Increasing at about 170 $ktCO_2$pa
- Building measures
  - Essentially new buildings with appreciable thermal capacity
  - Impact 5 to 15 $ktCO_2$pa depending on assumptions
  - Implementation could continue for at least 30 to 40 years
- Improved system efficiency
  - New and replacement systems
  - Impact around 90 $ktCO_2$ pa
  - Most systems would be improved within 20 years.

Scale of impact



- Not either/or choice but clearly different trajectories

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Conclusion

- Using the most efficient systems and products has most immediate impact
  - Easy to define policy instruments, especially at product level
  - In the medium term, bigger impact on carbon emissions
- Reducing cooling demands is longer term, smaller impact
  - Not easy to define effective policy instruments
- But both are needed
  - And probably decarbonisation of electricity supply too

bre

Some Aspects Regarding Summer Comfort and Cooling in Belgium

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VEROZO[1]
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1 Introduction

In Belgium, the regulations with respect to the energy performance of buildings (EPB-regulations) are the independent responsibility of each of the 3 regions (Flanders, Wallonia and Brussels). In general, there are to a greater or lesser extent differences among the regulations and calculation methods between the regions. But for the calculation aspects of summer comfort and cooling the methods have not been altered. So, the discussion below is equally valid for each of the 3 regions.

In the past, with previous thermal insulation regulations, severe problems of compliance have been observed during the execution phase of the building process. In order to achieve better results with the new EPB-regulations, the regions have now shifted the focus of compliance checking from the demand for building permit to the as-built situation. Therefore, for every project subject to EPB-requirements a report must now be drawn up after completion of the works. In this so-called "EPB-declaration" a (private) rapporteur must correctly describe all measures with respect to all EPB-aspects as they have been effectively executed, and it must be shown to what extent the requirements are respected or not.

For every non-compliance with a requirement a stiff financial fine directly proportional to the extent of the transgression is given to the building owner. If incorrect reporting is detected during secondary controls by the authorities, the rapporteur him/herself is fined.

This as-built reporting allows to take into detailed account the real properties of the materials and appliances that have been used in the project. In this way, the actual performance and quality can be valorised, and the market is stimulated towards products with better EPB-properties.

Specifically with respect to the summer situation, it should be noted that the Belgian climate is generally very mild. Many years, the number of hot days in summer (with temperatures exceeding 25°C) is only a handful. And only once every few years, hot spells totalling more than 2-3 weeks occur. The long-term average monthly temperature in July is no more than 18°C.

2 Evaluation of summer comfort in the EPB-regulation

For dwellings (including each individual apartment) a summer comfort indicator is calculated. In addition to the data already required for the heating calculations (thermal mass, insulation, air tightness, ventilation devices and window properties such as g-value, area, orientation/slope and fixed shading), the only extra information that is needed concerns the characteristics of mobile solar protection devices, if present.

The method calculates on a monthly basis the non-utilisable total gains for heating according to EN ISO 13790. These are then normalised through division by the overall heat transfer coefficient for the typical summer situation, i.e. higher ventilation rates than required for purely hygienic purposes.
This result gives the number of degree-hours that the room temperature will exceed the heating set-point temperature. This in turn, is directly related to the number of hours exceeding the comfort temperature (e.g. 25°C), as has been demonstrated by German doctoral research by S. Kolmetz in the '90s.

[1] VEROZO: Belgian professional association of shutter and solar protection manufacturers.

More recently, G. Dupont et al. in Belgium have shown that the monthly normalised non-utilisable gains are also reasonably well correlated to the adaptive thermal comfort as calculated by means of hourly simulations. This is shown in Figure 1.

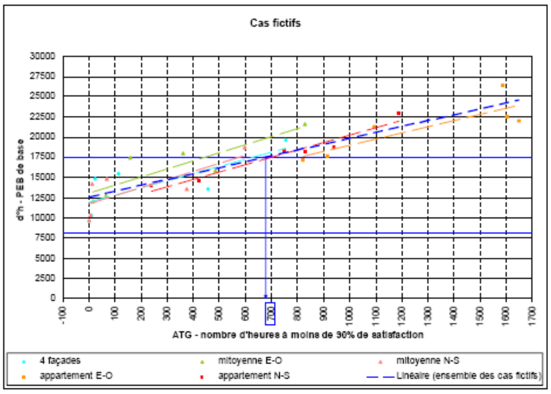

Figure 1 EPB-overheating indicator versus the number of hours with more than 10% dissatisfied persons. Source: G. Dupont et al.

The EP-regulations impose a maximum limiting value on the overheating indicator (equal to an annual value of 17500 Kh), independently whether active cooling is installed or not. This requirement is not very strict. So, exceeding this maximum is considered absolutely unacceptable. If the requirement is not fulfilled, the design should be modified (e.g. by integrating solar protection devices, or by reducing window area that is critically oriented). If in the as-built reporting to the authorities at the end of construction, the requirement is still not satisfied, an automatic financial fine ensues, proportional to the degree of transgression of the maximum value (0.48 euro per 1000 Kh and per m³ volume that the maximum is exceeded).

The main deficiency of the method until now is that (unlike solar protection devices and thermal mass) provisions for intensive ventilation are not yet integrated in the evaluation method. A (higher than hygienic, but) fixed ventilation rate is used, independent of any specific design provisions that may have been taken to facilitate intensive (night-time, or other) ventilation. A research project (EPICOOL) has started that will –among other things– look for a solution to this issue. Some challenges are:

- easy ways to quantify the opening area of windows or other ventilation openings (fully open, tilted, etc.) so that it does not become too time intensive for the user of the method
- realistic opening times of the windows etc. (e.g. to what extent –fully open, tilted, ...– can they be safely left open during absence and at night)
- associate realistic air flow rates with these areas and opening times
- integrate mechanically aided intensive extraction into the method

3 Cooling in the EPB-regulation

The present Belgian calculation method predates the last version of EN ISO 13790, but the monthly calculation basically applies a similar method, even if the numerical values of the parameters may be slightly different from the definitive numbers in the standard.

A specific feature in the Belgian method is the fact that consumption for cooling is sometimes taken into consideration, even if there is no active cooling device installed: this is called "fictitious cooling".

For dwellings, the method is as follows. If no cooling is installed during the construction phase, but if the risk of overheating exceeds a certain threshold value, it is considered that the chances are real that active cooling will still be installed later on during the life-time of the building. Therefore, with a mounting value of the overheating indicator, an increasing probability is associated that active cooling will be installed later. The cooling needs are then multiplied with this conventional probability factor.

This is illustrated in Figure 2: below the threshold value of 8000 Kh for the overheating indicator, the risk of overheating is considered so small that the conventional probability is set equal to zero. Above the maximum allowed value (which is forbidden, but which may occur anyway if the requirement is not being respected), the probability is set to 1. In between, it increases linearly from 0 to 1.

In this manner, a stimulus remains for designers to do better than the maximum allowed value for the overheating indicator. Only when the value drops below 8000 Kh, no further stimulus remains. In this way, the EPB-regulation encourages good summer thermal comfort, beyond the basic obligation. Obviously, if active cooling is installed during the construction, the probability is set to the fixed value of 1, independent of the value of the overheating indicator.

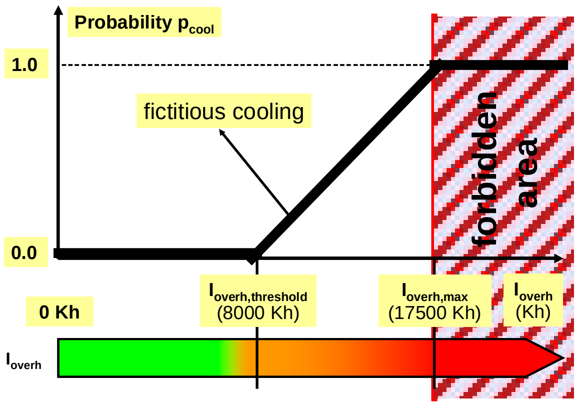

Figure 2 Conventional probability of a posteriori installation of active cooling as a function of the overheating indicator.

For offices and schools (as yet, there are no EPB-requirements for other types of non-residential buildings in Belgium), a more rudimentary concept of fictitious cooling is applied. The previously mentioned project, EPICOOL, will also investigate whether the methodology for dwelling can be extended to non-residential buildings.

A specific feature of the cooling method is also that for some variables different default values are used from those applicable for heating calculations, e.g. in dwellings:

- the default reduction factor for fixed shading is only 0.8 compared to 0.6 for heating
- the default air tightness is zero -i.e. the limiting case of perfect air tightness-, compared to the negative 12 m³/h/m² for heating calculations. Performing an air tightness measurement resulting in an intermediate value, will thus always improve the overall energy performance.
- once thermal bridges will be taken into account in the method (not yet applicable at present), it is foreseen to set their values equal to zero for summer calculations (compared to a rather high value for heating calculations)

This is in line with the basic philosophy that a default value is always on the negative side. Applying this principle to heating and cooling calculations separately, thus leads to different numeric values for both situations.

4 EPB-product database for solar protection devices

Context of the EPB-product database

The EPB-product database (www.epbd.be) is a common service offered by the 3 regional authorities to the building actors to give them, in a synthetic and convenient manner, product data to be used in the framework of the EPB-calculations. The use of the product data from the database avoids that the person in charge of the final (i.e. as-built) calculations in the EPB-declaration needs to address each time the producer or supplier for a specific product data.

In the database different products are covered (or will be in the future): building materials (insulating materials and other opaque materials), window components (glazings, frames and **solar protection devices**), heating devices, ventilation components, luminaires, etc.

The acceptance of a product data in the EPB-database is based on a certain number of requirements (accreditation of the testing body, determination of the performances according to the European standards, etc.), which should assure a good accuracy of the product data. If the requirements are fulfilled, then the product data are approved by the regional authorities in the framework of the EPB-calculations. This acceptance does not mean that the regional authorities give any judgment on the quality of the product. Only the characteristics considered in the EPB-regulation are mentioned in the database.

The publication of product data in the database is voluntary: the person responsible for placing building products on the market has a free choice to have the data of his products recognized in the database or not. Neither has the person in charge of the final EPB-calculations any obligation to use only the product data of the database.

Solar protection devices

For each product data mentioned in the EPB-database, the following information is given :

- information on the product identification: type of solar protection device, commercial name of the product, website, etc.
- product characteristics: solar transmittance τ_e, solar reflectance ρ_e at both sides and thermal resistance R_{sh} (if any) of the solar protection device alone.

Knowing the solar transmittance and reflectance of the solar protection device and the properties (thermal transmittance "U_g-value" and solar factor "g-value") of the glazing, the solar factor g_{tot} of the combination 'solar protection device & glazing' can be calculated according to the European standard EN13363-1:2003+A1:2007. The shading factor F_c is the ratio of the solar factor g_{tot} of the combination 'solar protection device & glazing' to that of the glazing alone g.

$F_c = g_{tot}/g$

The use of detailed product data (from the database) allows to determine a more favourable g-value and F_c value than the default values proposed in the regulation (since the default values are by definition on the negative side). As an illustration, Figure 3 shows the shading factor F_c calculated on the basis of measured solar properties of more than 3000 external solar protection devices (of the type 'fabric') available on the Belgian market. It shows that for high quality screens the calculated F_c is always lower than the default value of 50%. Figure 4 shows the results for more than 800 internal screens. Both figures are for a glazing with U_g = 1.2 W/m²K and g = 0.59.

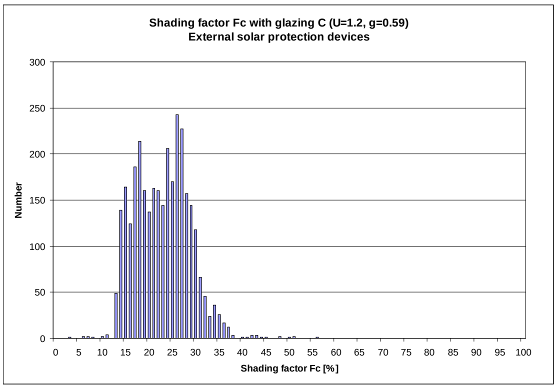

Figure 3 F_c for external solar protection devices

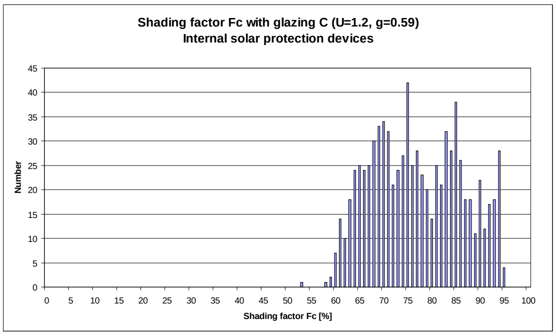

Figure 4 F_c for internal solar protection devices

5 Financial incentives for solar shading devices in Belgium[2]

Different forms of financial support for the installation of solar protection devices exist. These may be measures that apply to any construction activity. Others are targeted to energy savings in general. Finally, some are specifically for solar protection devices. The measures emanate from both national (federal) and regional bodies. These different measures are independent and cumulative. The present situation (spring 2009) is summarised in the table below. The support measures tend to change from year to year.

Unlike for a number of other energy saving measures (insulation, PV, ...), there are no additional subsidies given by provinces or communes for solar protection devices.

Figure 5 illustrates the subsidies given to new dwellings in Flanders when they achieve an E-level below E80, as listed in the table. (The maximum allowed E-level in 2009 is E100.)

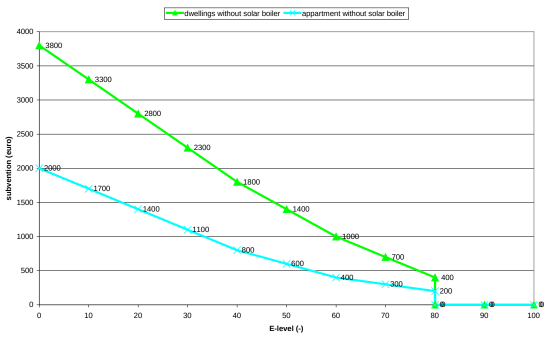

Figure 5 Flemish subventions as a function of the E-level

[2] Information contributed by VEROZO.

Federal		
		VAT reduction for renovations: • 6% instead of 21% • building at least 5 years old • valid until 31 Dec. 2010 • general measure, incl. solar protection devices and shutters
		VAT reduction for new construction: • 6% instead of 21% • anti-crisis measure • valid in 2009 only • valid for dwellings only • up to a maximum amount of 50keuro/dwelling • general measure, incl. solar protection devices and shutters
		personal income tax reduction • for passive houses • but nothing directly for solar protection devices (unlike a number of other energy saving measures)
Regional		
	Flanders	
		a number of electricity distributors: • for existing dwellings • 10 euro/m² solar protection devices • $F_C \leq 0.5$ • south, southeast, southwest
		a number of electricity distributors: • for new dwellings • the lower below E80, the higher the subsidy: see Figure 5 • on the basis of EPB-report (as-built dossier)
		property tax reduction • if building permit since 1/1/2006 • if below E60, 20% reduction during 10 years • if below E40, 40% reduction during 10 years • on the basis of the EPB-report (as-built dossier)
	Brussels	
		the electricity distributor: • for existing and new dwellings • 30 euro/m² solar protection devices, max 50% of invoice • $F_C \leq 0.3$ • east, south, west
	Wallonia	
		no subsidies at present

6 Perception of the Belgian market by the sector and impact of the EPB-regulations[3]

The Belgian construction market is a mature, medium-sized market, dominated by SMEs. There is an on-going tendency towards a more holistic approach of solar protection systems (including shutters) together with glazing, frames, lighting (control) systems and ventilation. But the sector is still seeking a better understanding of the impact of intelligent control on energy savings for cooling, lighting and heating. An intenser exchange of foreign experiences is now leading to a synthesis of the parameters determining the performance of solar protection.

The sector deplores the segmented introduction of the EPB-regulations in each of the 3 regions. This has lead to delays in Brussels and Wallonia. But positive is that solar protection is being considered in the EPB-calculations of each of the 3 regions, as a contributing factor to the reduction of overheating and of the cooling needs. However, the sector has the feeling that the impact of solar protections devices on overheating and cooling is maybe underestimated in the calculation methods.

In the calculation method a standard distinction is made between external, intermediate and internal solar protection, but the default values are rather negative. However, the impending activation of an EPB-product database for solar screens may offset this drawback, especially if an automatic link can be made with the official EPB-calculation software programmes.

Further development of the sector could be backed up by financial support for continued product development and for studies that show the advantages of solar protection devices. Also a standard mentioning of solar protection as energy saving measure on EPCertificates would support the sector.

[3] Information contributed by VEROZO.

7 Summary

Since a few years, the EPB-regulation is slowly but surely being rolled out in Belgium. The regulation strongly increases, in a systematic way, the attention that designers pay to summer thermal comfort, and the energy consumption caused by cooling.

In addition to the mandatory evaluation of the overheating risk and the imposition of an explicit requirement, the use of the concept of fictitious cooling has been instrumental to achieve this result. The introduction of an as-built report creates a context to validate real product performances.

The process of valorising the actual performance of product characteristics is now greatly facilitated by the establishment of a central product database, recognised by each of the 3 regions. Through its association, the solar shading companies are actively contributing to this work.

Complementary to that, a range of financial supports given by different authorities further stimulate the market for solar protection devices. A streamlining of the measures might improve their impact.

Further progress could be achieved by more future convergence among the 3 regions in their EPB-regulations. The sector can improve its products and services by acquiring a better understanding of the interaction between solar shading on the one hand and heating, overheating, cooling, lighting and ventilation on the other hand.

8 References

- S. Kolmetz, Thermal evaluation of buildings under summer conditions – A simplified method for the determination of room temperatures in buildings in summer and their frequency. Doctoral thesis, University Kassel 1996
- G. Dupont, S. Nourricier, M. Dipietrantonio, V. Feldheim, P. Lybaert, J.-M.Hauglustaine, Study of an additional criterium for the evaluation of overheating of buildings in the framework of the study on comfort in summer conditions. January 2007 (in French).
- EN13363-1:2003+A1:2007. Solar protection devices combined with glazing – Calculation of the solar and light transmittance – Part 1: simplified method.
- www.verozo.be see "premies".
- www.epbd.be (in Dutch and French) All information about the Belgian EPBD-product database: procedures for submitting data and recognised data.

9 Acknowledgments

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Workshop 'Summer comfort and cooling'
Barcelona, 31 March – 1 April 2009

Some Aspects Regarding Summer Comfort and Cooling in Belgium

ASIEPI

Intelligent Energy Europe

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Overview

- Introduction: Belgian context
- Evaluation of summer comfort
- Cooling
- Product database for solar protection devices
- Financial incentives
- Perception of the Belgian market by the sector and impact of the EPB-regs

Belgian context

- each of the 3 regions (Brussels, Wallonia and Flanders) is independently in charge of the building and (most) energy policy
  ➔ also for EPBD-implementation
- the regions have their own variations
- but specifically for summer comfort and cooling the technical procedures have not been altered and are thus identical
- so this presentation is +/- equally valid for all 3 regions

Belgian context: compliance and control

- with previous thermal insulation regs → poor compliance during construction was observed
- therefore: with introduction of overall EPB-regs:
  - drive for better compliance
  - shift of focus from the demand for building permit to the as-built situation

EPB-declaration

- for every project: upon completion of the works, an as-built report must be submitted: the so-called "EPB-declaration"
- drawn up by a rapporteur, assigned and paid by the by building owner
- all input for EPB-calculations must be given + results of the calculations: to what extent are all requirements met?
  - Flanders: EPB-declaration must be uploaded on central server and is automatically processed
- in case of non-compliance: stiff financial penalty for the building owner
- in case of incorrect reporting (secondary sample controls by the authorities): fine for the rapporteur

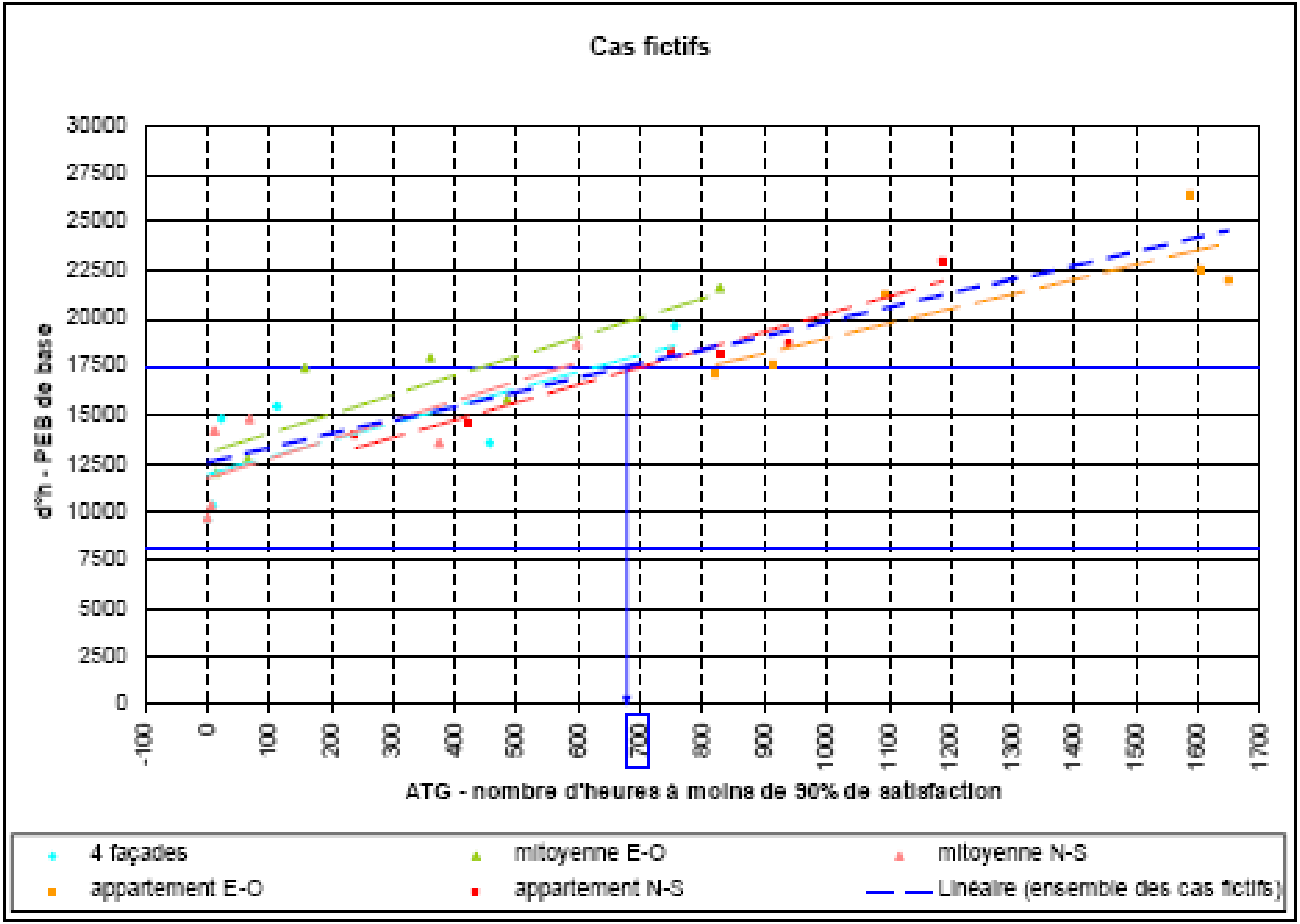
Belgian climate

- generally: mild summer weather
- average July temperature (long-term): not even 18°C
- typically only a handful days with temperatures above 25°C occur
- only every few years hot spells of 2-3 weeks occur
- even then, the minimum temperature drops below 20°C on nearly all nights

Evaluation of summer comfort

- done for dwellings (incl. each individual apartment)
- indicator: non-utilisable total gains above the heating set-point (18°C) + normalisation through division by the overall heat transfer coefficient (transmission + ventilation) under summer conditions
- based on German doctoral research in the '90s
- gives the number of degree-hours that the room temperature will exceed the heating set-point temperature
- is also directly related to the number of hours exceeding the comfort temperature (e.g. 25°C)

Overheating indicator versus number of hours with 10+% discomfort (hourly simulations)



Summer comfort requirement

- maximum is imposed (17500 Kh)
  - ➔ if not satisfied, change design, e.g.
    - by integrating solar protection devices,
    - by reducing window area that is critically oriented
    - by increasing the thermal mass
- 17500 Kh is not very strict
- but automatic fine in case of non-compliance
  - 0.48 euro per 1000 Kh and per m^3 of volume that the maximum is exceeded

Overheating indicator

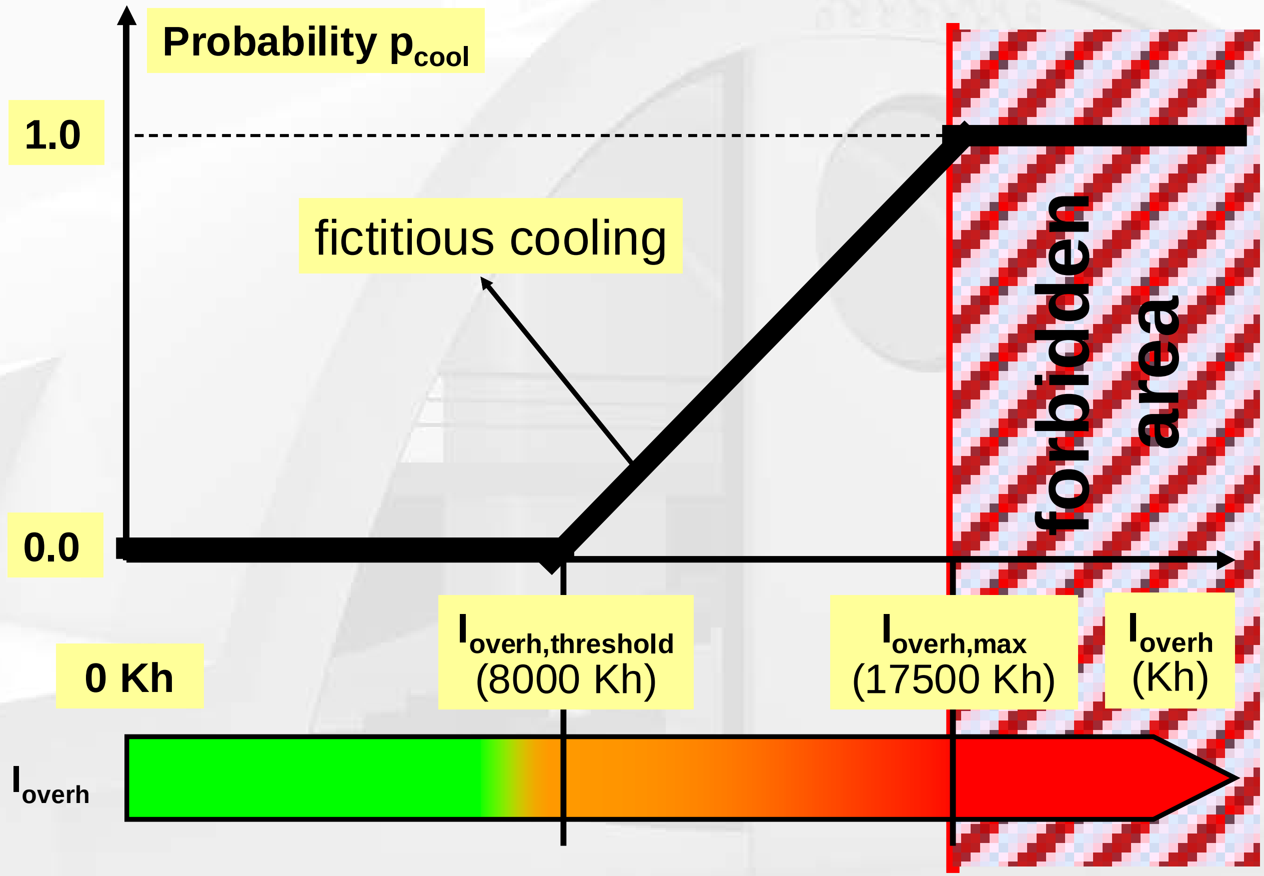
- present deficiency: alternative cooling techniques are not considered, in particular intensive ventilation (night-time, or other)
- subject of a new research project (epicool)
- some of the challenges:
  - easy ways to quantify the opening area (fully opened, tilted, ...)
  - realistic opening times, e.g. to what extent –fully open, tilted, ...– can they be safely left open during absence and at night
  - associate realistic air flow rates with these areas and opening times
  - integrate mechanically aided intensive extraction into the method
  - ...

Cooling

- as in EN ISO 13790
- special feature: fictitious cooling
- the following slides on fictitious cooling hold true for dwellings
  - for offices and schools a more rudimentary approach is used until now (but under evaluation in the epicool project)
- if no active cooling is installed upon construction, but if the overheating indicator exceeds a threshold value
- ➔ chances are that active cooling will be installed later on in the project
- ➔ already integrated in the initial evaluation with probability factor

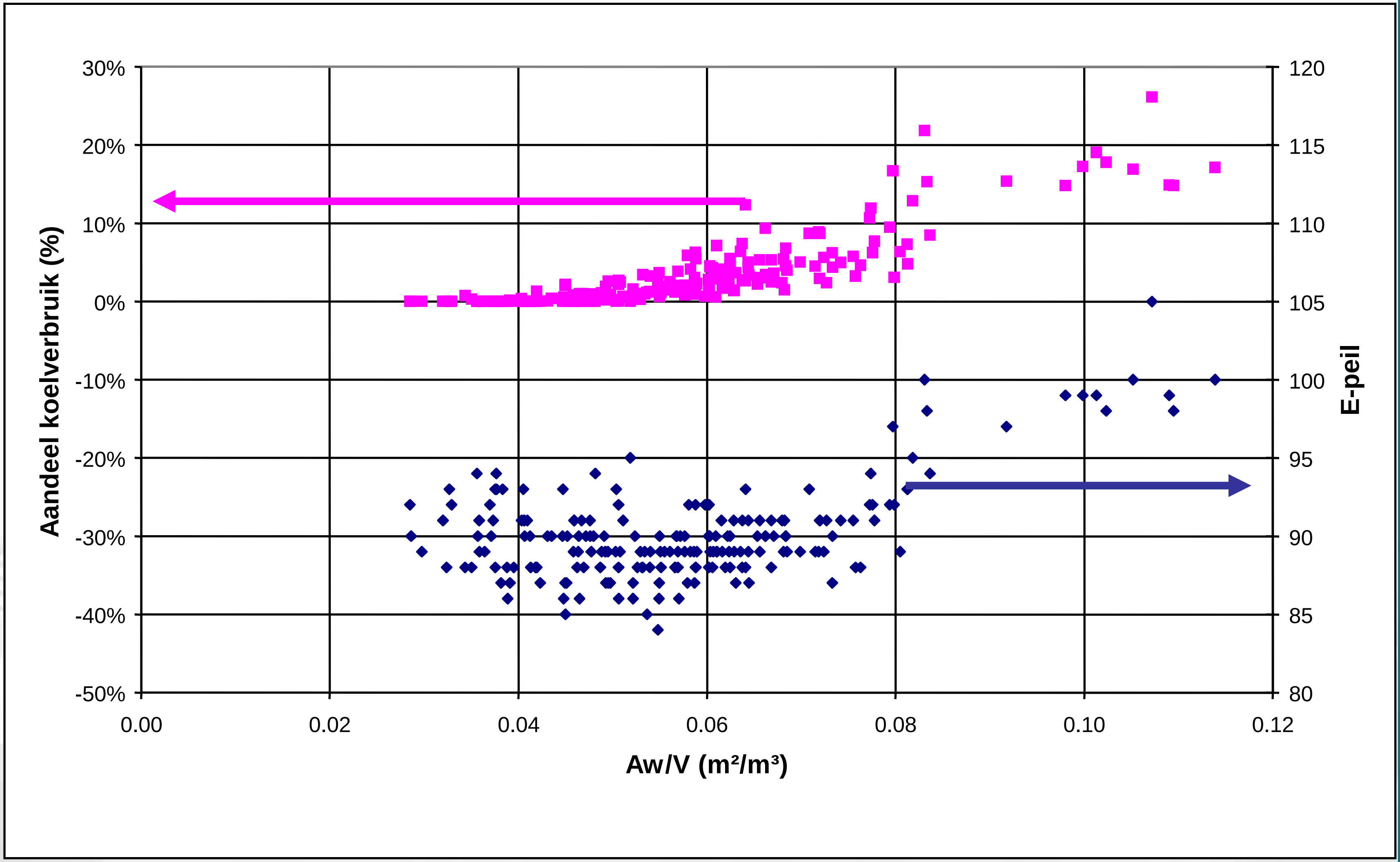
Conventional probability function

- if no active cooling



- if active cooling p=1

Impact of glazing size: without solar protection



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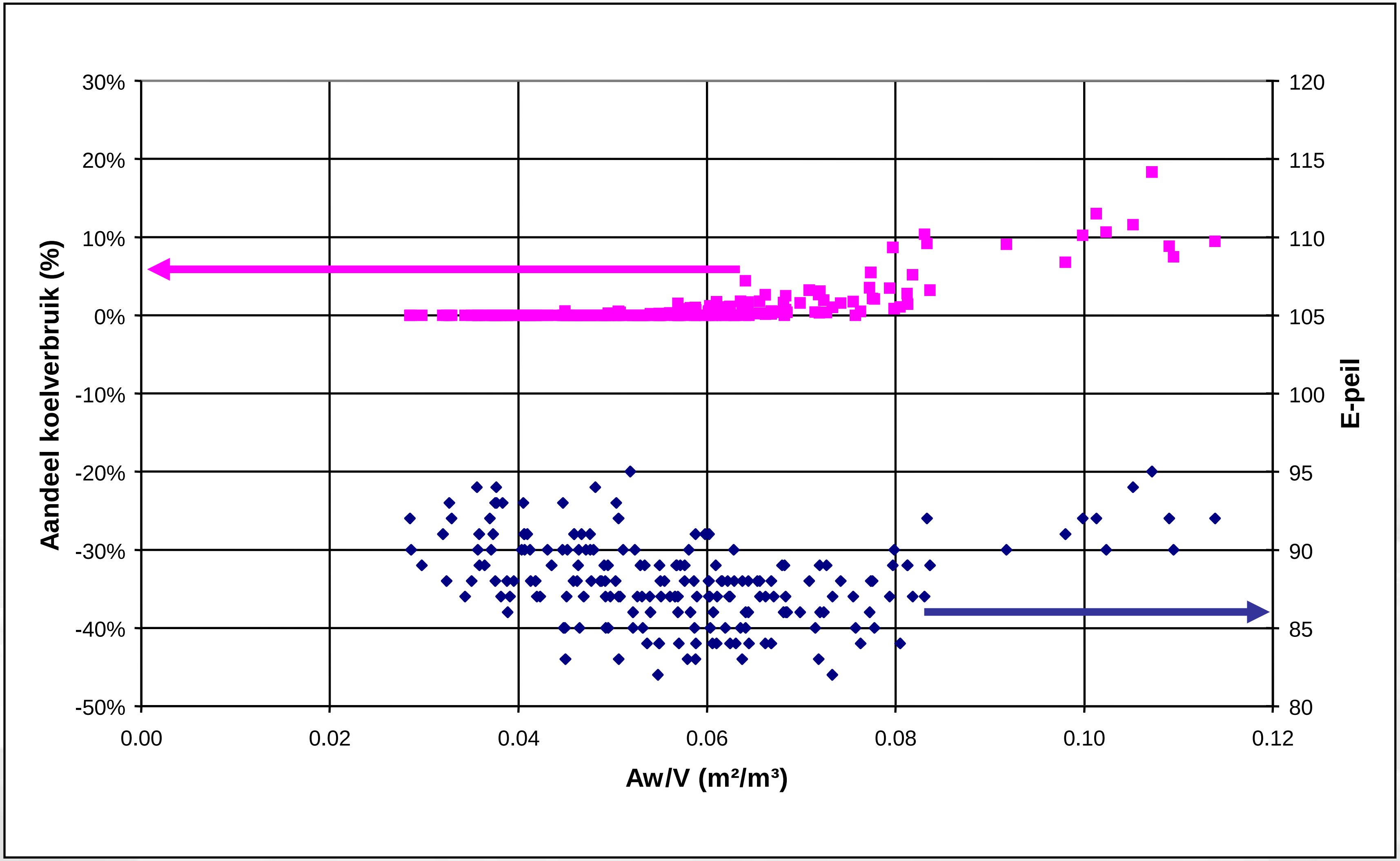
Impact of glazing size: with solar protection



Cooling: default values for input variables

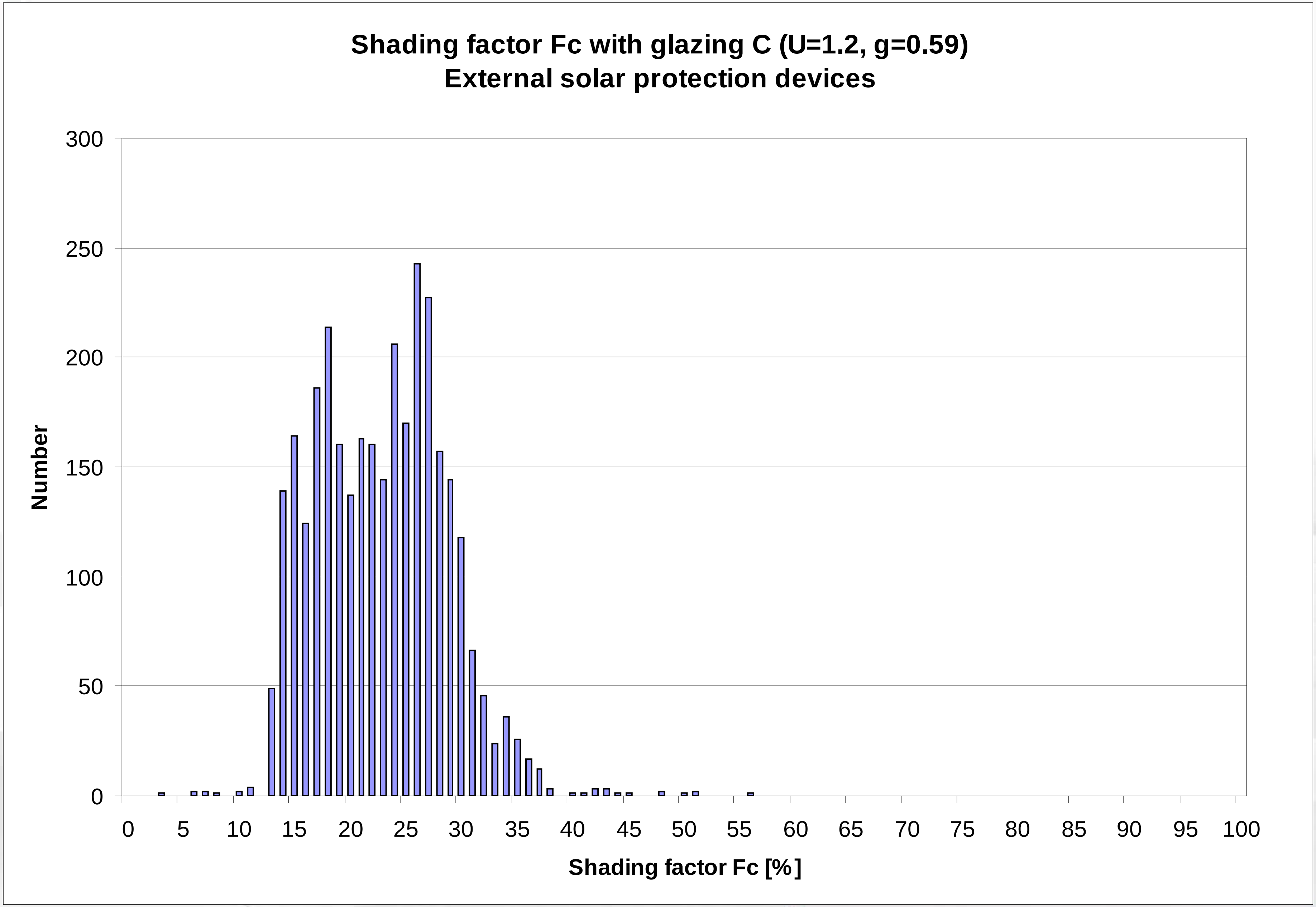
- in principle: always on the negative side
- but “negative” is different for heating and cooling
- for the major variables
  - the default reduction factor for fixed shading is only 0.8 compared to 0.6 for heating
  - the default air tightness is zero -i.e. the limiting case of perfect air tightness-, compared to the negative 12 $m^3/h/m^2$ for heating calculations. Performing an air tightness measurement resulting in an intermediate value, will thus always improve the overall energy performance.
  - once thermal bridges will be taken into account in the method (not yet applicable at present), it is foreseen to set their values equal to zero for summer calculations (compared to a rather high value for heating calculations)

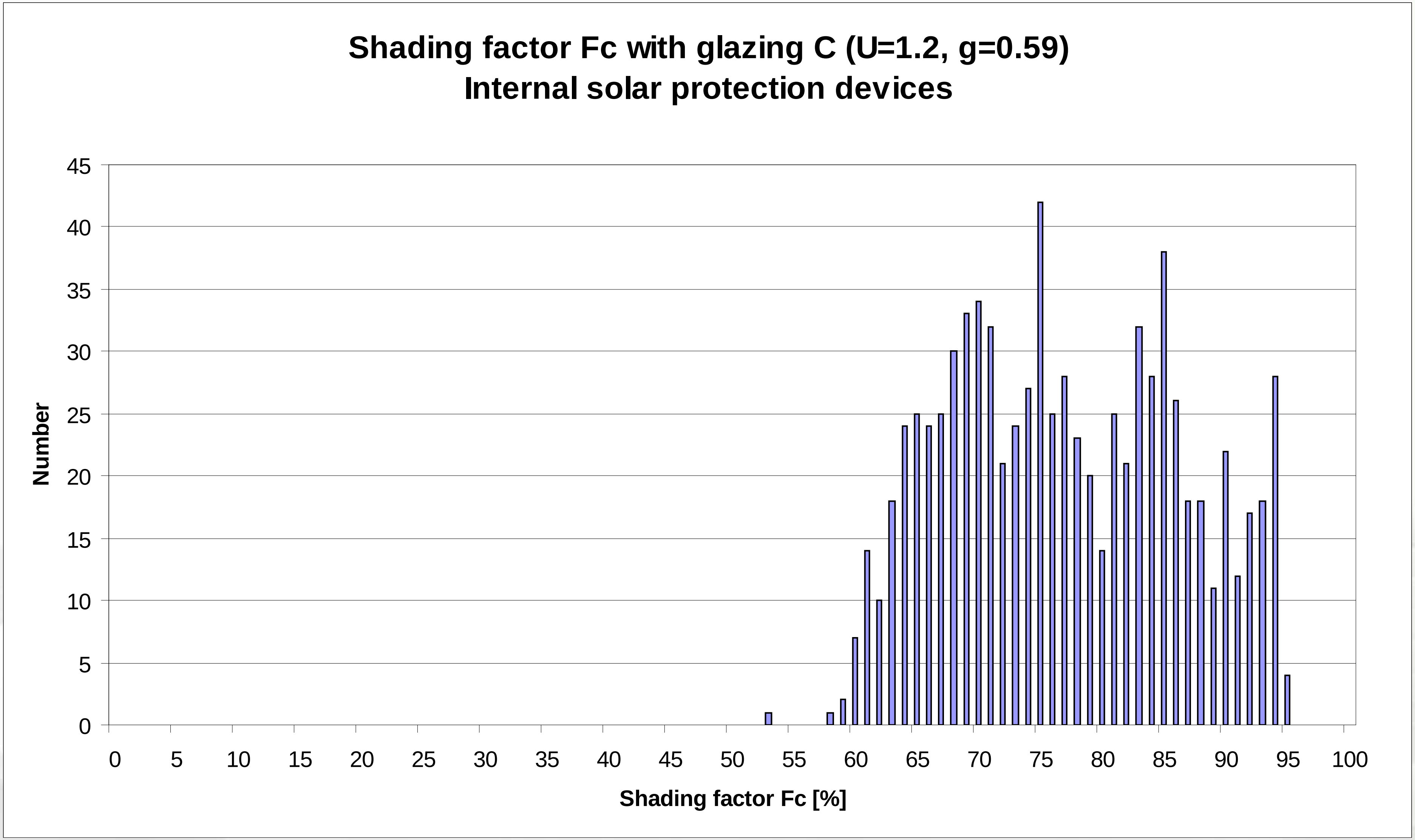
Product database for solar protection devices

- as-built dossier ➔ performance of individual product can be valorised
- need for reliable data
- common service of the 3 regions to the rapporteurs, industry and designers: published figures will not be discussed anymore in an EPB-declaration
- certain check of correctness of data (3rd party or CE)
- voluntary database of products:
  - insulation and other opaque materials
  - windows: glazing, frames and **solar protection devices**
  - ventilation products
  - etc.
- www.epbd.be: all info in French and Dutch

Product database for solar protection devices

- recently launched
- info:
  - product ID
  - solar transmittance τ_e,
  - solar reflectance ρ_e at both sides
  - and thermal resistance R_{sh} (if any) of the solar protection device alone
- together with U_g and g-values of the glazing, calculation of g_{tot} according to EN13363-1:2003+A1:2007
- definition of reduction factor: $F_c = g_{tot}/g$


Shading factor Fc with glazing C (U=1.2, g=0.59)
External solar protection devices
300
250
200
150
100
50
0
Number
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Shading factor Fc [%]


Shading factor Fc with glazing C (U=1.2, g=0.59)
Internal solar protection devices
Number
0
5
10
15
20
25
30
35
40
45
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Shading factor Fc [%]

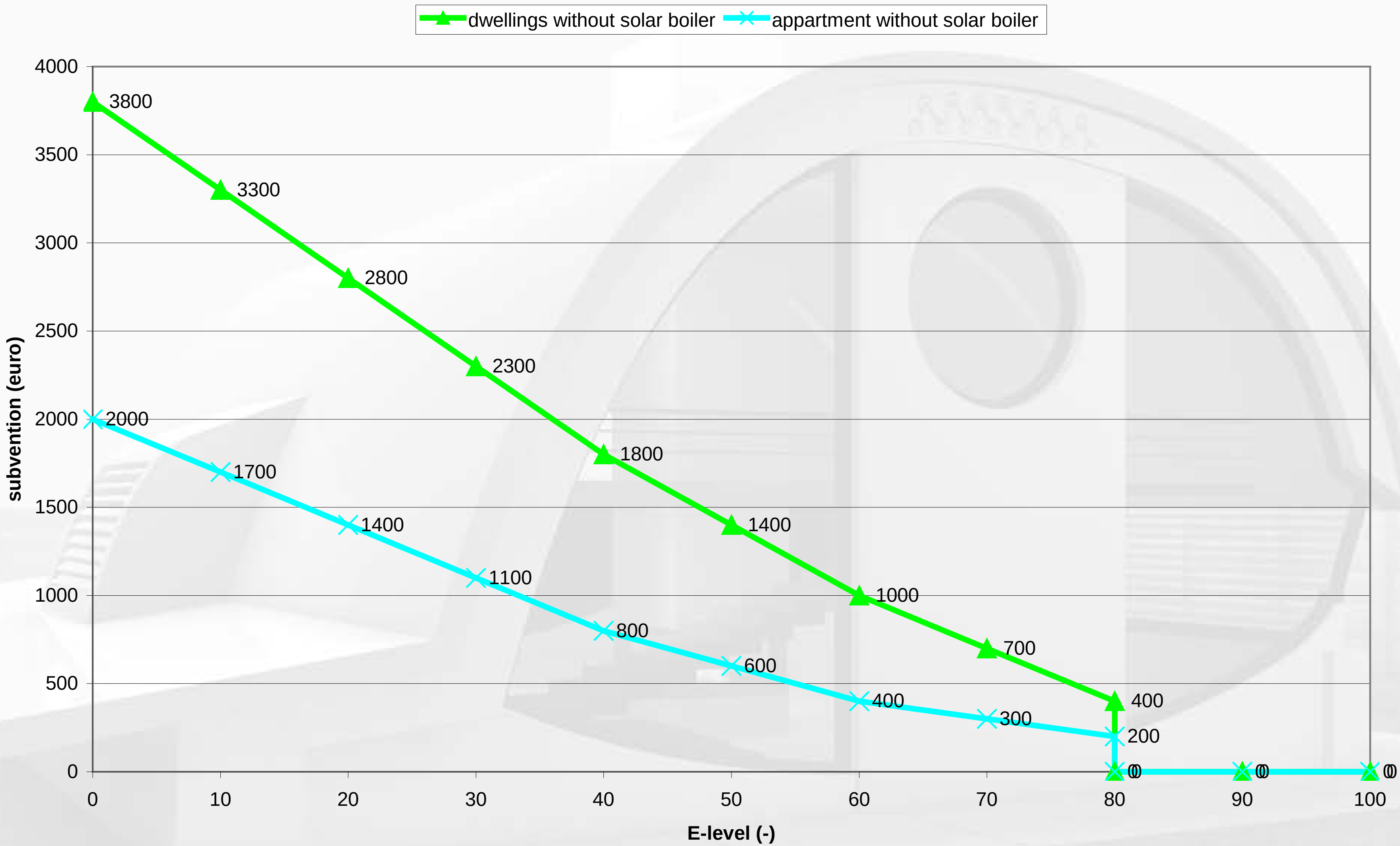
Financial incentives: federal (info: VEROZO)

- VAT reduction for renovations:
  - 6% instead of 21%
  - building at least 5 years old
  - valid until 31 Dec. 2010
  - general measure, incl. solar protection devices and shutters
- VAT reduction for new construction:
  - 6% instead of 21%
  - anti-crisis measure
  - valid in 2009 only
  - valid for dwellings only
  - up to a maximum amount of 50keuro/dwelling
  - general measure, incl. solar protection devices and shutters
- personal income tax reduction
  - for passive houses
  - but nothing directly for solar protection devices (unlike a number of other energy saving measures)

Financial incentives: regional (info: VEROZO)

- **Flanders**
  - a number of electricity distributors:
    - for existing dwellings
    - 10 euro/m² solar protection devices
    - $F_C \leq 0.5$
    - south, southeast, southwest
  - a number of electricity distributors:
    - for new dwellings
    - the lower below E80, the higher the subsidy: see Figure next slide
    - on the basis of EPB-report (as-built dossier)
  - property tax reduction (Flemish government)
    - if building permit since 1/1/2006
    - if below E60, 20% reduction during 10 years
    - if below E40, 40% reduction during 10 years
    - on the basis of the EPB-report (as-built dossier)
- **Brussels**
  - the electricity distributor:
    - for existing and new dwellings
    - 30 euro/m² solar protection devices, max 50% of invoice
    - $F_C \leq 0.3$
    - east, south, west
- **Wallonia**
  - no subsidies at present
- no financial aid from provinces or communes (unlike other efficiency measures)

Flanders: 2009-subvention for dwellings according to their EP-level



Legal requirement in 2009: EPmax = 100

Assessment of the Belgian market by the sector (info VEROZO)

- mature market, dominated by SMEs
- on-going tendency towards a more holistic approach of solar protection systems (including shutters) together with glazing, frames, lighting (control) systems and ventilation
  - but still a lack of understanding on these issues
  - international collaboration is expected to fill the gap
- request for continued financial support for product development
- solar protection as standard suggestion for improvement on EPCs

Evaluation of the EPB-regs by the sector (info VEROZO)

- good that solar protection devices are considered in the methods of all 3 regions, but divergences (timing of implementation, ...) among them are regretted
- default values for F_C are too negative, but the new database with real data may overcome this issue
  ➔ automatic link with software would greatly facilitate this
- some other aspects of the model in the EPB-regs are questioned since the impact of solar protection devices on overheating and cooling is less than expected

Acknowledgements and disclaimer

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  - the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.
  - The Belgian participation to ASIEPI is co-financed by the
    - Federal Public Service Economy, SME's, independent Professions and Energy,
    - the Flemish Region,
    - the Walloon Region
    - and the Brussels-Capital Region.

- The sole responsibility for the content of this presentation lies with the authors. It does not necessarily reflect the opinion of the European Communities. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein.

A manufacturer's view

AIVC workshop: summer comfort cooling, Barcelona, 2009

Brand and Trademarks

The brand under which Daikin is operating	Another brand of the Daikin Europe N.V. group:	The brand under which McQuay is operating
DAIKIN	ROTEX	McQuay International

Daikin's famous trademarks

>25 Years

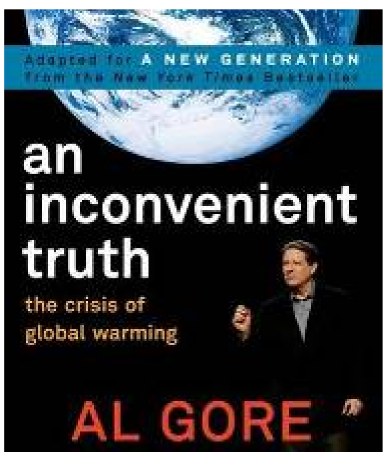
- VRV® — World's first inverter driven multi system for large commercial applications
- altherma™ — Daikin's entry in the residential heating market
- Ururu Sarara — World's first residential air conditioner including humidification and fresh air
- CONVENI-PACK — World's first refrigeration unit combining air conditioning and air curtains

>50 Years Heat pump

DAIKIN

Corporate social responsibility: Environment

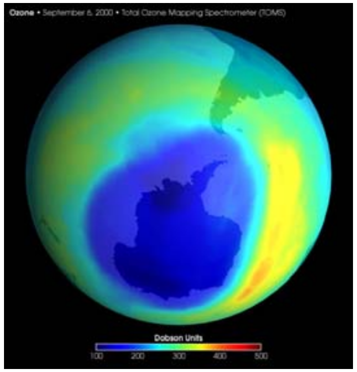
Global warming



DAIKIN

Environment : Major trends in International policies

1. Montreal Protocol : phase out ozone depleting substances → concern on high GWP refrigerant alternatives



UNEP

The ozone hole

2. Kyoto protocol & post Kyoto agreements : control of greenhouse gas emissions

→concern on high GWP refrigerants

→Opportunities for heatpumps

COP15 COPENHAGEN

UNFCCC

Global warming

DAIKIN

Environment: our Philosophy

Group Philosophy

Issue: August 2002

Our Group Philosophy

Striving to Be a Group that Continuously Evolves

DAIKIN INDUSTRIES, LTD.

6 Be a Company that Leads in Applying Environmentally Conscious Practices

As we continue developing our business operations in various fields, it is our mission to proactively develop initiatives to respond to environmental issues. Incorporating environmental initiatives throughout our management must be a priority for us.

In all aspects of our business operations, including product development, manufacturing and sales, we need to formulate initiatives that sustain and improve the environment. Meanwhile, we need to promote the development of new products and the innovation of technologies that will lead to a more environmentally healthy world.

Under the precept "environmental response is an important management resource," we must integrate environmental initiatives into our corporate management since they can lead to business expansion, improved business performance, and further enhancement of our credibility with outside parties. We intend to continue being a leading company in the practice of "environmental management," thus contributing to a healthier global environment as a good citizen of the earth.

In all of us, a green heart

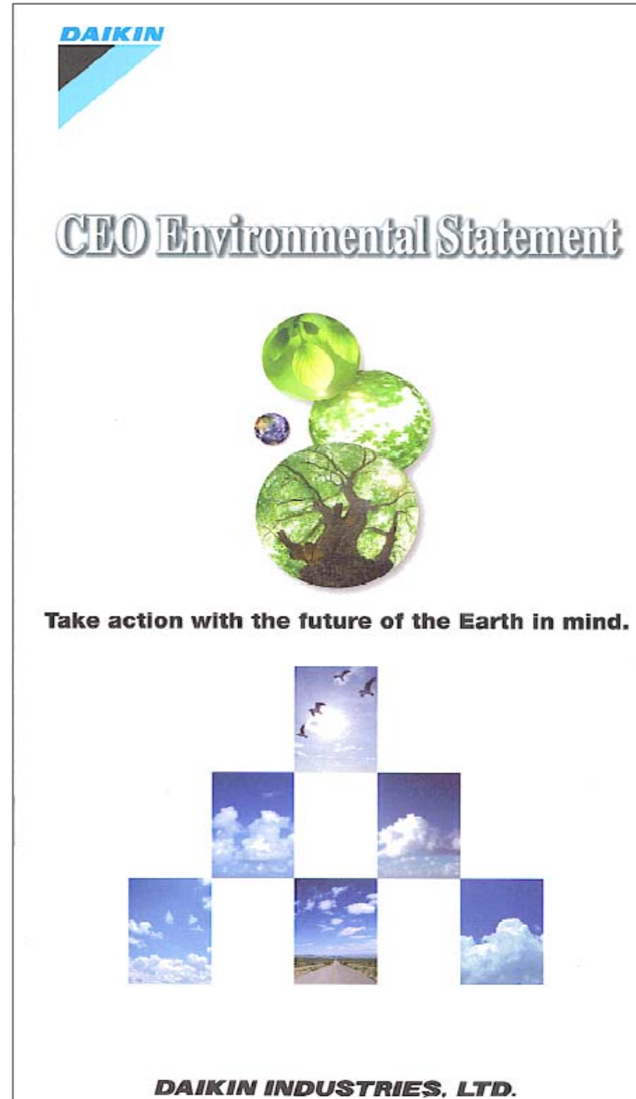
7

Environmental policy: Initiated and supported from the Top

Group Philosophy

CEO Environmental Statement

- Enhance our creativity centering on the environment
- Ensure environmentally conscious practices in all business activities.
- Take action with the future of the Earth in mind



DAIKIN

CEO Environmental Statement

Take action with the future of the Earth in mind.

DAIKIN INDUSTRIES, LTD.

DAIKIN

Environment: legislation

Legislator

Climate Change
- Climate Change Policy EC (2007)
- Regulation on fluorinated greenhouse gases (F-gases) (2006)

Energy efficiency
- Energy Policy of the EC (2007)
- Directive energy labelling (2002)
- Energy Performance on Buildings (2003)
- Ecodesign requirements (2010)

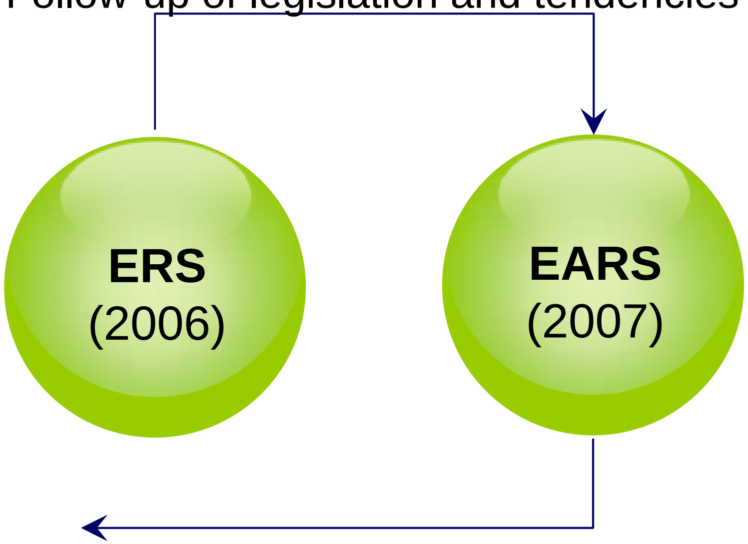
Energy source
- Directive on renewable energy (2009)

Dangerous Substances
- Directive on the restriction of Hazardous Substances (2006)
- REACH regulation (2007)

Waste
- WEEE (2005)

Environment: an example of our practices

Environment Research Centre



DAIKIN test house

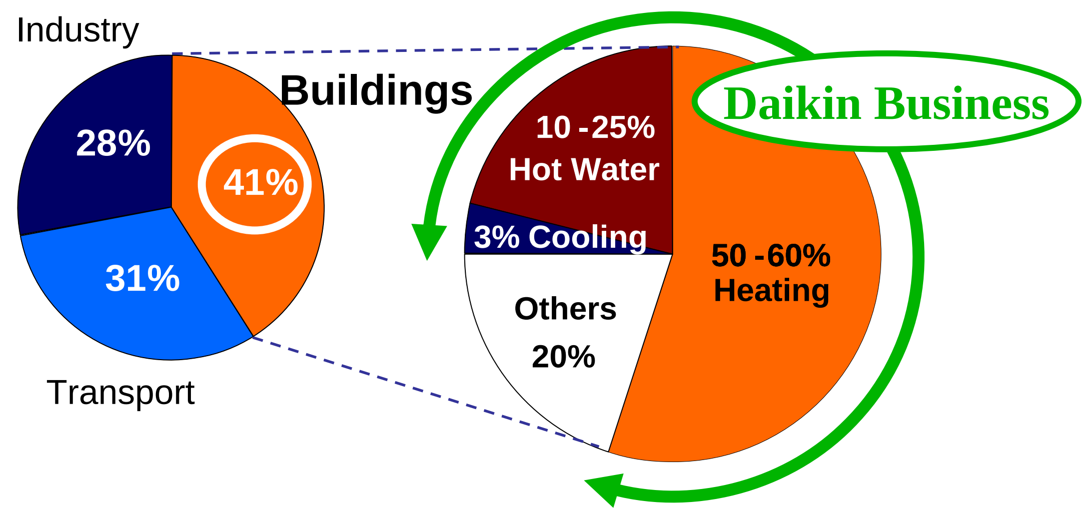
*ERS: Environmental Readiness Section
EARS : Environmental Application Research Section

DAIKIN

Environment: Daikin's span of responsibility

Importance for Daikin

Energy consumed in Europe



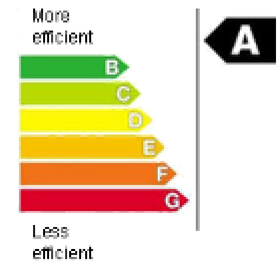
Environment: Our Vision

Turn the environmental developments into OPPORTUNITIES

Contribute to CO_2 reduction by promoting heat pumps

Reduce Environmental Burden from Business Activities

To be No.1 in high efficient product range



No.1 as HVAC-R energy solution consultant

Reduce impact of refrigerant emissions towards non-HCFC's

5 examples

DAIKIN

Environment: Our Vision

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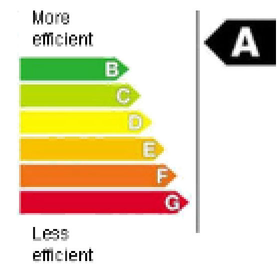

Reduce Environmental Burden from Business Activities

No.1 as HVAC-R energy solution consultant

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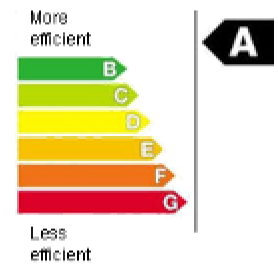


5 strategic directions

Pillar 1: Direct Expansion

Application overview

SPLIT Residential Applications

SKY AIR

Restaurants
Small Shops
Small Offices

VRV

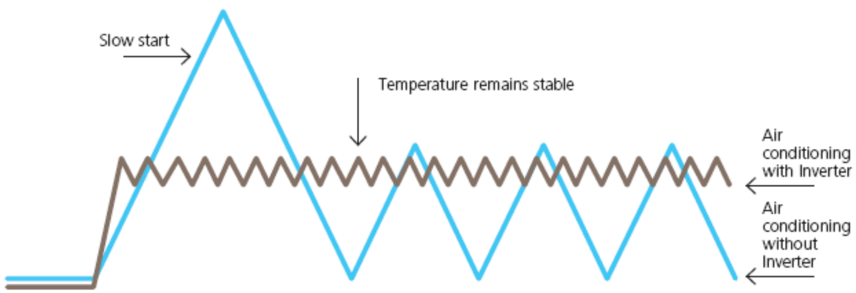
Offices
Hotels
Supermarkets

Pillar 1: Direct Expansion

1. Global Environment

- **New pair Split R-410A** models
  All Energy class A
- Obtaining **Ecolabel certification** for Altherma
- Focus on the incorporation of the **"Best Environmental Available Technologies"** (BEAT) in our development of new models

Highest efficiency in its segment



Pillar 1: Direct Expansion

2. Evolving Markets

Market focus of maturing market

- Health & Wellness
- Design & Aesthetics
- Perceived value of a brand

Ururu Sarara technology	• Humidity control and ventilation • Ururu Sarara Wall mounted & Split Wall mounted

Ururu Sarara®

Environment: Our Vision

Turn the environmental developments into OPPORTUNITIES

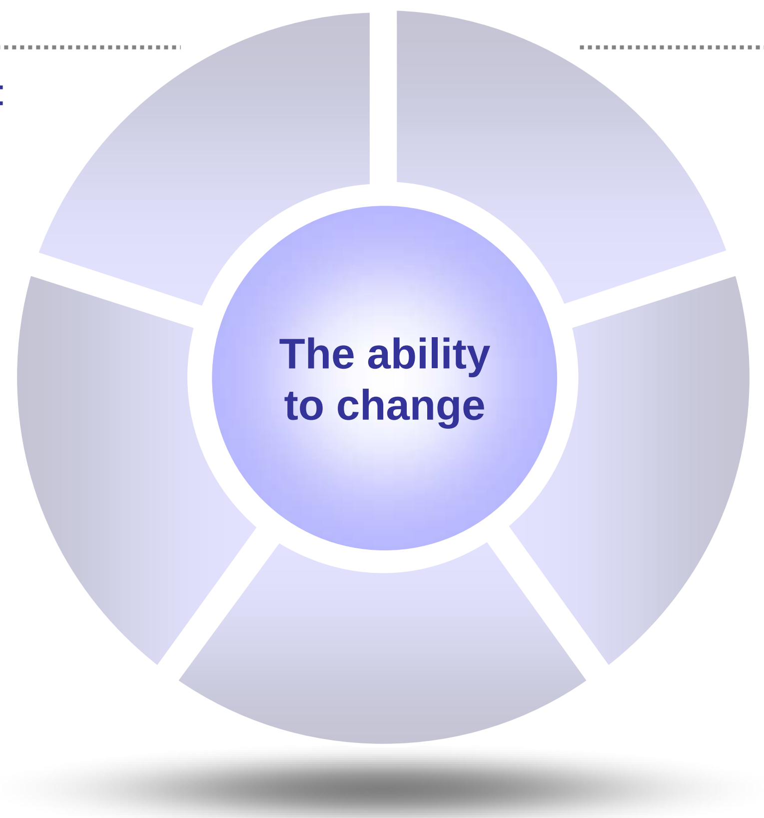
Reduce impact of refrigerant emissions towards non-HCFC’s

Daikin’s strength

CUSTOMER CENTRIC FOCUS

The unique position to develop:
(In)direct expansion,
compressors and refrigerants

A first class product supported
by a premium quality policy



Pre-sales support

After sales network

World coverage and presence
in the market

Environment: Our Vision

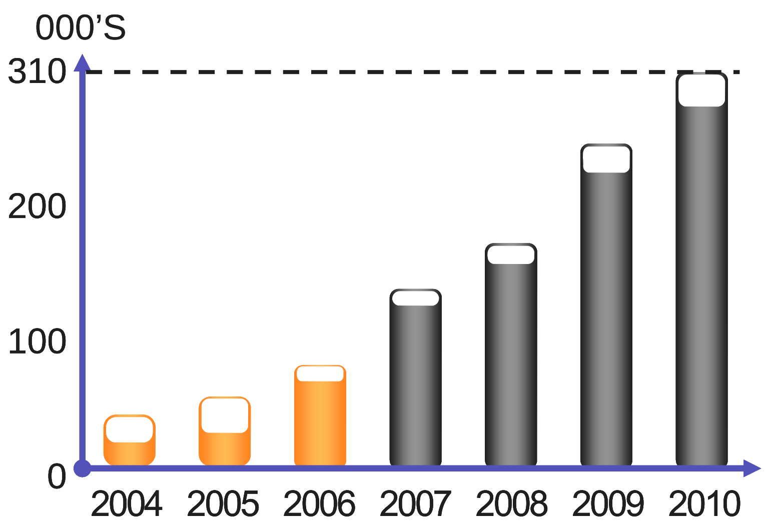
Turn the environmental developments into OPPORTUNITIES

Contribute to CO_2 reduction by promoting heat pumps

Pillar 3: Heating

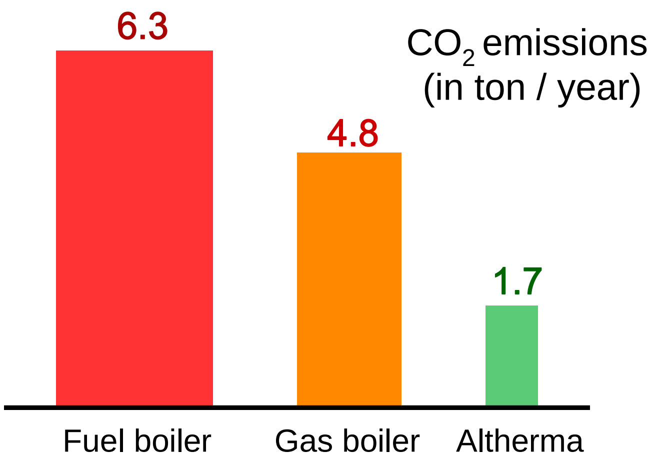
Market Trend

Trend: pressure from rising energy prices and on CO2 emissions makes that H/P market continues exponential growth



EU A/W H/P market: 2004-2006: BSRIA figures - 2007-2010: BSRIA forecast

Environmental advantage of Altherma™



Calculations under the following conditions: country: Belgium;
Electricity emission: 276 g CO_2/kWh;
gas emission: 202 g CO2/kWh;gas boiler efficiency: 90%;
fuel emission: 268 g CO2/kWh; fuel boiler efficiency: 90%

Pillar 3: Heating

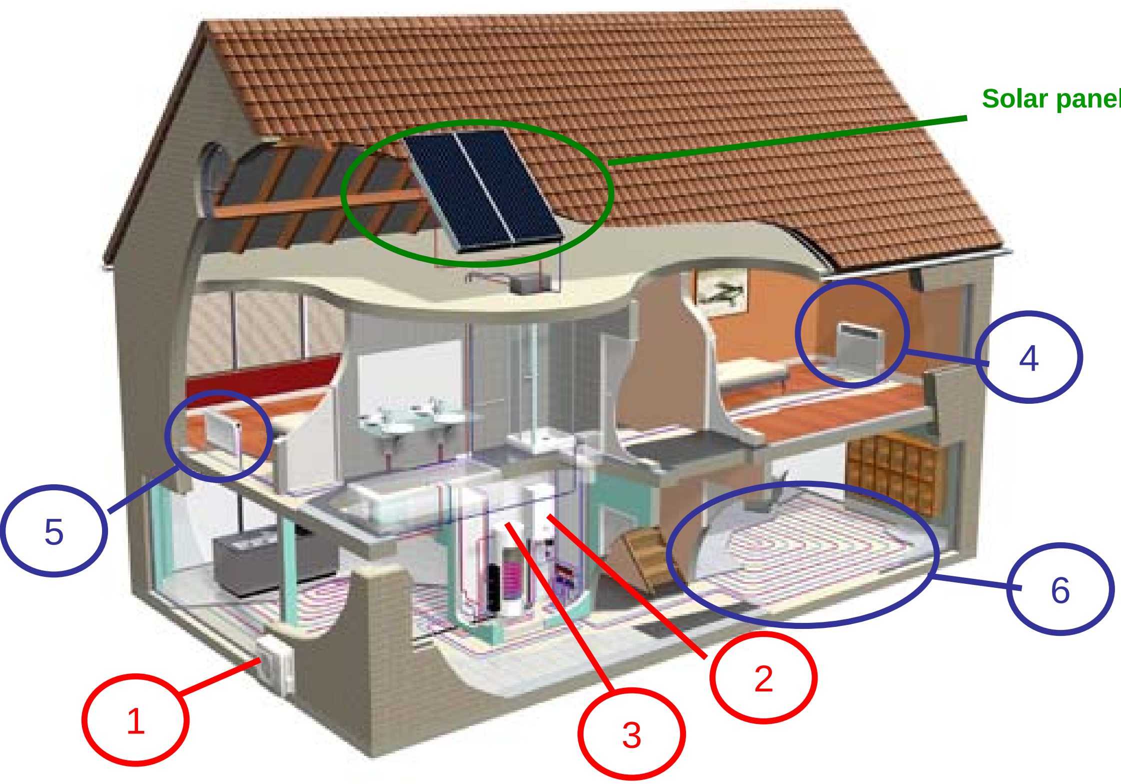
altherma™

"Altherma, the intelligent way to comfort"

Product concept

CAPACITY RANGE:

- room heating : 5.7 – 16.0 kW
- domestic hot water: 150 – 300 l
- room cooling: 5.1 - 13.0 kW



COMPONENTS:

1. Outdoor unit (6 types)
2. Indoor unit = Hydrobox
3. Domestic hot water tank (optional)

EMITTERS

4. Fan Coils
5. LT radiators
6. Floor heating

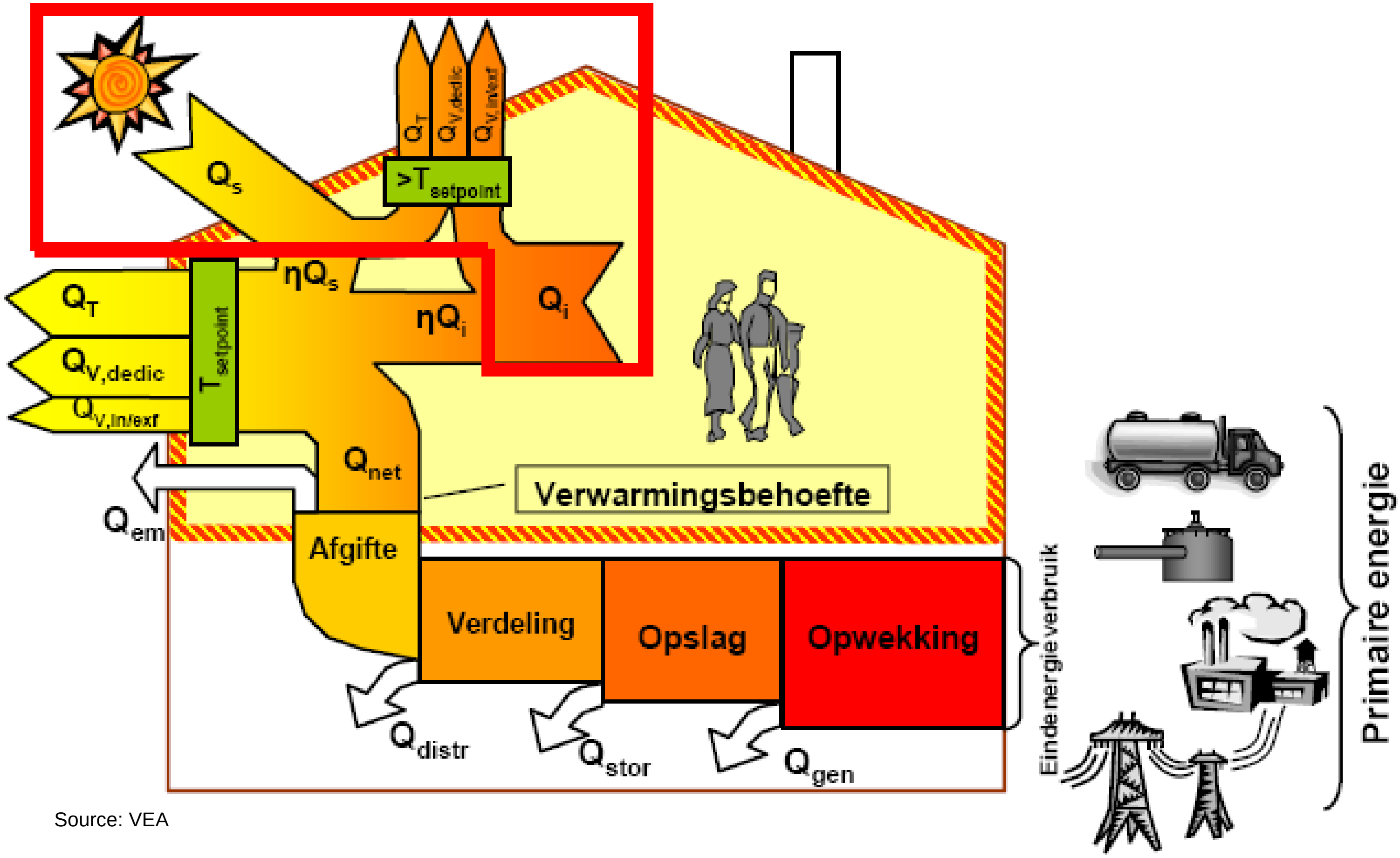
Environment: Our Vision

Turn the environmental developments into OPPORTUNITIES

Reduce Environmental Burden from Business Activities

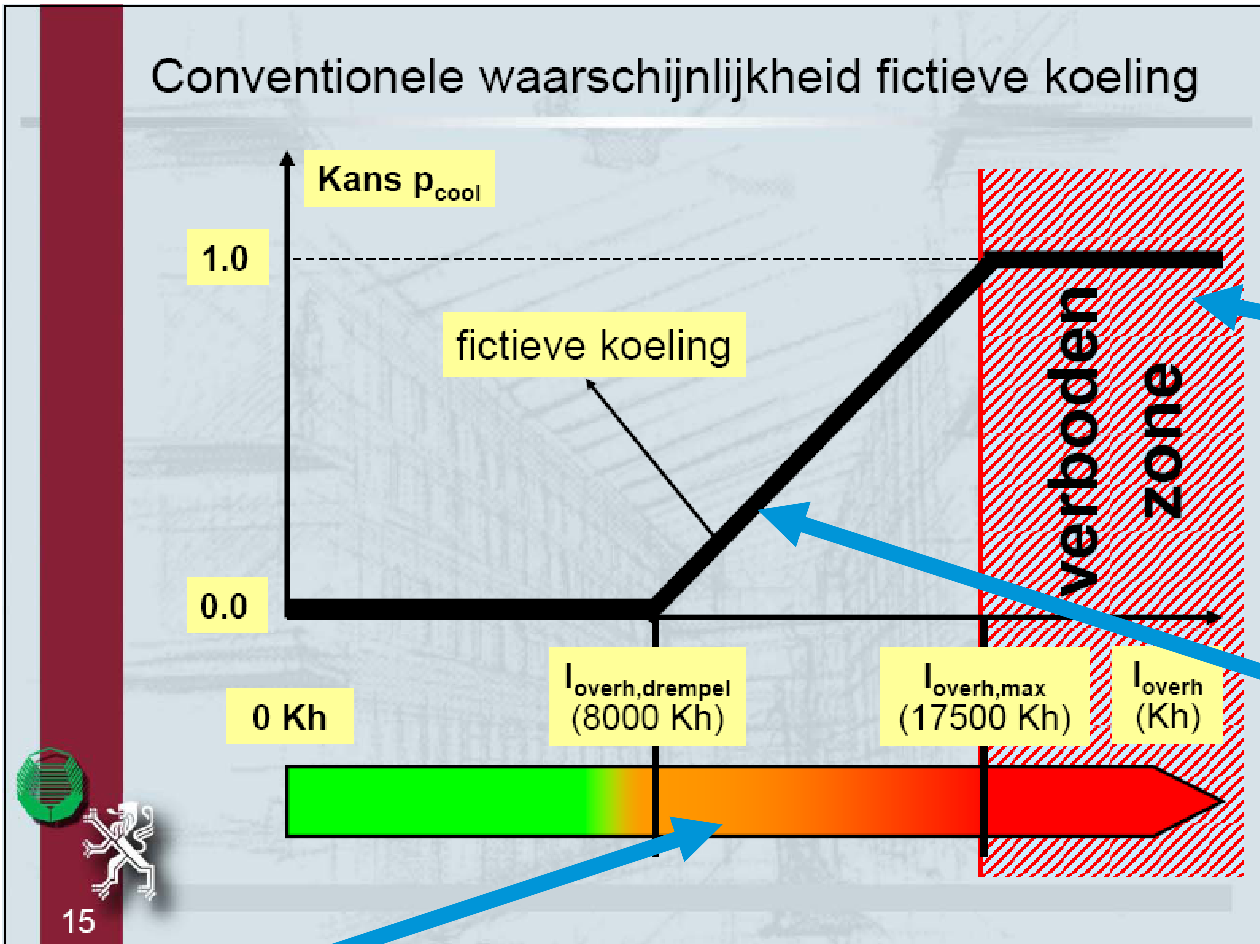
Importance of efficient summer comfort cooling
Example: Belgium

Overtollige warmtewinsten: t°stijging boven setpoint



Source: VEA

Importance of efficient summer comfort cooling
Example: Belgium



Source: VEA

Forbidden zone: building needs to be redesigned (e.g. solar shading)

Energy performance result: additional (fictive) energy demand for summer comfort cooling

In this zone it is realistic to expect that people will buy summer comfort cooling
-> if it is an inefficient airconditioner: **will savings of forbidden zone be realized??**

Environment: Our Vision

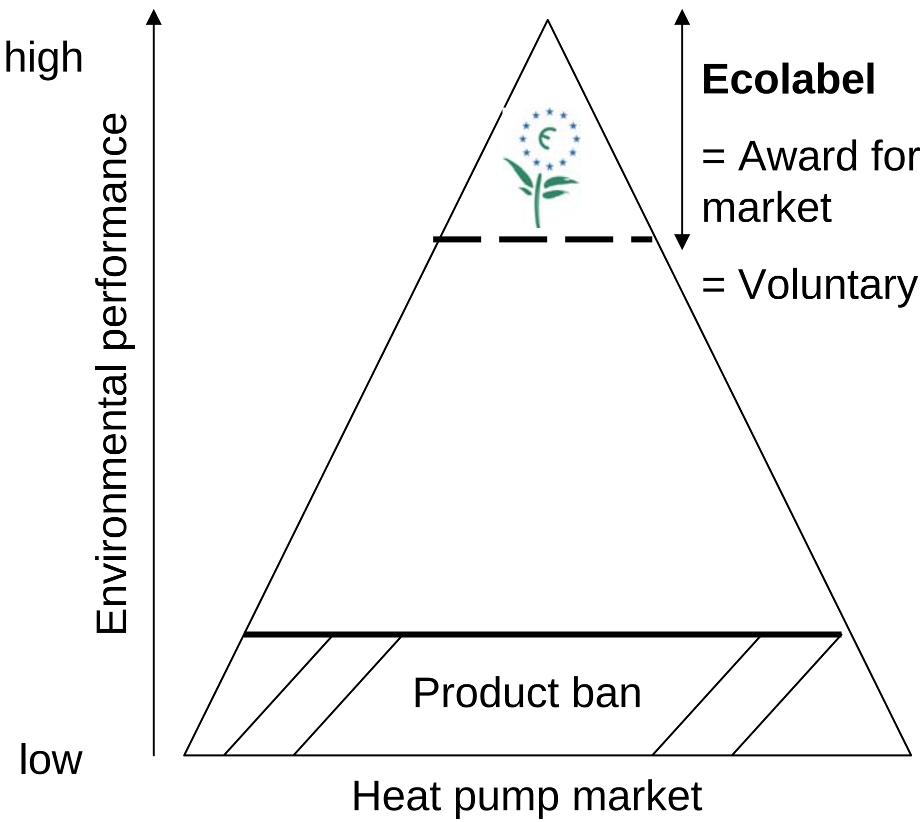
Turn the environmental developments into OPPORTUNITIES

No.1 as HVAC-R energy solution consultant

Importance of efficient summer comfort cooling
Example: Ecolabel for Heatpumps includes high efficient summer comfort cooling

Relation between Ecolabel & Ecodesign / EuP ?

→ Purpose of ECOLABEL is different from ECODESIGN / EuP !



Ecolabel

= Award for top market

= Voluntary

Ecodesign

= Setting the minimum environmental requirements for CE marking

= Mandatory

Importance of efficient summer comfort cooling
Example: Ecolabel for Heatpumps includes high efficient summer comfort cooling

Today the Ecolabel is available for **23 product groups** (+4 under development) :

- Cleaning Products
- Paper Products
- Home and garden Products
- Tourism
- Lubricants
- Appliances: Dishwashers, Light bulbs, Personal and portable computers, Refrigerators, Televisions, Vacuum cleaners, Washing machines

HEAT PUMPS are a new product group

DAIKIN

Importance of efficient summer comfort cooling
Example: Ecolabel for Heatpumps includes high efficient summer comfort cooling

What are the criteria for the EU ecolabel ?

SCOPE	INCLUDING : • Electrically driven, gas driven or gas absorption heat pumps • up till 100 kW heating capacity • hot water production or cooling function may be optional	EXCLUDING : • heat pumps which only provide hot water • cooling only models
AIM	• To limit the environmental impact from manufacture, operation and end of life of heat pumps.	
OUTLOOK	Amongst heat pumps, this product has : • higher energy efficiency • lower global warming impact	

Importance of efficient summer comfort cooling
Example: Ecolabel for Heatpumps includes high efficient summer comfort cooling

Other sales & service criteria :

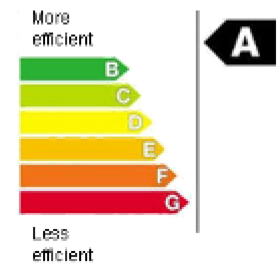
INSTALLER TRAINING	• Suitable training for installers shall be ensured in the countries where product is to be marketed. (= proper sizing and installation of HP : F gas certificate is not sufficient)
DOCUMENTATION	• Installation, maintenance and operation manual according to EN378
SPARE PARTS	•To be available for 10 years from sales date
INFORMATION FICHE	• Information fiche to be available at point of sale. • Fiche for installers to be made available to installers. • Supply suitable tools, computer programs and guidance for installers to calculate SPF, SEER, PER and annual CO2 emissions.
NOISE	Sound power levels to be stated in information fiche

Environment: Our Vision

Turn the environmental developments into OPPORTUNITIES

Contribute to CO_2 reduction by promoting heat pumps

To be No.1 in high efficient product range



Reduce Environmental Burden from Business Activities

No.1 as HVAC-R energy solution consultant

Reduce impact of refrigerant emissions towards non-HCFC's

Importance of efficient summer comfort cooling

- Biggest energy consumer: buildings
- Energy saving tendency in buildings
  -> low energy, passive house
- Risk: forgetting about indoor air quality and comfort

- Could Europe proceed neglecting
  efficient summer comfort cooling?

HarmonAC

Harmonizing Air Conditioning Inspection and Audit Procedures in the Tertiary Building Sector

Roger Hitchin

Intelligent Energy Europe

Background

- An Intelligent Energy Europe project
- Builds on earlier AuditAC project (completed 2006)
  - With much the same people
    - Welsh School of Architecture (project leaders for HarmonAC)
    - MacWhirter Ltd (maintenance and service contractors)
    - BRE
    - Armines, France (project leaders for AuditAC)
    - Austrian Energy Agency
    - Universities of Liege, Porto, Athens, Ljubljana, Turin
  - Started 2007, finishes 2010
  - Total budget 1.8M Euro

Aims

- Field-tested procedures for cost-effective assessment and improvement of air-conditioning energy efficiency.
- Directly relevant to EPBD A/C Inspection requirements
  - But wider in outlook and scope
- Supported by
  - Documented Case Studies
  - Training material

AuditAC deliverables

- Downloadable Guides
  - For Auditors/Inspectors
  - For Building Managers
- Downloadable Software
  - For Auditors
- Case Studies
  - To demonstrate actual savings
- Training Information

AUDITAC

- The AuditAC deliverables can be downloaded from the Hamonac website
  - www.harmonac.info

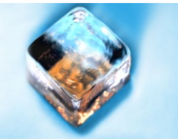
- Well received by industry and Member States but short of field experience

- HarmonAC aims to refine them in the light of field experience.

Some definitions

- **Pre-Inspection:** collection of information before visiting site
  - in order to focus on-site work.
- **Inspection:** non-intrusive on-site assessment. Required by EPBD but may be carried out for other purposes.
  - Identifies clearly effective (usually low-cost) measures
  - And measures that require more investigation through “Audit”
- **Audit:** in-depth assessment that may require measurement or intrusive inspection.
  - For major work, full engineering design “investment-grade audit” may be needed

ECO checklist



- Auditac produced a list of “energy conservation opportunities” for air conditioning systems:
  - Reduce loads
    - Building refurbishment
    - Reduce equipment loads
  - Improve system technical efficiency
    - Maintenance
    - Refurbishment
  - Improve operational practices

HARMONAC

HARMONAC monitoring aims

- Focussed guidance at several levels:
  - Priorities for **pre-inspection** information
  - Most cost-effective elements for **inspection**
  - Most promising elements for **Audit** to focus on

- More informative set of "Energy Conservation Opportunities", divided into (for example)
  - Easily identified, savings likely
  - Easily identified, saving uncertain without further work
  - Difficult to identify

HARMONAC monitoring: Field Trials

- Over 600 Field Trials of implemented procedures, to identify:
  - Time taken and difficulty of each inspection element
  - Frequency of finding potential improvements
  - Classify potential measures
    - Savings likely: easy to implement
    - Savings likely: more difficult or expensive to implement
    - Savings possible: needs more investigation
    - Cost-effective savings unlikely

HARMONAC monitoring: Case Studies

- At least 40 detailed Case Studies of A/C system energy use.
  - From 12kW up to systems over 1MW.
  - At least 12 months detailed monitoring
    - Supported by use of developed versions of Auditac analysis tools
  - Quantify impact of potential measures
  - Where possible: measure; inspect; intervene; re-measure
  - Extract general conclusions where possible

- Cross reference to Field Trial results

- Will be on public database

HARMONAC

Summary so far

- Pre-inspection
  - Looks the most potentially productive area for identifying potential improvements
  - Initially this data is difficult to obtain, with many buildings not having information on their construction details, etc.
- Inspection
  - Yields clear Energy Conservation Opportunities (ECOs)
  - Requires significant time and cost
- Audit
  - Case studies should illuminate value, but too early to report

Initial findings

- This initial data is primarily taken from UK field trials
  - But will be developed as new information is collected
- Example results are for packaged systems
- Similar information for
  - Buildings (load reduction)
  - Central systems

HARMONAC

Packaged systems – ranked by time

Inspection Item	Short Description	Time (mins)	Savings
P19	Write report	68	-
P6	Compare records of use or sub-metered energy with expectations	30	-
P10	Check external heat exchangers	26	
PP8	Design cooling load for each system	24	4% - 13%
PP9	Description of the occupation of the cooled spaces	15	-
P5	Compare size with imposed cooling loads	11	4% – 13%
P1	Review available documentation from pre-inspection	10	-
	etc... (28 items)		
	TOTAL AVERAGE TIME TAKEN	271	
		(4.5 hrs)	

HARMONAC

Packaged systems – ranked by savings

Inspection Item	Short Description	Time (mins)	Savings
PP2	Method of control of temperature.	2	Up to 60%
PP3	Method of control of periods of operation	5	Up to 50%
P14	Note the set on and off periods	3	Up to 50%
PP8	Design cooling load for each system	24	4% - 13%
P5	Compare size with imposed cooling loads	11	4% – 13%
P8	Check for signs of refrigerant leakage.	10	
P10	Check external heat exchangers	26	
P12	Assess zoning in relation to internal gain and orientation	2	
	etc… (28 items)		
	TOTAL AVERAGE TIME TAKEN	271	
		(4.5 h)	

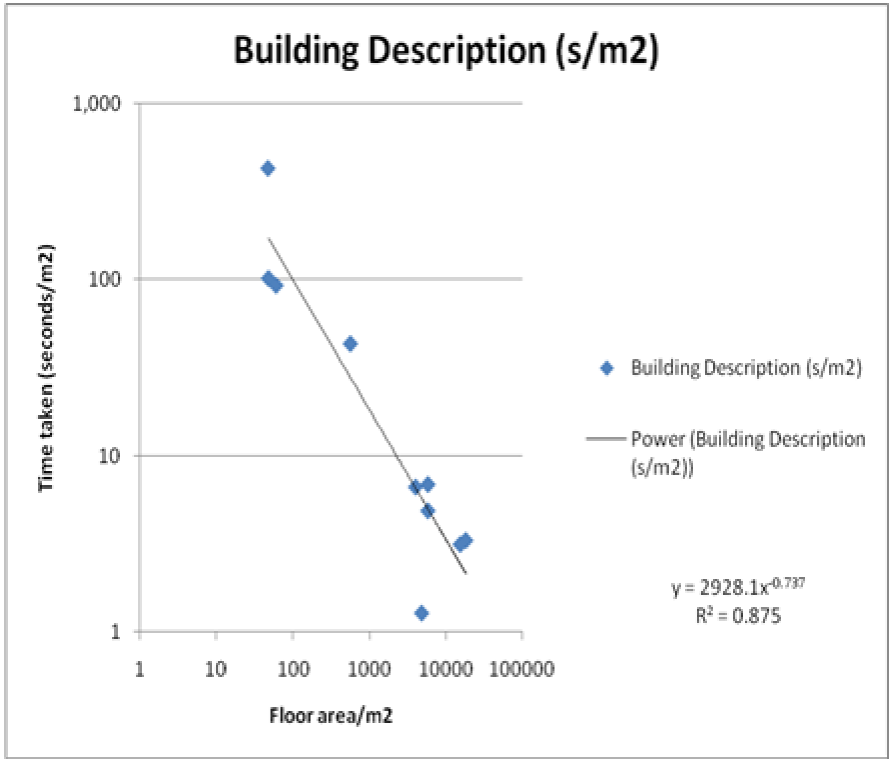
HARMONAC

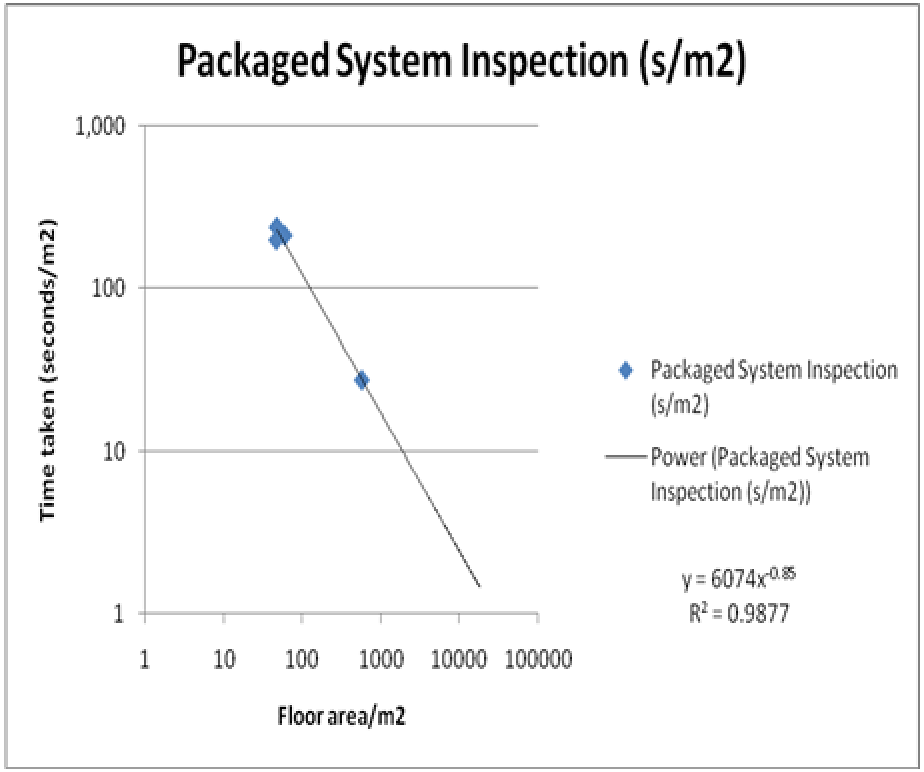
Initial Outcomes

- Main energy savings:
  - Choosing the correct system type
  - Altering hours of use of the systems
  - Altering the temperature setpoints of the system
  - Ensuring the system filters are kept clean
  - Using VSD controllers instead of dampers and fixed speed motors

- Most easily achievable are those that require:
  - Change in the control and operation of the systems.
  - Improvement of the maintenance regime

Inspection time– packaged systems





- So far, good correlation between floor area and time taken to obtain building data and undertake inspections

HARMONAC

Some Observations

- Substantial savings are possible – but not always
- Many significant savings
  - need **little time commitment**
  - often **without a visit to site**
- May be more cost-effective to use initial pre-inspection screening to identify systems that cannot demonstrate acceptable performance.

Which data need a site visit?

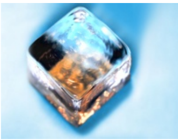
Short Description	Savings
Description of method of control of temperature (system type)	Up to 60%
Method of control of periods of operation (time clocks, etc)	Up to 50%
Compare AC usage with expected hours or energy use	Up to 50%
Occupancy schedules per zone	Up to 50%
Check type, rating and operation of distribution fans and pumps	Up to 50%
Note the set on and off periods	Up to 50%
Monitoring to continually observe performance of AC systems	10% – 20%
Design cooling load for each system	4% - 13%
Compare size with imposed cooling loads	4% – 13%
Monthly schedule exceptions per zone	Up to 10% each month
Building mass/air tightness per zone	
HVAC system description and operating setpoints per zone	
Annual energy consumption of the system	
Annual energy consumption of the building	

HARMONAC

Outline of possible filtering procedure

- Pre-inspection demands
  - Consumption records and comparison with benchmark
    - Benchmark relates to building type and age and system type
  - Maintenance records and schedule that includes adequate inspection elements
- If satisfactory no mandatory inspection needed
  - Or perhaps very "light" inspection

Why adopt this type of system?



- Cost of inspection could be significantly reduced:
  - Especially for repeat inspections
- Involvement of system owners:
  - provides an incentive to monitor A/C energy use, by potentially removing a costly physical visit.
  - Perhaps more likely to induce action
- Better information for Member States
  - Actual consumption levels and trends

Digression: EPBD Recast

- Compare existing system sizing with need
  - Harmonac tools could help but don't provide full sizing
    - (and some systems become more efficient when generously sized)
- Compare existing system with best available
  - Harmonac tools could help but not a very meaningful exercise
- Frequency of inspection determined by cost-effectiveness
  - Harmonac deals with cost of inspections and likely savings
  - NOT cost of implementation (except in crudest maner)
- Formal report to give cost-effective measures
  - As for frequency of inspections

Invitation

- Comments and participation welcome
  - Especially practical experience or voluntary trials of procedures
  - All actor's views are welcome
- If you wish to become involved, especially to provide feedback on
  - Methodologies
  - Training materials
  - Tools
- Or simply to receive the project newsletter
- please contact www.harmonac.info

HARMONAC

Project team

Welsh School of Architecture/Cardiff University

UK (Project co-ordinator)

Instituto de Engenharia Mecanica e Gestao Industrial - INEGI

Portugal

National and Kapodistrian University of Athens

Greece

Université de Liège

Belgium

Politecnico di Torino

Italy

Univerza v Ljubljani

Slovenia

MacWhirter Ltd

UK

Austrian Energy Agency

Austria

Association pour la Recherche et le Développement des Méthodes et Processus Industriels - ARMINES

France

Building Research Establishment - BRE

UK (Subcontractor)

Recent Trends and Developments Regarding Summer Comfort and Low Energy Cooling in Greece

M. Santamouris + Others
University of Athens, Greece

Introduction

The increase of family income in developed countries has made the use of air conditioning systems highly popular. In Europe the main commercial market for cooling and air conditioning systems totals 8 billion Euros. Almost 6% of office, commercial and industry buildings are cooled, making a total volume of about 20 million cubic meters (Adnot, 1999). The volume of air-conditioned buildings in Europe is expected to increase four times by the year 2010.

The impact of air conditioner usage on electricity demand is an important problem as peak electricity load increases continuously, forcing utilities to build additional plants. In parallel, serious environmental problems are associated with the use of air conditioning.

Passive and hybrid cooling techniques involving microclimate improvements, heat and solar protection, and heat modulation and dissipation methods and systems can greatly contribute to buildings' cooling load reduction and increase thermal comfort during the summer.

Past and existing thermal comfort standards and methods cover mainly thermal comfort conditions under steady state conditions. Most of the thermal comfort studies have been carried in laboratories and are based on evaluations of the heat transfer between the human beings and their environment and of the required physiological conditions for thermal comfort.

Recent thermal comfort standards propose the adaptive approach for naturally ventilative buildings. Analysis from various researchers has shown that when adaptive and variable indoor temperature comfort standards are used in air conditioned buildings remarkable energy savings may occur. (Auliciems, 1990, Milne, 1995; Wilkins, 1995).

This report aims to present the actual state of the art in the field of summer comfort and passive cooling of buildings in Greece. The first part of the paper discusses the actual penetration of air conditioning systems and problems resulting from using mechanical cooling. The second part presents the existing legislative frame concerning summer comfort and cooling, Following that the trends and perspectives on low energy cooling are presented, while the future legislative requirements are discussed.

1 Use of Conventional Cooling in Greece

Greece presents one of the higher figures concerning the average cooled-floor area per inhabitant for EU countries, Figure 1, (EECCACC study, 2003). In parallel, according to the same study, the air conditioned area is continuously increasing, (Figure 2).

High penetration of air conditioning in the buildings sector increases the absolute energy consumption of the building sector and the corresponding carbon dioxide emissions, while increases highly the peak electricity demand during the summer period

The total energy consumption because of the used cooling equipment in 2000, was estimated close to 2909 GWh, and it expected to rise up to 9734 GWh by 2020, (EECCAC, 2003). In parallel, the expected CO2 emissions because of the coolin equipment will increase from 1018 Kt in 2000 to about 3407 in 2020, (Table 1)

2000	2005	2010	2015	2020
1018	1878	2544	3289	3407

Table 1 : Actual and expected CO2 emissions in Kt/y because of the air conditioning equipment, (EECCAC Study, 2003).

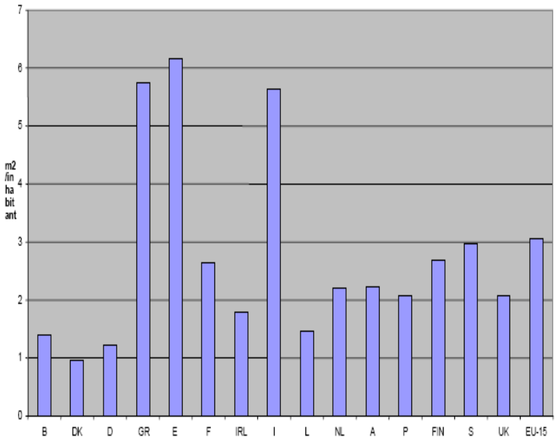


Figure 1 : Average cooled-floor area per inhabitant for EU countries and the EU as a whole in 2000, (EECCACC study, 2003)

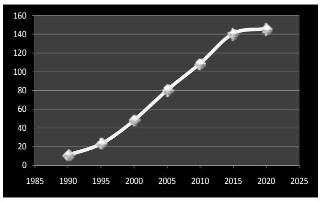


Figure 2 : Building's Area conditioned per year, in Mm2, (EECCACC study 2003).

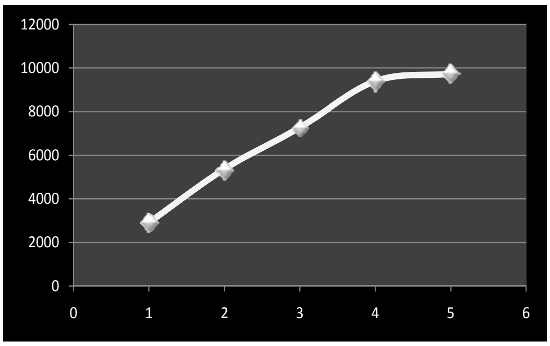


Figure 3. Cooling only energy consumption per year in GWh, (EECCAC 2003)

Increased air conditioning use, exacerbates peak electricity demand and obliges utilities to built additional power plants. In Greece, peak electricity demand has continuously increased in the recent years mainly because of the rapid penetration of air conditioning, (Figure 4).

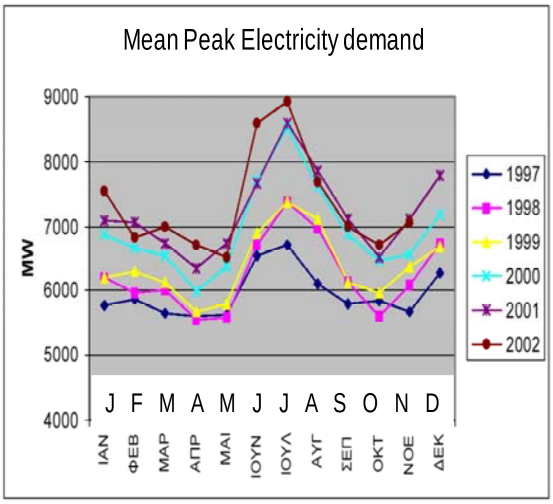


Figure 4. Mean Peak Electricity Demand in Greece

+ Information on Market on passive cooling, like market on solar control, ventilation, etc.

2 Legislative Frame Concerning Summer Comfort and Cooling

For new buildings or buildings under refurbishment, the Greek Energy Building Code (reference) requires :

a) Respect of maximum U values for the various components of the building envelope.

b) Respect of a maximum annual total final energy consumption.

For the existing public buildings specific mandatory requirements based on passive cooling technologies have been set. In particular :

a) All air conditioning equipment has to be inspected on an annual basis

b) The CEN 15251 standard has to be used regarding indoor environmental conditions. All buildings should respect indoor conditions of class B buildings.

c) Cool coatings have to be used in the roofs and external walls of the public buildings

d) Ceiling fans have to be installed in public buildings

e) Night Ventilation techniques have to be used when possible.

f) All external openings have to be shaded properly

g) All external positioned air conditioned systems have to be shaded

h) Planted Roofs may be used when possible

i) Free cooling techniques should be employed

j) Heat has to be recovered from the condensers of the air cooled conditioning systems

k) Heat recovery systems have to be used in the exhaust of the ventilation systems.

l) Adaptive thermal comfort control has to be used in naturally ventilated buildings.

In parallel, the National Plan for energy conservation in the existing buildings stock (reference) , proposes specific short, mid and long term technical measures for the residential and tertiary buildings. In particular, the short term requirements are :

a) Improvement of the U value of the envelope

b) External shading of all non shaded openings when possible

c) Decrease of the infiltration rates

d) Use of ceiling fans

e) Use of night ventilation

f) Replacement of low efficiency RAC's with new of higher efficiency

g) Economiser control in the tertiary sector

h) Heat recovery in the ventilation systems, (only for the tertiary sector).

It is expected (reference) that the application of the whole set of measures the cooling energy consumption in the residential sector may be decreased by 1.663 GWh/year?, in the next ten years (corresponding with X %), while the corresponding cooling energy conservation in the tertiary sector is expected to be close to 843 GWh/year? (corresponding with Y %).

4. Low Energy Cooling Technological Trends and Perspectives.

During the recent years intensive research, demonstration and application projects have been carried out in the country aiming to investigate the potential of low energy and passive cooling techniques. Four types of technological systems, techniques and components have been studied (reference) :

a) Heat and Solar Control techniques involving the use of cool coatings, increased insulation, advanced glazing, reduced infiltration, appropriate solar control, etc.

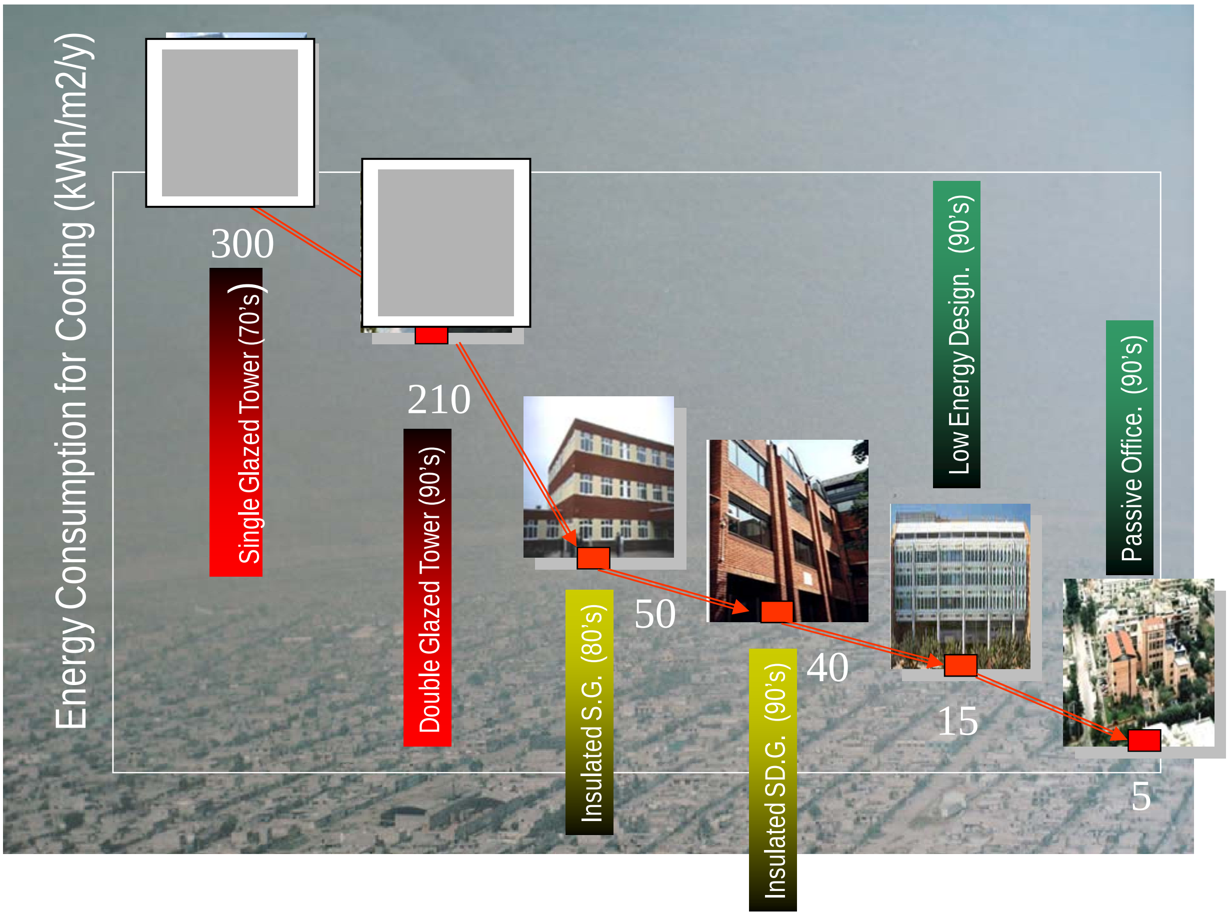
b) Heat amortisation techniques involving the use of additional thermal mass and night ventilation techniques

c) Heat dissipation techniques based on the use of low temperature environmental sinks like the air, the water, the ground and the sky.

d) Advanced and high COP air conditioners, like indirect evaporative coolers, absorption solar assisted coolers, cool water and ice storage, etc.

Various buildings have been monitored and the specific energy consumption of the various classes of air conditioned buildings has been evaluated. The following figure 5 reports the annual cooling energy consumption of various types of office buildings as measured.

Figure 5. Annual Energy Consumption for cooling for various types of offices in Greece.



As shown, glazed buildings may present an annual cooling energy consumption between 200 to 300 kWh/m2, while conventional offices have a consumption between 40-50 kWh/m2/y. In parallel, buildings designed using passive cooling techniques like appropriate solar control, night ventilation, ceiling fans, improved insulation, increased thermal mass, minimisation of the internal gains, ice storage and BMS systems, present a cooling energy consumption lower than 15 kWh/m2/year.

In parallel, design and construction of residential buildings using passive cooling techniques has shown that it is possible to reduce the overheating period of a building by 95 %, and thus to avoid or minimize the use of air conditioning. Actually, many residential buildings presenting zero energy consumption for cooling have been built and are under monitoring.

5. Future Legislative Perspectives and Requirements

It is evident the existing knowledge on passive and low energy cooling techniques and systems permits to design and built buildings with minimum energy consumption during the summer period. However, scientific and technical knowledge is not enough to counterbalance the market trend to install compression air conditioning systems.
There is a need to undertake specific mandatory legislative measures aiming first to minimise the cooling load of building, while at a second phase to use advanced and high COP systems based on the use of heat sinks and renewable energy systems.

6. Conclusions

7. References

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EECCAC Study, Adnot J (Editor), program, EEC , 2003

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Santamouris M, and Assimakopoulos D.N. (Editor), James and James Science Publishers, London

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SUMMER COMFORT AND COOLING IN GREECE

Mat Santamouris

The Problem

We face an important change of the climate.

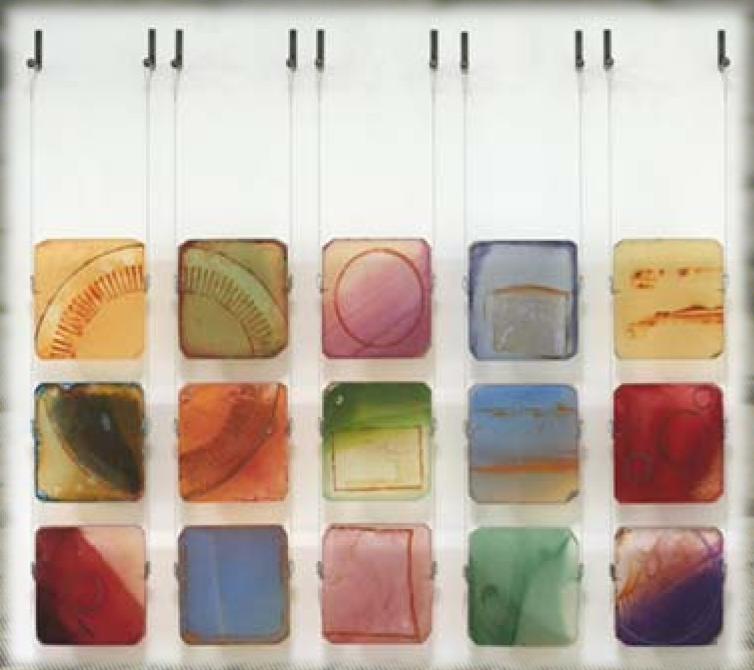
Ambient temperatures increase.

Heat waves are more frequent.

Hot spells have a longer duration.

Poor design and uncontrolled development of urban areas increase the heat island intensity.

Human beings are more vulnerable and respond by using more mechanical cooling.

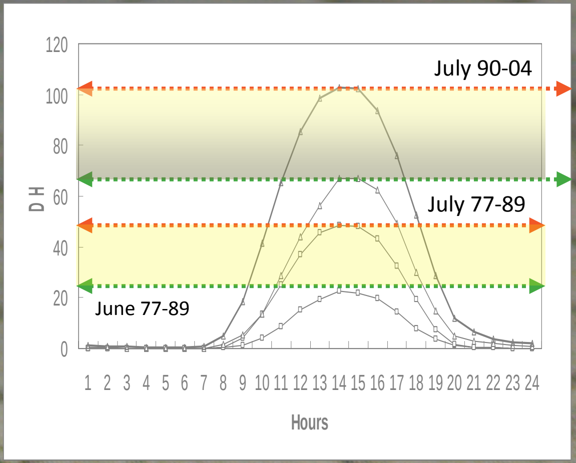


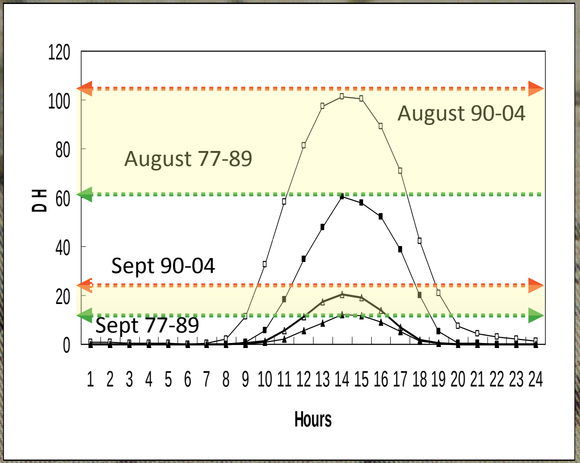
The Problem

In Athens the number of hours as well as the Degree Hours over 30 degrees have been substantially increased during the period 1990-2004, compared to the corresponding value of the period 1977-1989. The phenomenon is statistically significant.

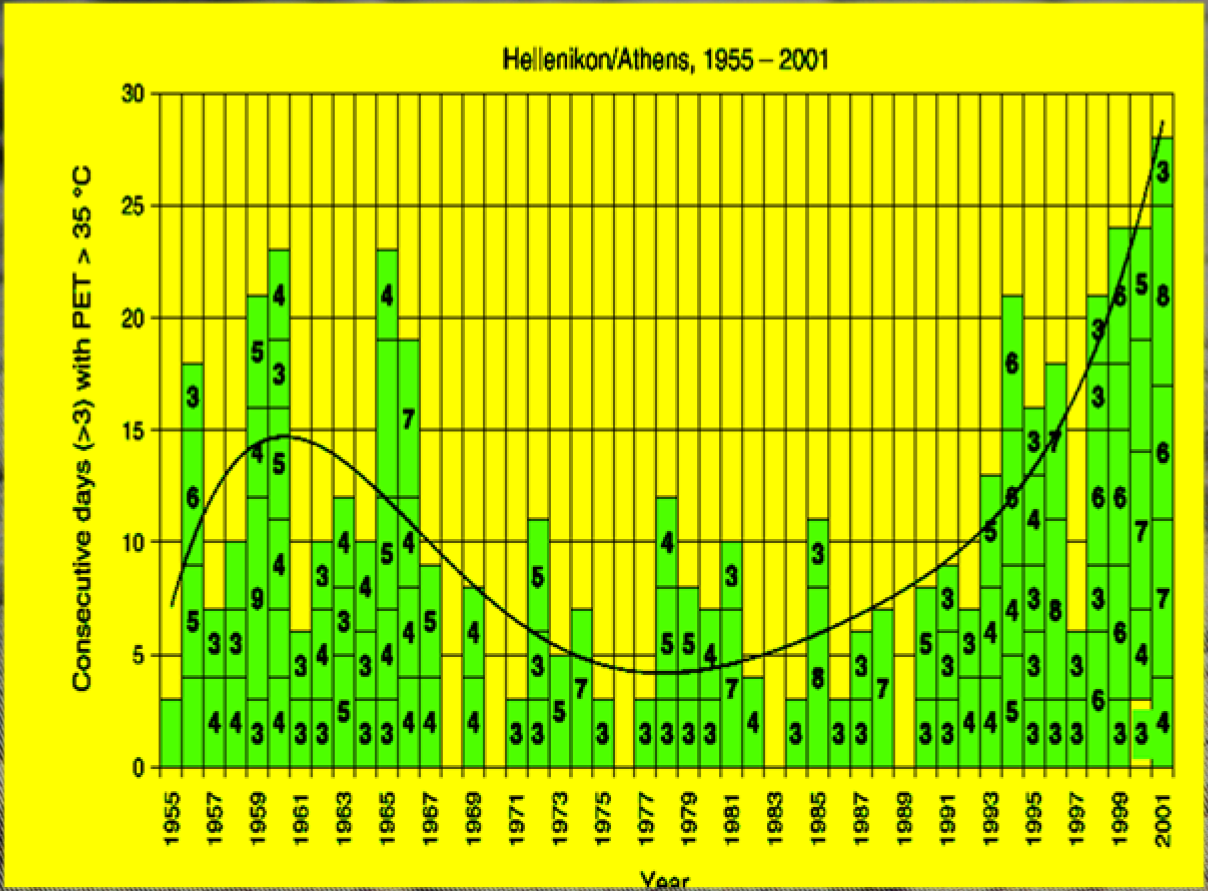
For July and August the increase is close to 30-40 %.

The phenomenon appears during the whole day period.





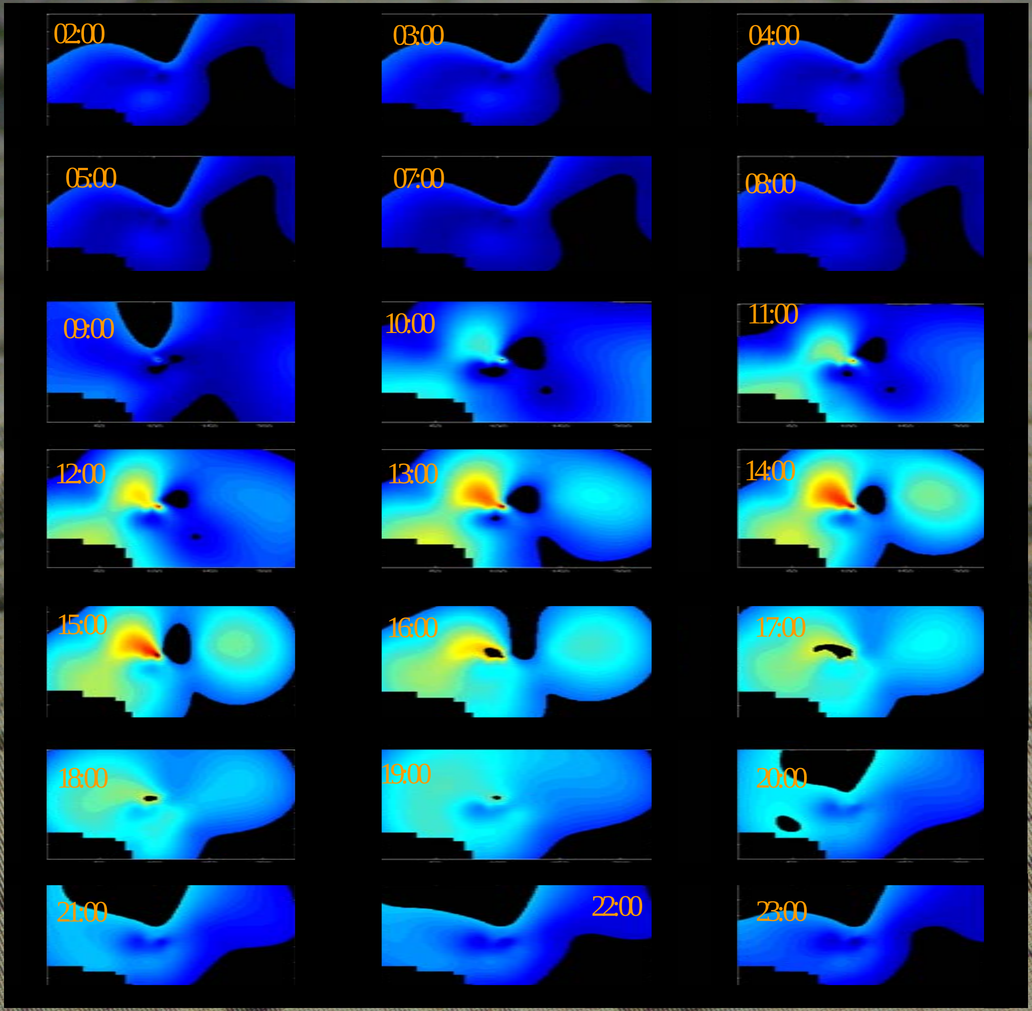
The duration of hot spells is continuously increasing



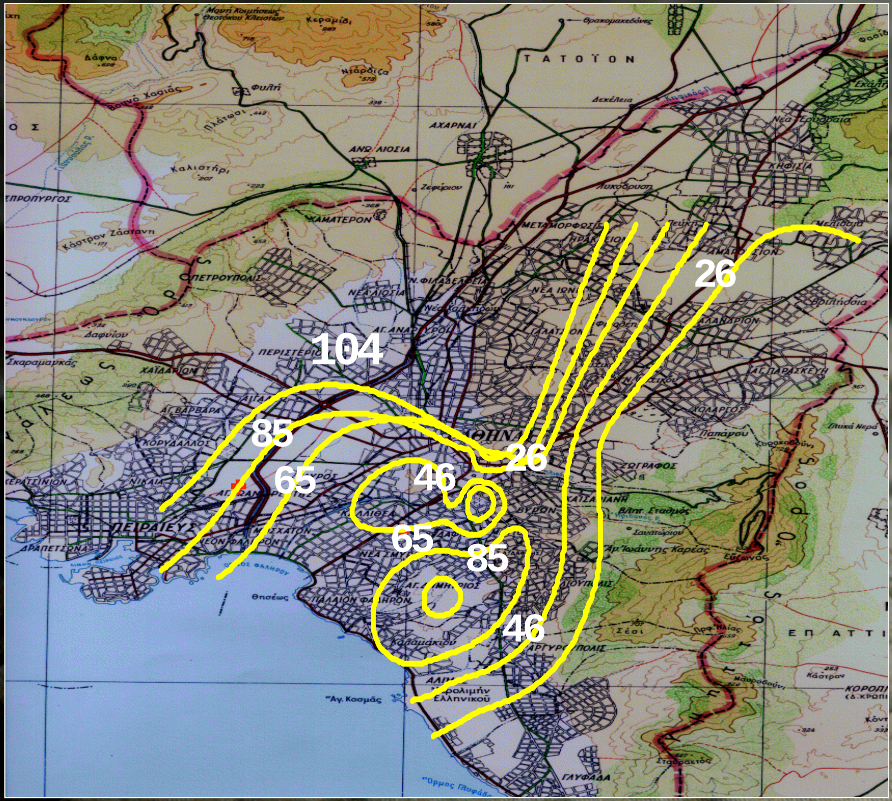
The Problem

Heat island is developed as a function of the synoptic climatic circulation in the lower troposphere.

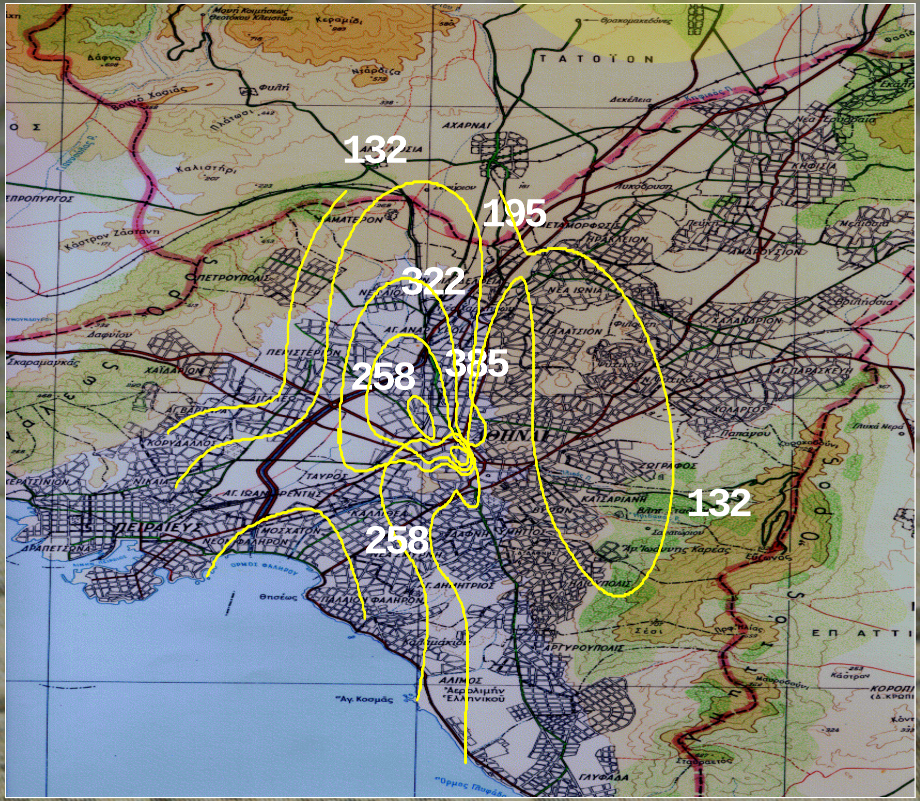
Heat island is mainly developed during the day time in the center and western part of Athens. These areas are characterised by high density and strong anthropogenic heat generation



The Problem



Iso-Cooling Degree Hours > 26 C at 1:00 during August



Iso-Cooling Degree Hours > 26 C at 13:00 during August

Calculation and mapping of cooling degree hours shows a strong stratification between the various areas of the city. Thus, a strong impact on the cooling energy demand has to be expected

M. Santamouris, N. Papanikolaou, I. Livada, I. Koronakis, C. Georgakis, A. Argiriou and D. N. Assimakopoulos :' On the Impact of Urban Climate to the Energy Consumption of Buildings' Solar Energy, 70,3,201-216,2001.

The Problem

Using the measured temperatures in all stations detailed simulations have been carried out for a typical office building using TRNSYS. Simulations have been performed for a two years period and for a set point temperature of 27 C, and are compared against measurements collected in the building and it is found that the model is accurate.
It is found that monthly sensible cooling loads in the center of the city increases up to 130 % compared to the reference region. In parallel, cooling load in western Athens increases by 75 %. Lower cooling loads are calculated in the coastal area where the impact of the sea breeze is important

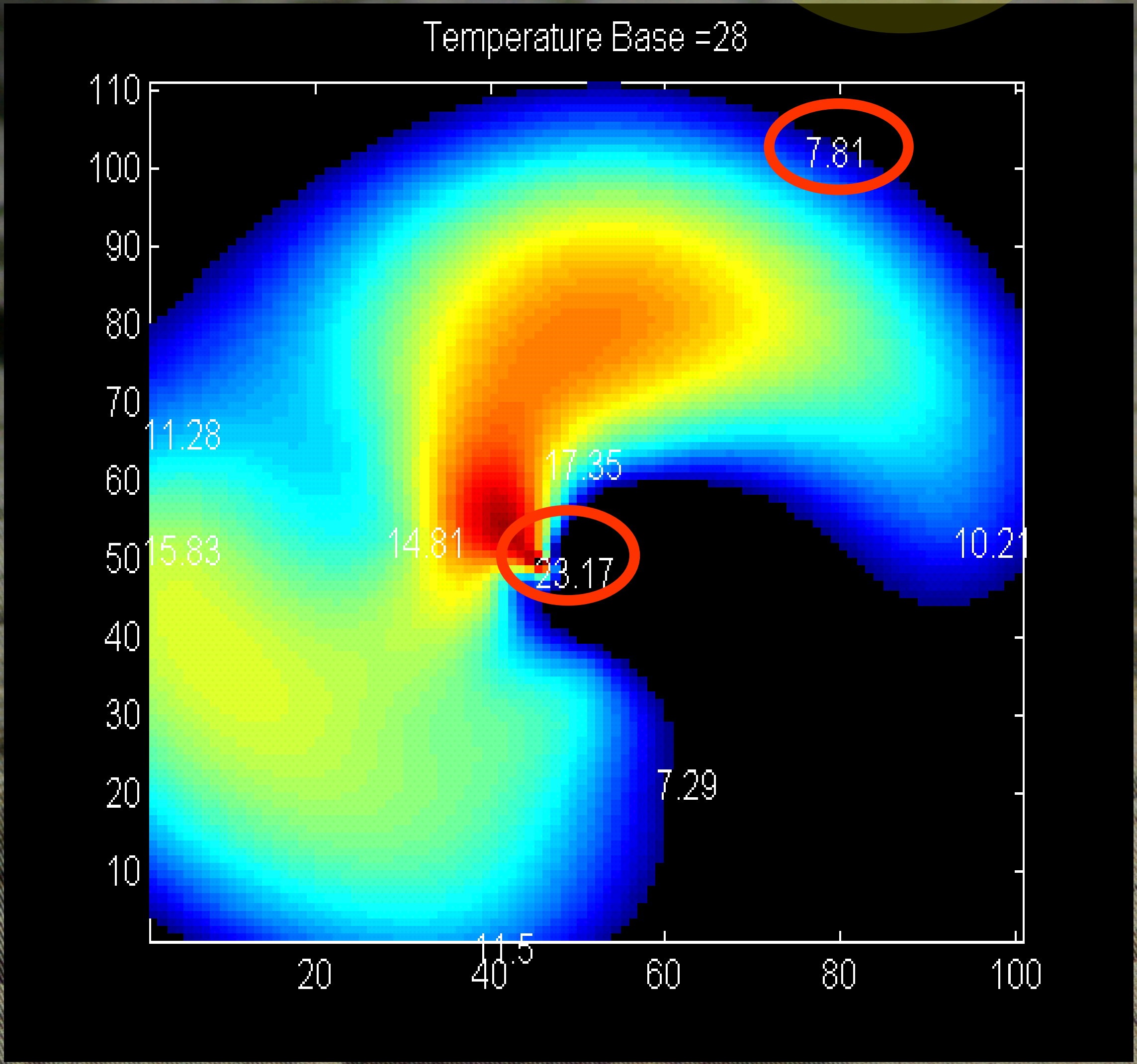
M. Santamouris, N. Papanikolaou, I. Livada, I. Koronakis, C. Georgakis, A. Argiriou and D. N. Assimakopoulos :' On the Impact of Urban Climate to the Energy Consumption of Buildings' Solar Energy, 70,3,201-216,2001.

The Problem

In parallel, using TRNSYS simulations for the same typical building, the peak electricity load for sensible cooling has been calculated for a two years period and for a set point temperature of 27 C.

It is found that peak electricity demand in the city center may increase up to 300 % , compared to the reference region while in western Athens, the relative increase is up to 200 %.

In parallel, it is calculated and measured that COP of room air conditioners decreases up to 25 % in the central Athens area



M. Santamouris, N. Papanikolaou, I. Livada, I. Koronakis, C. Georgakis, A. Argiriou and D. N. Assimakopoulos :' On the Impact of Urban Climate to the Energy Consumption of Buildings' Solar Energy, 70,3,201-216,2001.

The Problem

Only 28 % of the Low income population in Greece lives in insulated houses while the corresponding figure for high income households is 73 %.

In parallel, only 8 % of the low income households are insulated and have double glazing while for high income the percentage is 63 %.

Finally, low income houses present a much higher infiltration rate at 50 Pa.

The Problem

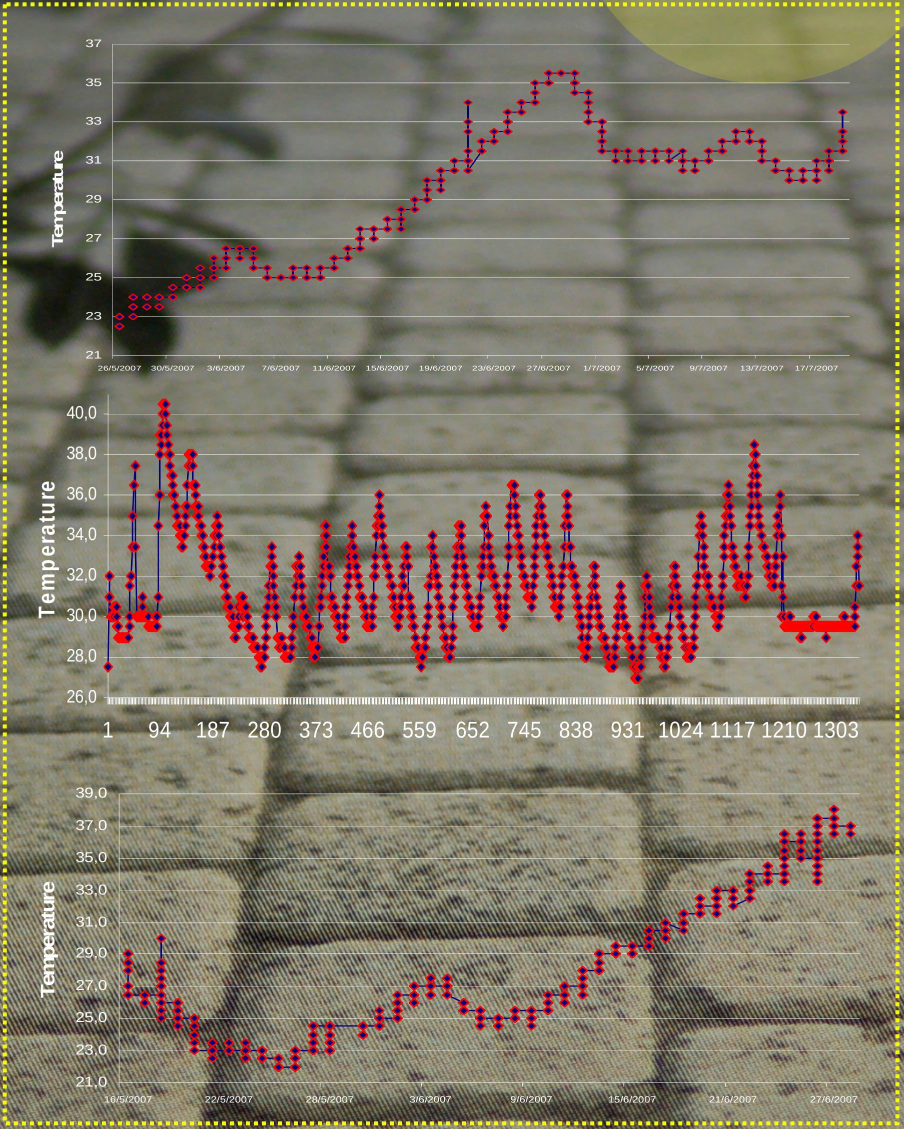
The use of air conditioning considerably increases the annual electricity expenses especially in the low income groups. As a mean value, the use of air conditioning increases the annual expenses to about 100 Euros per household, or 0,6 Euros/m2, or 12.5 Euros per person.

The increase is much higher for the low income groups, where the relative increase of the cost because of the air conditioning use is close to 195 Euros/household, or 1.2 Euros/m2, or 87 Euros/person.

The Problem

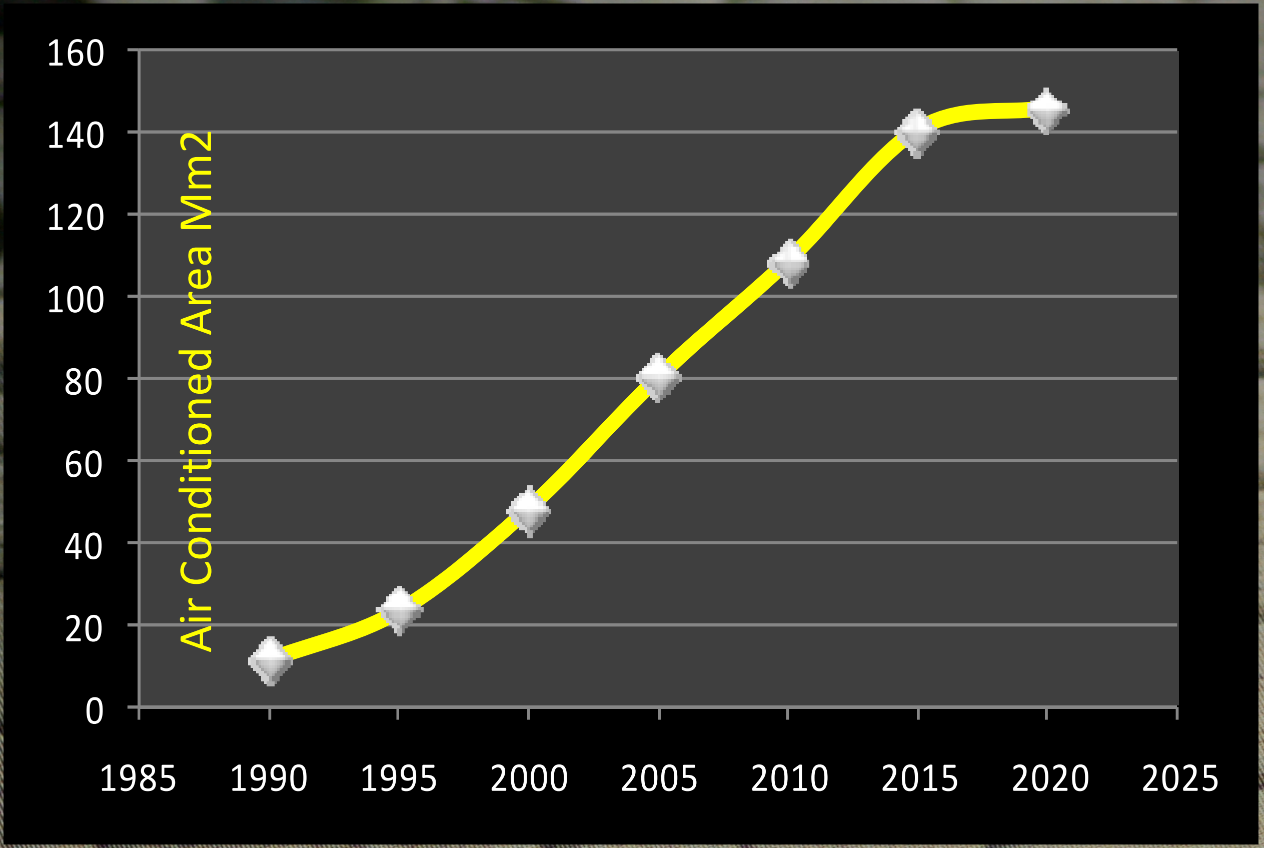
Measurements of indoor temperatures in almost 60 low income houses without air conditioning, insulation and double glazing, have been performed in Athens, during the whole summer of 2007.

For almost 50 % of the measurement period, indoor temperatures where higher than 34 C, presenting maximum close to 40 C.
Hot spells of more than 38 hours above 30 C have been recorded.



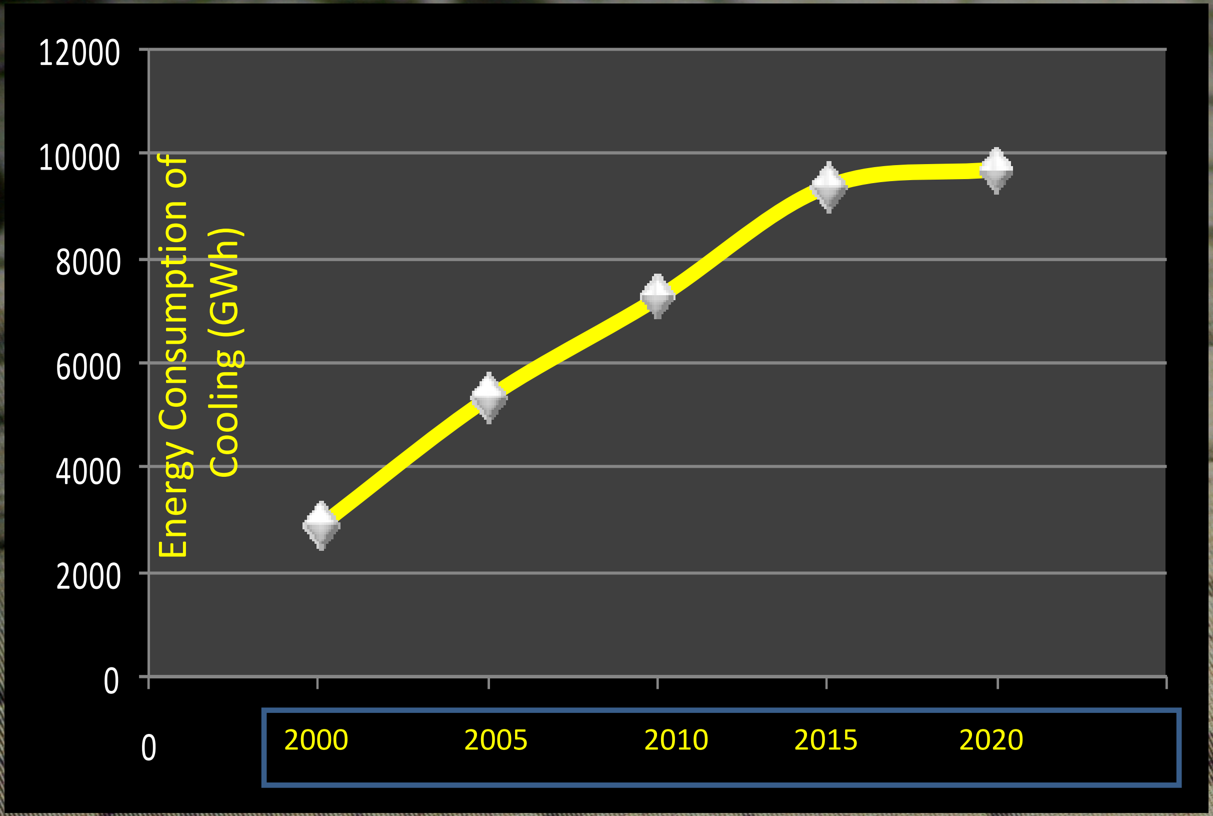
The Problem

The air conditioned area is continuously increasing



The Problem

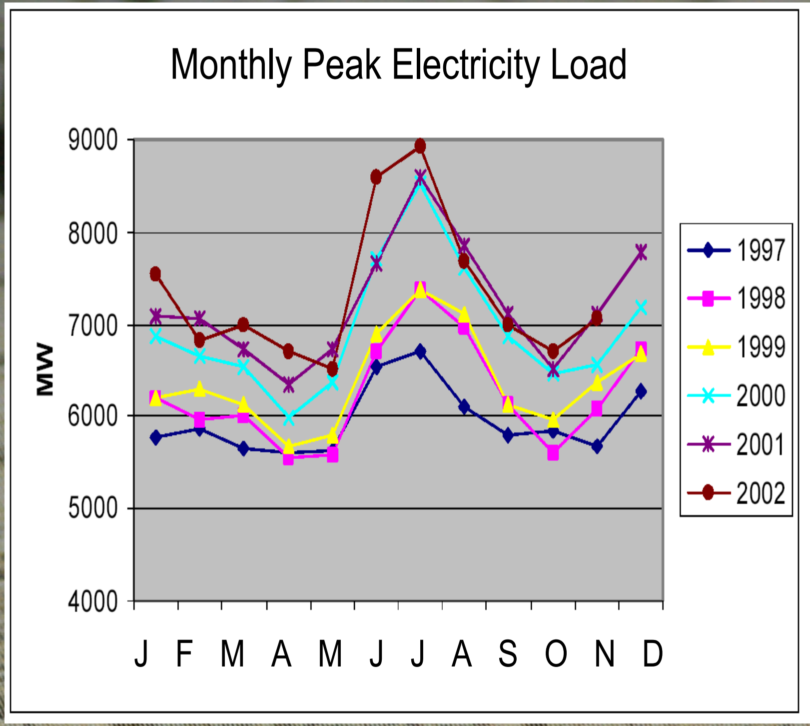
The energy consumption because of the cooling is continuously increasing



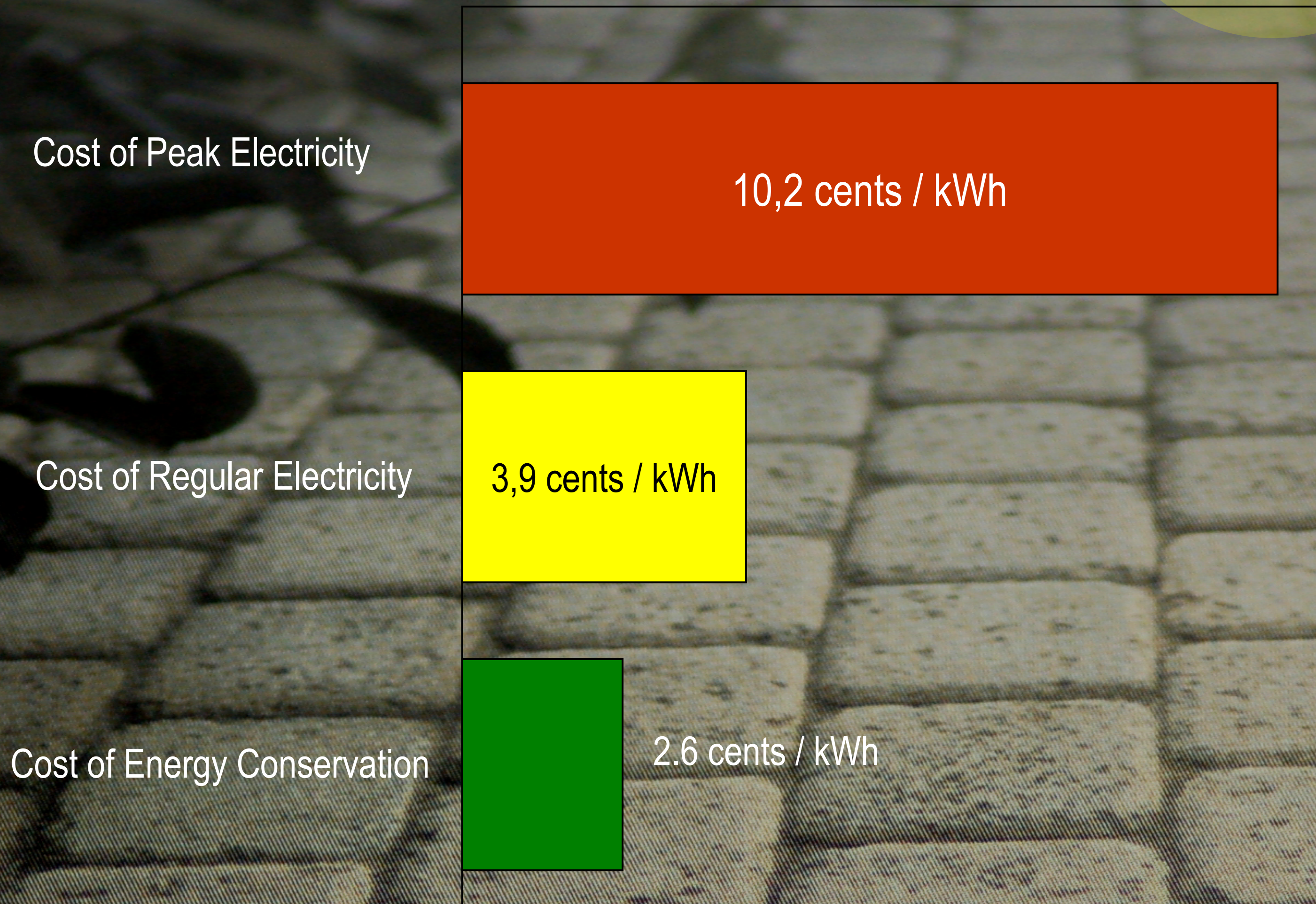
The Problem

The use of air conditioning increases the peak electricity demand in most of the Southern European countries.
In parallel, this is the main reason of blackouts and electricity shortages.

Such a huge increase of the peak electricity demand oblige utilities to built additional power plants operating under a low utilisability factor, and thus, increase the cost of electricity



The Problem


Cost of Peak Electricity
10,2 cents / kWh
Cost of Regular Electricity
3,9 cents / kWh
Cost of Energy Conservation
2.6 cents / kWh

•Legislative Frame Concerning Summer Comfort and Cooling

For new buildings or buildings under refurbishment, the Greek Energy Building Code (reference) requires :

•Respect of maximum U values for the various components of the building envelope.

•Respect of a maximum annual total final energy consumption.

The Actions

For the existing public buildings specific mandatory requirements based on passive cooling technologies have been set. In particular :

•All air conditioning equipment has to be inspected on an annual basis

•The CEN 15251 standard has to be used regarding indoor environmental conditions. All buildings should respect indoor conditions of class B buildings.

•Cool coatings have to be used in the roofs and external walls of the public buildings

•Ceiling fans have to be installed in public buildings

The Actions

•Night Ventilation techniques have to be used when possible.

•All external openings have to be shaded properly

•All external positioned air conditioned systems have to be shaded

•Planted Roofs may be used when possible

•Free cooling techniques should be employed

•Heat has to be recovered from the condensers of the air cooled conditioning systems

•Heat recovery systems have to be used in the exhaust of the ventilation systems.

•Adaptive thermal comfort control has to be used in naturally ventilated buildings.

The Actions

In parallel, the National Plan for energy conservation in the existing buildings stock (reference) , proposes specific short, mid and long term technical measures for the residential and tertiary buildings. In particular, the short term requirements are :

•Improvement of the U value of the envelope

•External shading of all non shaded openings when possible

•Decrease of the infiltration rates

•Use of ceiling fans

•Use of night ventilation

•Replacement of low efficiency RAC's with new of higher efficiency

•Economiser control in the tertiary sector

•Heat recovery in the ventilation systems, (only for the tertiary sector).

The Actions

During the recent years intensive research, demonstration and application projects have been carried out in the country aiming to investigate the potential of low energy and passive cooling techniques. Four types of technological systems, techniques and components have been studied (reference) :

•Heat and Solar Control techniques involving the use of cool coatings, increased insulation, advanced glazing, reduced infiltration, appropriate solar control, etc.

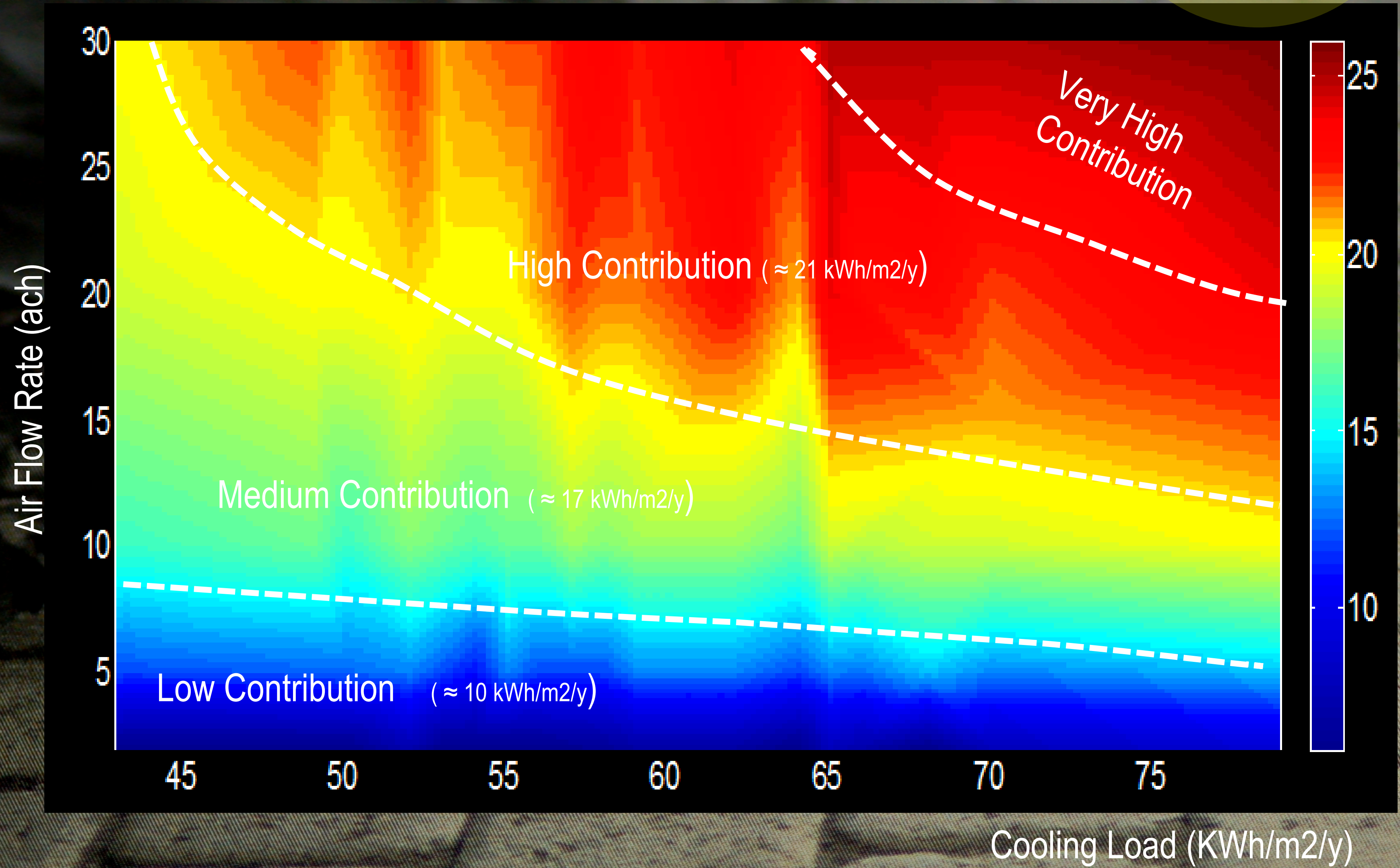
•Heat amortisation techniques involving the use of additional thermal mass and night ventilation techniques

•Heat dissipation techniques based on the use of low temperature environmental sinks like the air, the water, the ground and the sky

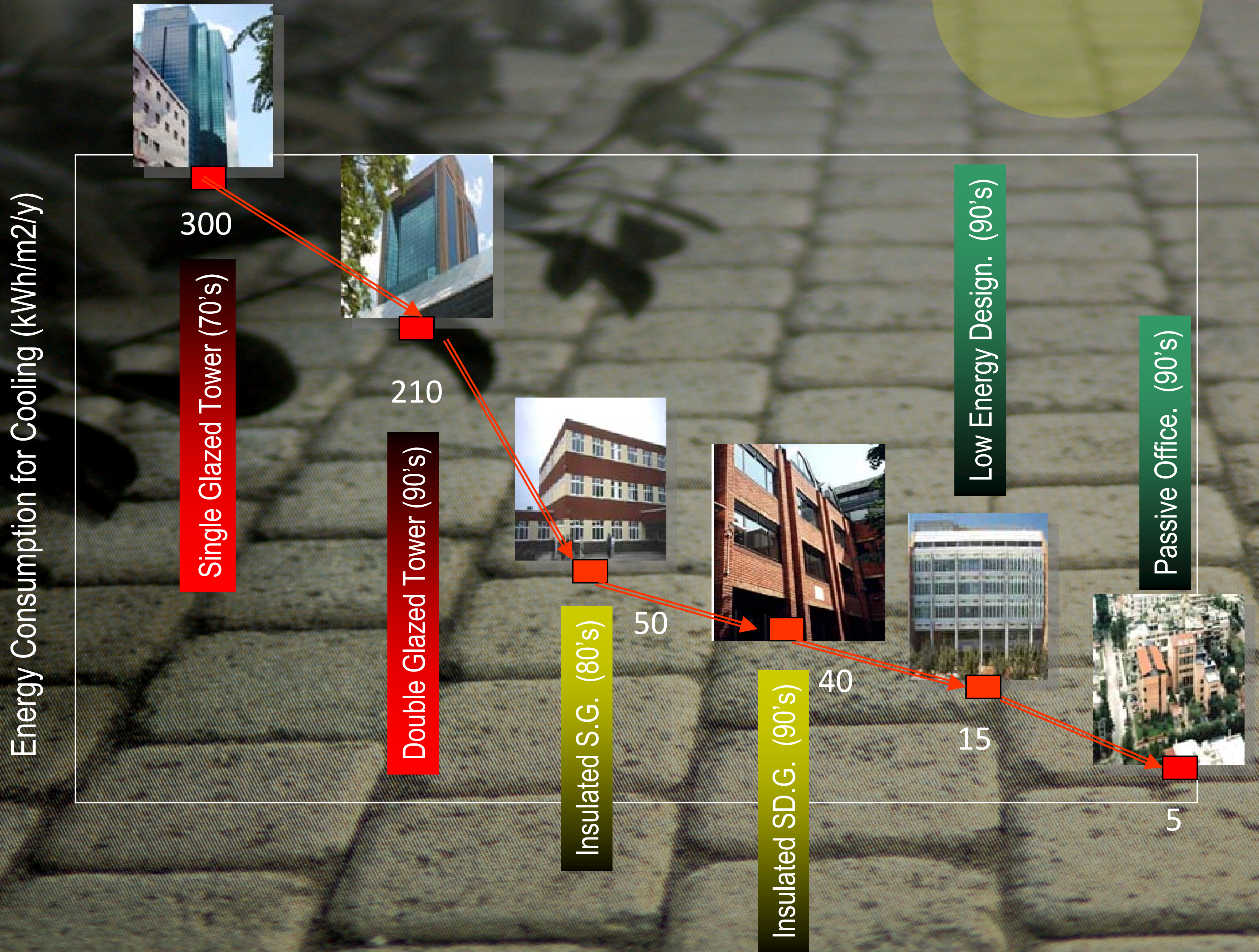
•.

•Advanced and high COP air conditioners, like indirect evaporative coolers, absorption solar assisted coolers, cool water and ice storage, etc.

The Actions


Very High Contribution
High Contribution (≈ 21 kWh/m2/y)
Medium Contribution (≈ 17 kWh/m2/y)
Low Contribution (≈ 10 kWh/m2/y)
Air Flow Rate (ach)
30
25
20
15
10
5
45
50
55
60
65
70
75
Cooling Load Reduction (kWh/m2/y)
25
20
15
10
Cooling Load (KWh/m2/y)

The Actions



Energy Consumption for Cooling (kWh/m2/y)
300
Single Glazed Tower (70's)
210
Double Glazed Tower (90's)
50
Insulated S.G. (80's)
40
Insulated SD.G. (90's)
15
Low Energy Design. (90's)
5
Passive Office. (90's)

The Actions

Glazed buildings may present an annual cooling energy consumption between 200 to 300 kWh/m2, while conventional offices have a consumption between 40-50 kWh/m2/y.

In parallel, buildings designed using passive cooling techniques like appropriate solar control, night ventilation, ceiling fans, improved insulation, increased thermal mass, minimisation of the internal gains, ice storage and BMS systems, present a cooling energy consumption lower than 15 kWh/m2/year.

In parallel, design and construction of residential buildings using passive cooling techniques has shown that it is possible to reduce the overheating period of a building by 95 %, and thus to avoid or minimize the use of air conditioning.

Actually, many residential buildings presenting zero energy consumption for cooling have been built and are under monitoring.

Future Legislative Perspectives and Requirements

It is evident the existing knowledge on passive and low energy cooling techniques and systems permits to design and built buildings with minimum energy consumption during the summer period. However, scientific and technical knowledge is not enough to counterbalance the market trend to install compression air conditioning systems.

There is a need to undertake specific mandatory legislative measures aiming first to minimise the cooling load of building, while at a second phase to use advanced and high COP systems based on the use of heat sinks and renewable energy systems.

Recent Trends and Developments Regarding Summer Comfort and Low Energy Cooling in Spain

J. Martí, J. Cipriano, X. Cipriano,
J.Carbonell, D. Pérez
CIMNE- Bee Group, Spain

Introduction

Spain is characterized by a very variable climatology. Hard winters in the middle and north of the country are typical every year, and hot summers happen in the centre and southern regions of the country. The Mediterranean seaside cities have soft winters and variable summers which change from hot to very hot. As shown in Figure 1, during the heat wave of 2003, the temperatures can be extreme also during the night.

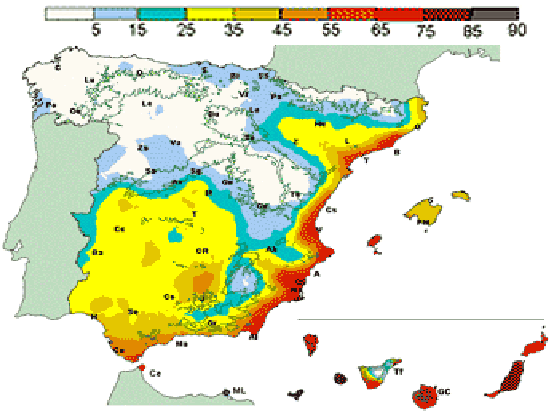


Figure 1. Number of days with minimum temperature higher or equal to 20ºC (summer 2003) (AEMET, 2003)

Historically, summer comfort was reached through passive cooling strategies in buildings and reducing the activity of the citizens during the hottest hours (the *siesta*).

In the 20th century, most of the constructed buildings were designed without any energy saving criteria, so summer and winter passive comfort strategies were scrapped. The main reason was the carbon, and later the cheap petrol fuel. Although fossil fuels have been used mostly for heating purposes, the cooling passive strategies banished as well during this period.

Since the 90s, the use of mechanical air conditioning for cooling becomes massive in buildings, mainly due to the increase of the families income and good performance of the economy. The mechanical air conditioning replaced the deficit on summer comfort strategies on buildings built during the last century, and caused a big increase of energy consumption in Spain. The energy consumption for cooling was 11,1% of the total in 2004. (IDAE, 2004).

In 2006 a new Spanish Building Code (CTE, 2006), aiming to improve the rational use of energy from buildings and assuming the ideas from the EPDB, was officially set up. The passive strategies for summer comfort such as solar shadings in openings, thermal mass, low emissivity, etc. are properly considered and evaluated. The thermal comfort is guaranteed by the mechanical air conditioning system, rewarding the energy efficiency of the machines that are used. Natural ventilation or night ventilation are not yet considered, although along 2009 the Building Code is supposed to be extended including alternative capacities which should describe these phenomena's.

This report aims to present the existing situation of summer comfort in buildings in Spain. The first section of the paper exposes the introduction of air conditioning systems and problems resulting from using mechanical cooling. The second section presents the existing legislative frame concerning summer comfort and cooling. Subsequently the trends and perspectives on low energy cooling will are presented in the next section. The report finishes with a discussion about further legislative requirements.

1 Use of Conventional air conditioning systems in Spain

Spain is the European country with the highest cooled floor per inhabitant, as shown in Figure 2 (EECCACC study, 2003). The report of the EECCACC also shows the prediction of the evolution of the cooled area for the next ten years, Figure 3. This report was carried out in 2003 with the data from 2002, hence, the heat wave which affected Spain in 2003 was not considered. In 2003 the selling of air conditioning machines increased in respect of the year before on 159% (Consumer, 2003).

The total energy consumption for cooling in Spain is the highest in Europe with 28.333 GWh followed by Italy, France and Greece as shown in Figure 4 (EECCACC study, 2003). Concerning to the peak load in summer, every year, a new record in the daily energy consumption is reached (see Figure 5), leading to a reduction in the difference between summer and winter peak loads. The 18th july 2006, the energy–consumption was 826 GWh as it is shown in Figure 5 (REE, 2008). This day, the energy consumption between 15:00 and 18:00 hours was nearly the 20% of the overall energy consumption of the country. These peak loads force to increase the number of power stations and the size of the electric grid in order to avoid a sudden cut offs. The annual energy consumption for cooling in Spain is similar to the energy produced by three nuclear power plants (IDAE, 2004).

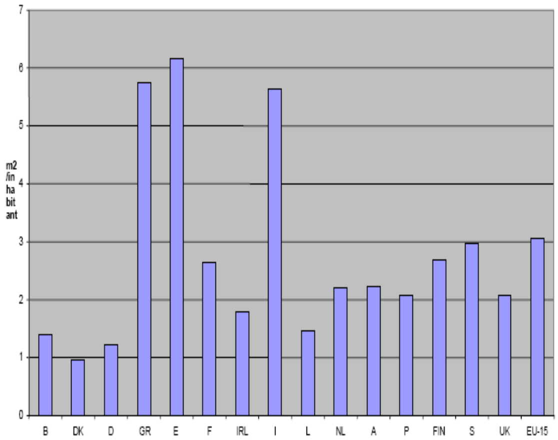


Figure 2: Average cooled-floor area per inhabitant for EU countries and the EU as a whole in 2000, (EECCACC study, 2003)

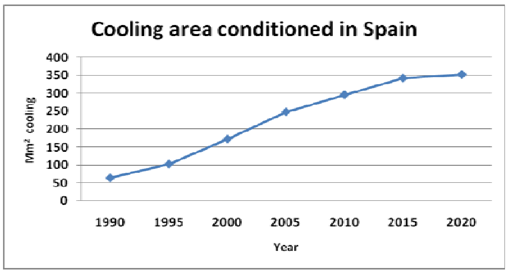


Figure 3. Cooling area conditioned in Spain by year, (EECCACC study, 2003)

In Spain it is estimated that three million homes are equipped with air conditioning systems. This number only represents 2% of the overall cooling energy consumption, since 98% corresponds to public buildings, offices and the service sector as restaurants and hotels (IDAE, 2004). Although the housing cooling consumption is relatively small compared to the overall consumption, this percentage is dramatically increasing (see figure 3). It has also to be considered that 3.000.000 new homes have been constructed from 2003 to 2006 in Spain, hence, the updated status will be substantially different.

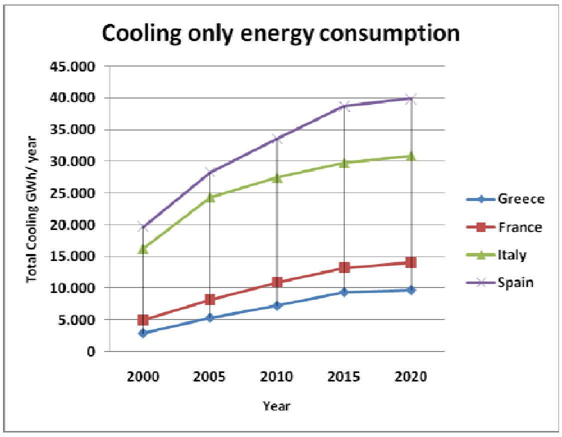


Figure 4. Cooling ~~only~~ energy consumption by country and year, (EECCACC study, 2003)

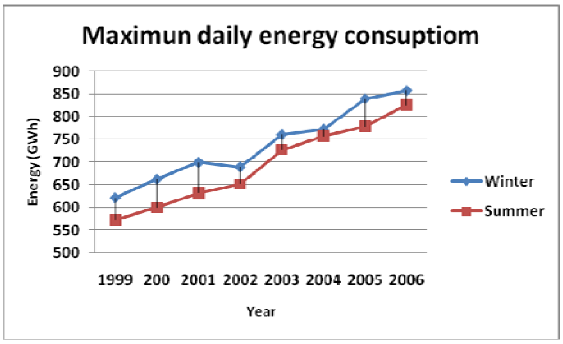


Figure 5. Maximum daily energy consumption in Spain by year, (REE, 2008)

2 Legislative Frame Concerning Summer Comfort and Cooling

The new Spanish Building Code (SpBC) was approved in 17th march 2006 (CTE, 2006) and the building energy labelling scheme was approved in 2007 (CEE, 2007). 12 climate areas, classified by the severity of the winter and summer, were defined for Spain. Two steps are required to get the energy labelling:

1. First of all, the cooling and heating demand of the building must be estimated through a comparison with a reference building. This reference building is similar to the target one but with the minimum requirements established by the SpBC.
2. And second, the energy consumption and the CO_2 emissions needed to cover the heating and cooling loads are calculated and the building energy labelling is obtained.

Hence, the main idea which underlies the regulation is to design a building with low heating and cooling loads, in order to reduce the CO2 emissions produced by the building energy systems. A good energy efficiency of the heating and cooling systems is rewarded with a better energy certification.

In the first step, refereed to the passive design of the building, the rewarded measures to get a low heating and cooling loads are:

a) Improvement of U values of the envelope of the building in respect of a reference building. The U values of the reference building are higher according with the severity of winter climatology.

b) Properly shaded external openings.

c) Quality and type of windows.

d) Number and area of the openings in the south and north façade.

e) Low internal load and occupancy for warm climates.

f) The air changes per hour are defined by a mean annual value. Shaded and ventilated interior patios can improve the energy performance during the summer. Ventilation is required by the SpBC and is defined in the health section by the occupancy, the floor area and mostly by the number of bathrooms (15 l/s each one) and size of the kitchen (2 l/s per m^2). Values near 1 ACH are common.-

The summer comfort is considered initially in the building design by the estimation of the cooling load requirements. These requirements are estimated assuming three different control strategies: air conditioning, day/night and ventilation. The general idea is to estimate the cooling load required to keep the indoor temperature below 27ºC. The thermal performance simulations within the first step are carried out using the official software called LIDER.

The second step refers to the energy consumption of the heating and cooling systems to meet the conditioning energy loads estimated on the previous step. It is divided in two different methodologies; for dwellings and small tertiary sector at one side (Calener VyP), and for medium and high tertiary sector at the other side (Calener GT).

In Calener VyP only the nominal characteristics of the heating and cooling secondary systems are required.

In Calener GT, primary and secondary heating and cooling systems can be considered. In this case the time schedule can be defined for air flow rate, air infiltration, occupancy, internal loads, lighting, performance of pumps, power, and type of strategies control.

In this second step the energy consumption, due the efficiency of the machines used and the time schedule, is obtained. However, the thermal comfort of the inhabitants does not have any kind of requirement in these calculations, thus allowing to a sub dimensioning of the systems to get lower CO_2 emissions and better energy labeling as have been reported (Garcia, 2009). In this sense it is necessary to introduce limits to the sub dimension of the systems. These limits should be restricted to a minimum size able to meet the summer comfort conditions.

4. Low Energy Cooling Technological Trends and Perspectives.

In Spain there is an increasing interest in low energy cooling techniques able to reach summer comfort conditions. This is mainly due to the favorable climatology of the country and the existing high levels on buildings energy consumption.

At present, there are many research projects (ARFRISOL, PVT-Building, RECONSOST, etc.) trying to improve the natural cooling of buildings using natural ventilation through windows, solar chimneys with thermal inertia for night ventilation, night radiative cooling, buried pipes, evaporative cooling systems, PV ventilated and ventilated façades, phase change materials, ventilated greenhouses, advanced glassing, etc.

This research on different cooling techniques can improve the energy saving and get a better building energy labeling as the SpBC requires. However, a further improvement of the software tools, so that these new low energy cooling systems can be analyzed, is required. Concerning to the reference building used to calibrate the energy labeling, there is a lack of reliable database which collects the energy consumption of existing buildings, including the discrimination among heating, cooling and lighting loads. The creation of real data benchmarking about cooling energy consumption on buildings should be one of the main task in next years in order to improve the evaluation of the energy efficiency of low energy cooling techniques.

As an example of similar approaches, a benchmarking about the overall energy consumption in schools, offices, social centers and sports centers in Catalonia is shown in Figure 6. It can be seen that, in case of schools (over 50 monitored schools), the overall energy consumption varies from 25 to 150 Kwh/m^2 and the percentage of low energy schools, bellow 35 Kwh/m^2, is less than 15 %. Similar benchmarking analysis should be carried out for each building typology include in the building regulation.

These buildings, with expected similar typology and use, illustrate a huge variability, which can be explained mainly by the user behavior, also by materials and design. There is no benchmarking about cooling energy consumption in Spain. As example, the table 1 shows the cooling energy consumption for 4 monitored buildings, showing as well, a big variability on the data. The low energy consumption for cooling on these buildings is due by the building use time-schedule and that the buildings are closed during august.

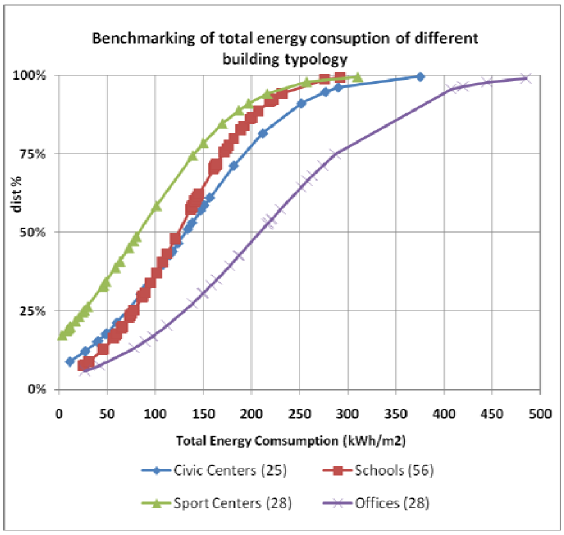


Figure 6: Benchmarking of the total energy consumption of different building typology. In brackets the number of buildings considered for the benchmarking (SIE, 2008).

Building	Cooling energy consumption	Date of construction / retrofitting
Office ITL	19 KWh/m^{2}Y	1978
Public library	11.2 KWh/m^{2}Y	1999
Social center 1	7.3 KWh/m^{2}Y	2003
Social center 2	16.5 KWh/m^{2}Y	2003

Table 1: Cooling energy consumption of different buildings in Catalunya (SIE, 2008).

The user behavior plays a key role in the energy consumption. An example of it can be seen in the influence of night ventilation. An energy diagnosis (monitoring and calibrated simulation) of four dwellings from a block tower in Terrassa (Catalonia) has been carried out. This city is characterized by soft winter and summers, and the buildings were constructed in the 80s. The results presented are referred to air conditioning, night ventilation and summer comfort conditions (Cipriano, 2008). One of the four dwellings has no air conditioning (noAC), but the other three have (AC). The air conditioning energy consumption varies between 5.6-7.5 KWh/m²·year, which represents the 45-55% of the total energy consumption of the summer period.

In the noAC house, night ventilation through opened windows, from 21:00 to 10:00 is realized with 3 ACH, while in the AC houses not.

The summer comfort has been estimated for the noAC house considering a T< 25ºC and relative humidity in branch of 20-80%. In the AC case, a ventilated situation has been considered due the air movement produced by the air conditioning, and the summer comfort corresponds to T<27ºC and relative humidity in branch of 20-100%.

The results from the calibrated simulations show that the house with noAC reaches thermal comfort in summer in 42% of the hours. The ones with AC reach thermal comfort in 62% of the hours with cooling energy consumption of 6.4 KWh/m²·year (50% of total energy consumption of summer period). If the AC houses also decided to open windows for night ventilation, the cooling energy consumption would be reduced to 3.10 KWh/m²Y (52% of reduction) and the thermal comfort would increase to 85% of the hours. These results are illustrated in Figure 7.

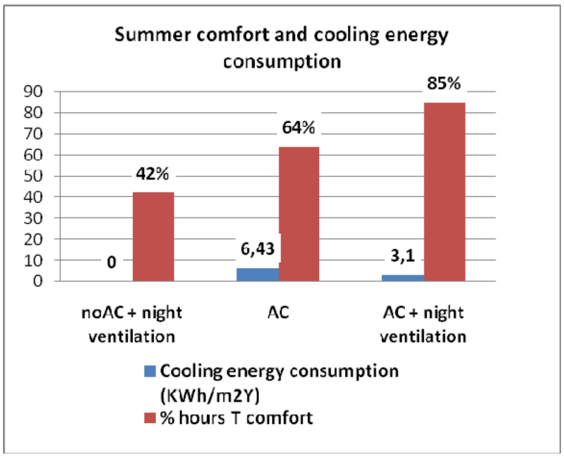


Figure 7: Summer comfort and cooling energy consumption for different scenarios on night ventilation for AC and noAC (Cipriano, 2008).

These measurements lead to the conclusion that very simple cross night ventilation techniques, combined with a proper user performance, can lead to a significant energy consumption reduction. However, in the existing SpBC, are not yet considered. The potential of these two aspects seem to be important in the future trends of energy saving in cooling.

5. Future Legislative Perspectives and Requirements

The present SpBC has meant a great advance on the energy efficiency on buildings due to the fact that CO2 emissions are now computed to give an energy labelling to the new buildings. In 2009 it is expected that two new legislative requirements will be approved. Firstly, the publication of an energy labelling methodology for existing buildings. And second, the opening of the source code of the official software, LIDER and CALENER (VyP and GT). This new approach will open the possibility of insertion of ‘alternative capacities’, such as; natural ventilation, ventilated façades, solar walls, night ventilation, solar chimneys, etc.

In this paper three issues which may improve further building regulations have been highlighted:

a) The inclusion of the thermal comfort in the energy labelling (Garcia, 2009), not only in the cooling and heating loads estimation (LIDER), but also in the set temperatures for the conditioning systems (CALENER)

b) The development of a national benchmarking database on energy consumption for all the building typologies and with discrimination in heating, cooling and lighting loads. This national database should be used as a reliable reference for the energy labelling of buildings.

c) The inclusion of user behaviour in the energy labelling of buildings of user behaviour on use of a schedule of shading devices, natural, cross and night ventilation, since the great energy saving this measure can mean.

6. Conclusions

The summer comfort in Spain has been faced by the introduction of air conditioning systems in a massive way, not only at homes, but also in the offices and terciary sector.

Since 2006 the new Spanish Building Code establishes methodologies to estimate the cooling loads and calculate the CO_2 emissions derived from the air conditioning of the buildings.

A variety of different cooling techniques can be considered, but those associated with the natural ventilation are not properly considered.

The energy efficiency of the air conditioning systems is considered and rewarded with better energy certification. Since the thermal comfort is not considered, the sub dimension of the systems could be a trick to get a better energy labelling.

There is a need of development of energy consumption national benchmarking database reliable enough to become the reference base for the energy labeling.

Finally, the user behavior, or the possibilities that the design of the building offer to the user to interact in order to get a more energy efficiency, should be considered due to the great energy saving it can lead to summer periods.

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Recent Trends and Developments Regarding Summer Comfort and Low Energy Cooling in Spain

Summer comfort and cooling
Barcelona, Spain
31 March & 1 April 2009

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J. Cipriano, X. Cipriano,
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Building Energy and Environment Group, BEEGroup - CIMNE,

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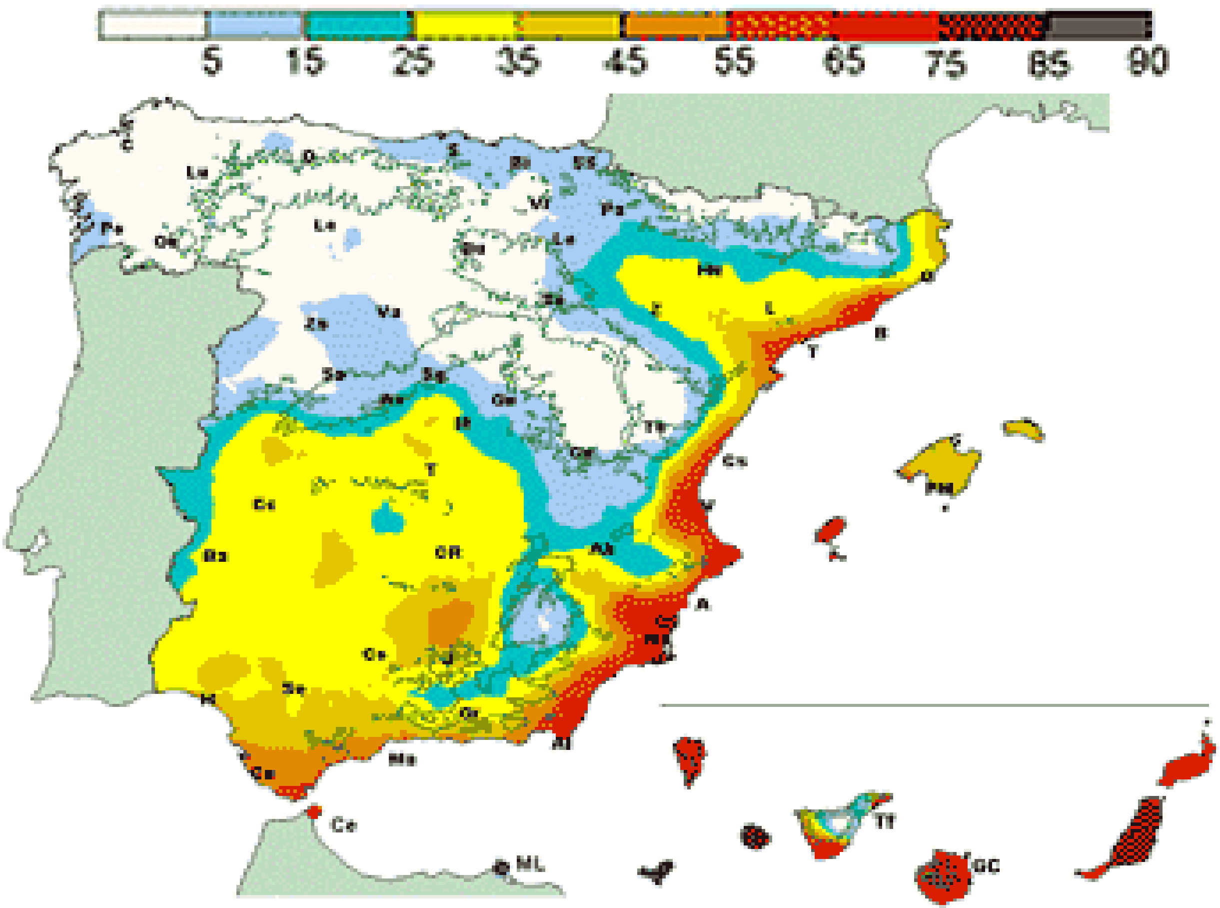
Background

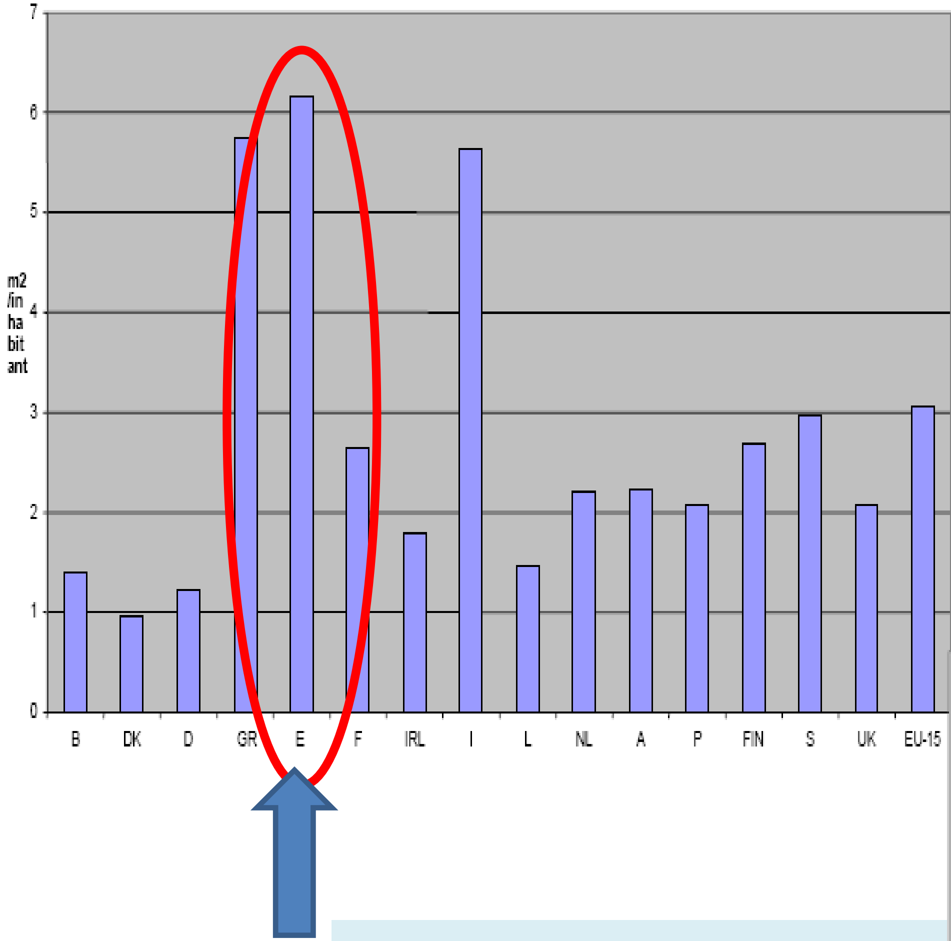


90s:
Massive penetration of air conditioning machines

From 2003 to 2006 :
Construction 'Boom',
3 million of new dwellings

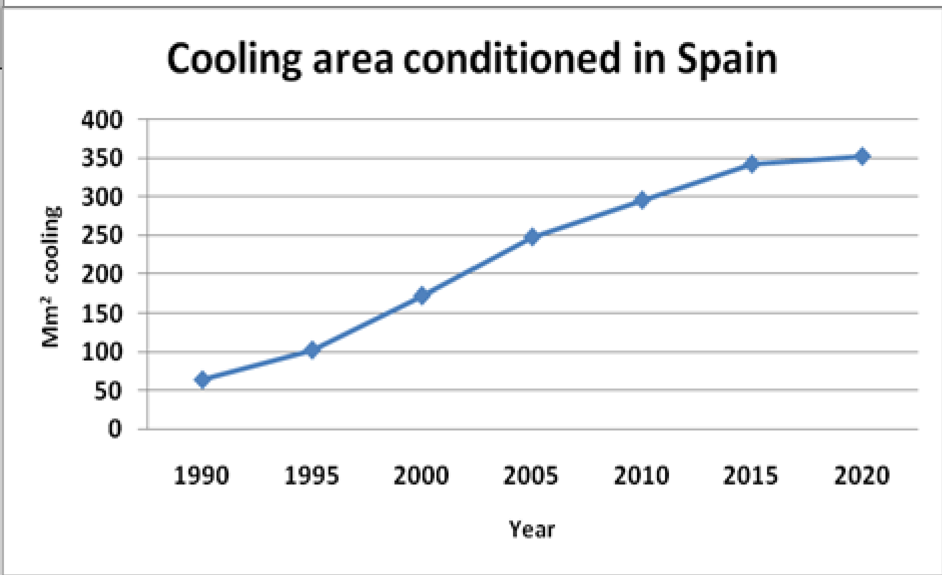
17th march 2006: New Spanish Building Code (SpBC).

Present situation

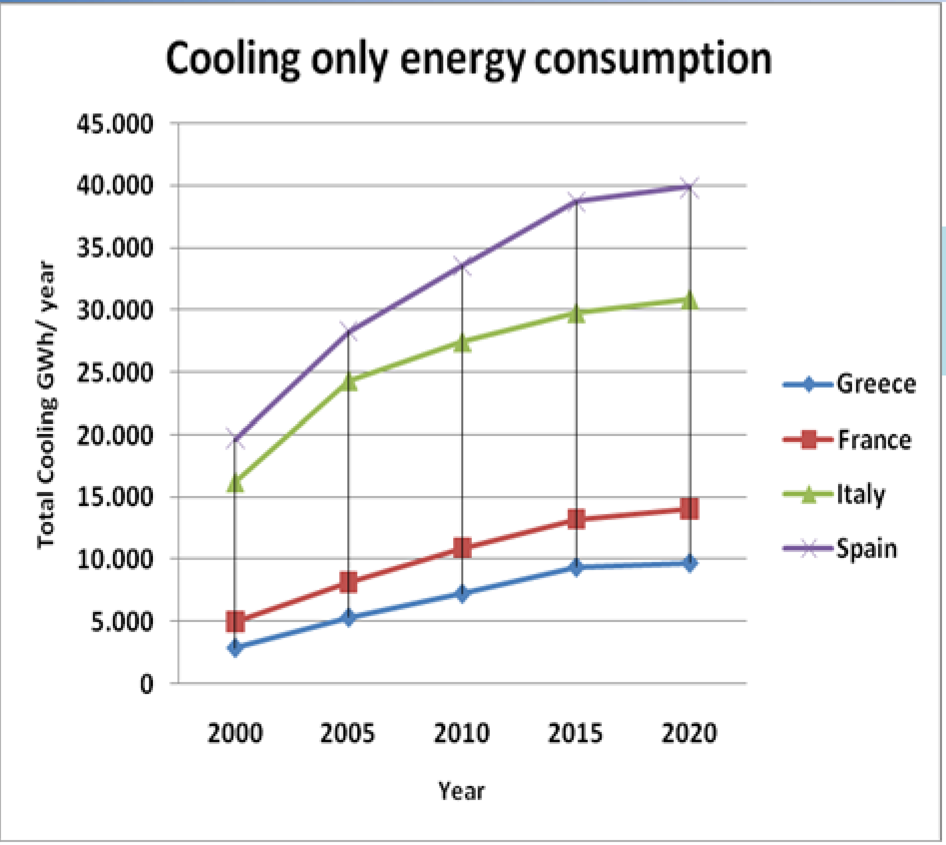


Spain: is the European country with the highest cooled floor area per inhabitant (2003 data)

Spain: the tendency is increasing (2003 data)

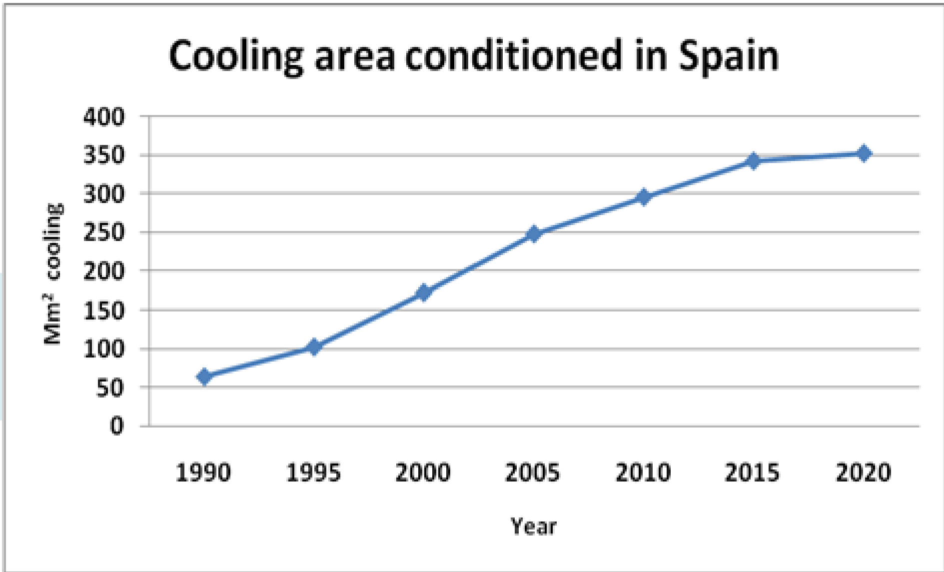


Present situation

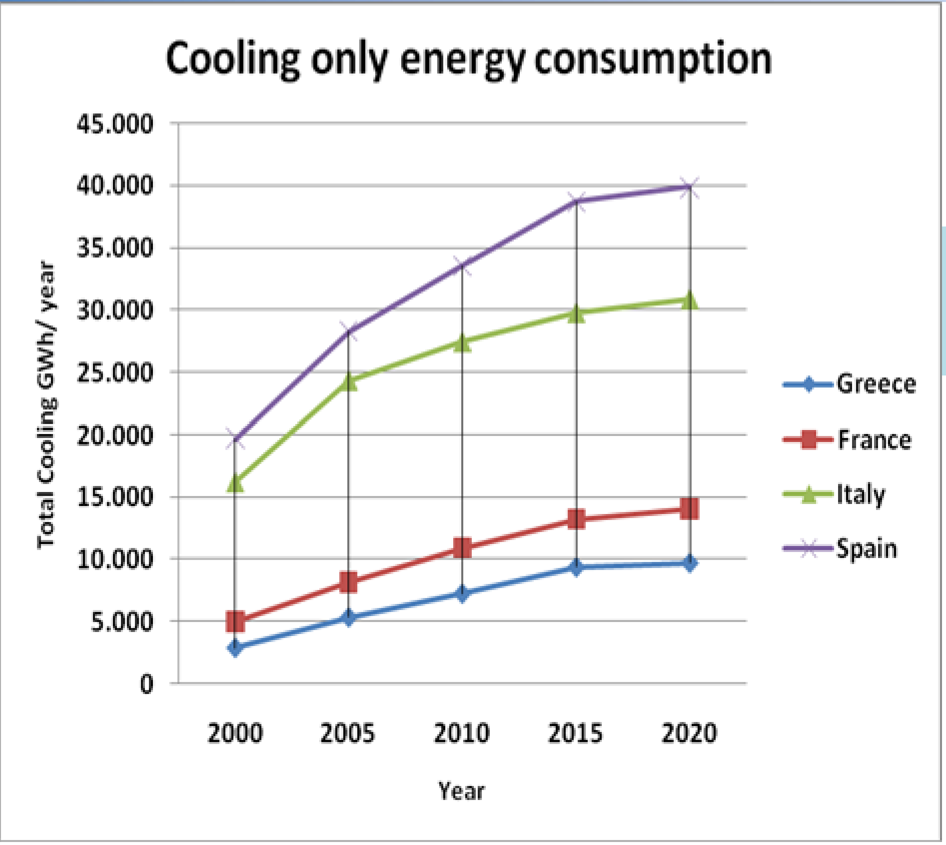


Expected stabilisation for 2020

Spain: the tendency is increasing (2003 data)

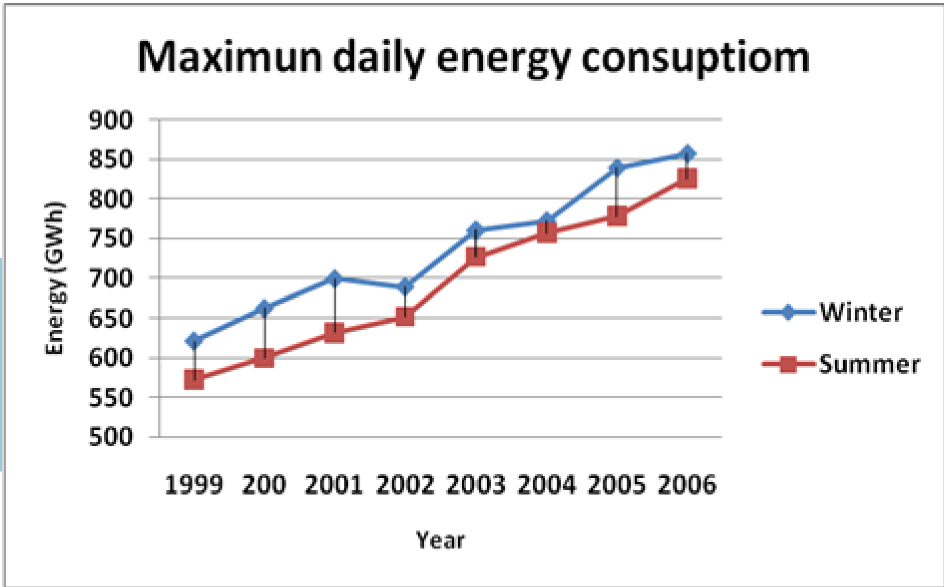


Present situation



Expected stabilisation for 2020

Yearly energy consumption increase, also daily peaks.



Spanish Building Code

17 march 2006, new Spanish building Code (adaptation EPBD)

Introduction of energy efficiency concept

31 January 2007, new Spanish Energy labelling scheme (adaptation EPBD)

Energy labelling scheme

Spanish Building Code

Two steps

CTE
CÓDIGO TÉCNICO
DE LA EDIFICACIÓN

LIDER: Heating and cooling demands

CALENER: Scaled energy efficiency by CO_2 emissions produced by the thermal conditioning

Spanish Building Code

CTE
CÓDIGO TÉCNICO DE LA EDIFICACIÓN

LIDER: Heating and cooling demands

Cooling load Vs summer comfort

Summer comfort :

Air conditioning:

-If T< 20°C – Heating to keep 20ºC in the zone.

-If T> 27°C – Cooling to keep 27ºC in the zone.

Day / Night:

-From 23:00h to 7:00h, if T< 10°C – Heating to keep 10ºC

-From 7:00h to 23:00h, if T< 20°C – Heating to keep 20ºC

-Every hour, if T> 27°C – Cooling to keep 27ºC

Ventilation:

-From 18:00h to 7:00h – Ventilation on.

-From 7:00h to 18:00h – Ventilation off.

If no heating system exists:

-From 7:00h to 18:00h, If T> 27ºC – cooling to keep 27ºC

-From 18:00h to 7:00h – cooling system off.

In this case, the ventilation is supposed to produce 11,4 ACH of exterior air.

Cooling loads relative to a reference building (minimum requirements)

Spanish Building Code

CTE
CÓDIGO TÉCNICO DE LA EDIFICACIÓN

LIDER: Heating and cooling demands

Heating load Vs summer comfort

Summer comfort :

-If T> 27°C – Cooling to keep 27ºC in the zone.

Design strategies:

Improvement of U values
Solar shading
Quality and type of windows.
Openings in the south and north façade.
Low internal load and occupancy for warm climates.

Ventilation - Defined by healthy section.

-Occupancy,
-Floor area and
-Mostly by the number of bathrooms (15 l/s each one) and size of the kitchen (2 l/s per m^2).

A constant ACH value for the whole year.

Spanish Building Code

CALENER: Scaled energy efficiency by CO_2 emissions produced by the thermal conditioning

CALENER VyP **for dwellings** and small tertiary sector.

Only **nominal characteristics** of the conditioning system are required

CALENER GT for medium and high **tertiary sector**

Primary and secondary heating and cooling systems
time schedule:
- -air flow rate
- -air infiltration,
- -occupancy,
- -internal loads,
- -lighting,
- -performance of pumps,
- -type of strategies control.

Spanish Building Code

CALENER: Scaled energy efficiency by CO_2 emissions produced by the thermal conditioning

No summer comfort required on the dimensioning of the systems.

Undersize the systems, a better energy label is achieved

Spanish Building Code

CTE
CÓDIGO TÉCNICO DE LA EDIFICACIÓN

Heating loads relative to a reference building (minimum requirements)

A constant ACH value for the whole year.

Ventilation - Defined by healthy section.

No summer comfort required on the dimensioning of the systems.

Trends in summer comfort

Research projects:
ARFRISOL, PVT-Building, RECONSOST, etc

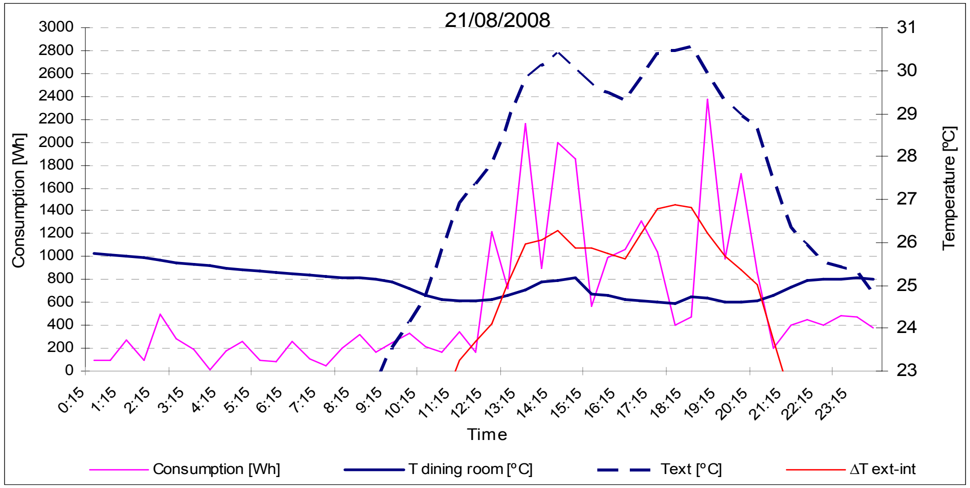
-Natural ventilation through windows,
-Solar chimneys with thermal inertia for night ventilation,
-Night radiative cooling, buried pipes, evaporative cooling systems,
-PV ventilated and ventilated façades,
-Phase change materials,
-Ventilated greenhouses,
-Advanced glassing, etc.

Trends in summer comfort: CASE

Natural ventilation is not yet considered: a case study

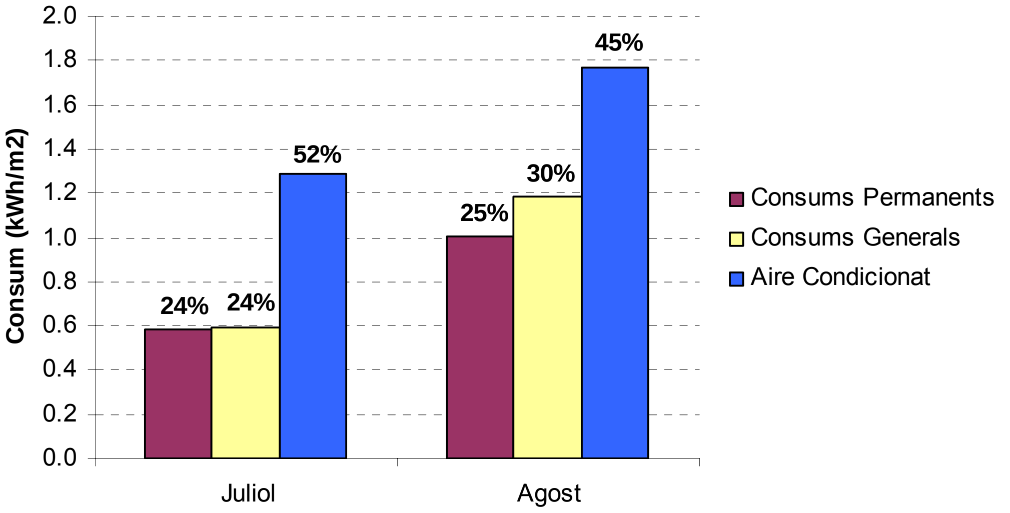
Four dwellings monitored in Can Jofresa, Terrassa.

3 with AC (AC)
1 with out AC (noAC)



Consumption A.C: 5.6-7.5 kWh/m2·a

45-50% Energy consumption during summer.



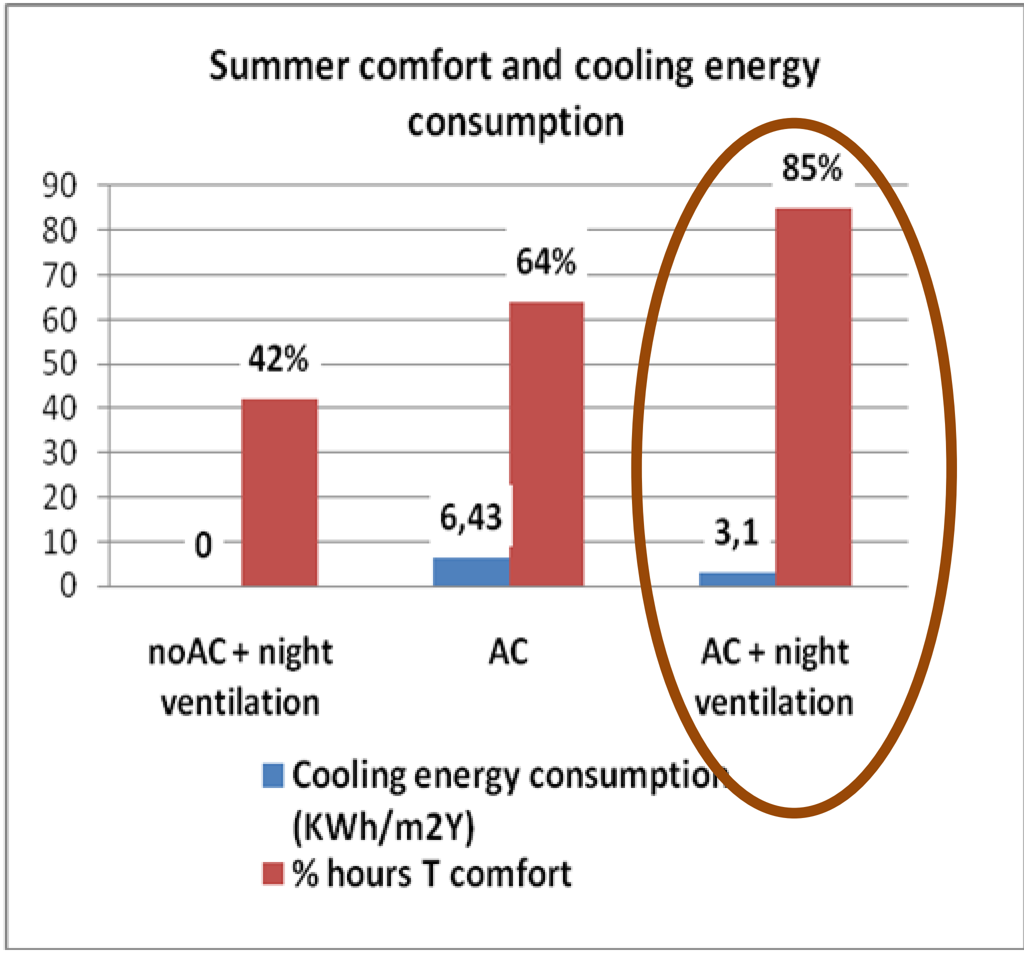
Trends in summer comfort: CASE

noAC house, night ventilation through opened windows, from 21:00 to 10:00 is realized with 3 ACH, while in the AC houses not.

Summer comfort

noAC house
T< 25ºC and relative humidity in branch of 20-80%.

AC case, (ventilated situation)
T<27ºC and relative humidity in branch of 20-100%.

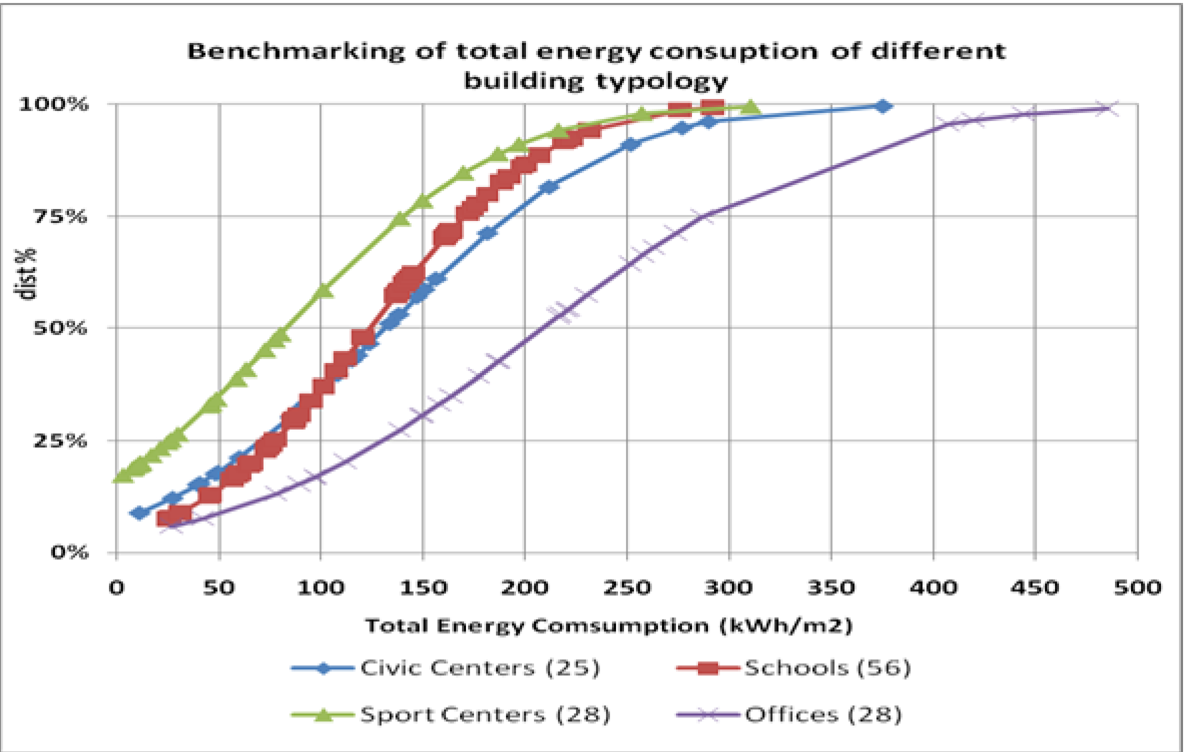


Importance of the natural ventilation and user behavior

Trends

Importance of user behavior

Building	Cooling energy consumption	Date of construction / retrofitting
Office ITL	19 KWh/m^{2}Y	1978
Public library	11.2 KWh/m^{2}Y	1999
Social center 1	7.3 KWh/m^{2}Y	2003
Social center 2	16.5 KWh/m^{2}Y	2003



National benchmarking needed

Perspectives and conclusions

Coming in 2009

New Methodology for energy labelling for existing buildings

Opening of the source code of LIDER and CALENER

Expected to come in 2009

Incorporation of 'alternatives capacities' on the Spanish Building Code

Proposals to consider

Comfort conditions considerations on CALENER

Potential of user behaviour on natural, cross, night ventilation

National benchmarking on heating and cooling loads as reference

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Recent Trends and Developments Regarding Summer Comfort and Low Energy Cooling in Italy

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1 Introduction

One of the fastest growing sources of new energy demand is space cooling. The studies EECCAC and EERAC predict a four-fold growth in air-conditioned space between 1990 and 2020 (Adnot, J. et Al, 2003). The IEA Future Building Forum identified space cooling as one of the fastest growing sources of new energy demand (International Energy Agency, 2004).

In its preamble, the European Energy Performance of Buildings Directive (EPBD) states that "Priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To this end there should be further development of passive cooling techniques, primarily those that improve indoor climatic conditions and the microclimate around buildings" (European Communities, 2003, p. L1/66).

But such passive cooling technologies, which are already available and cost effective (such as use of well designed sun shades, efficient lighting and office equipment, passive cooling via thermal exchange with the ground, night ventilation etc.) are not widely used in an integrated way today: the most common choice for a building owner when addressing summer comfort issues is still mechanical cooling, often without previously investigating other available measures regarding the optimization of envelope features (e.g. solar protections, glazing solar factor, thermal insulation of opaque surfaces, thermal mass).

This paper is based on some preliminary results of the project KeepCool2 (KC 2 in the following) to contribute to a broad market transformation from "a cooling approach" to "a sustainable summer comfort approach" which makes effective use of

- the most advanced knowledge and technologies for good design of building envelope (or redesign through retrofit actions)
- passive cooling techniques and
- comfort responses and adaption mechanisms of occupants (according to the new European Standard EN15251/ 2007, (CEN 2007a), (Nicol and Pagliano 2007))

In the Keepcool project "sustainable summer comfort" is defined as "achieving good summer comfort conditions with no or limited use of non renewable energy[1] and through the use of environmentally non-harmful materials", according to the definition set up in the KeepCool project (Varga and Pagliano 2006, see also http://www.keep-cool.net/keepcool.html).

2 Evolution of Urban micro-climates in Italy

About the evolution of the Italian urban climate, significant data were collected in the last years.

Despite not extreme boundary conditions (the climate is prevalently temperate-Mediterranean and the individual area of the cities is not very large), a steady increase of temperatures in many urban centers is evident. In the large metropolitan cities (Roma and Milan), among main causes may be listed the limited presence of green areas compared to paved areas, the high reliance on private means of transport and in general the increased use of energy within city boundaries.

As the following graph shows, in the main Italian cities the mean temperatures recorded between 1997 and 2007 are higher than the values relative to previous 30 years. In some cases, this trend is more pronounced: in Milan, in the last 10 years, the average temperature has increased of 1,8°C with respect to the levels of 50 years ago; in Napoli there was an increase of 1,2°C.

[1] non-renewable energy is defined as "energy taken from a source which is depleted by extraction (e.g., fossil fuels)" in the European Standard prEN 15603:2007: E., (CEN 2007b)

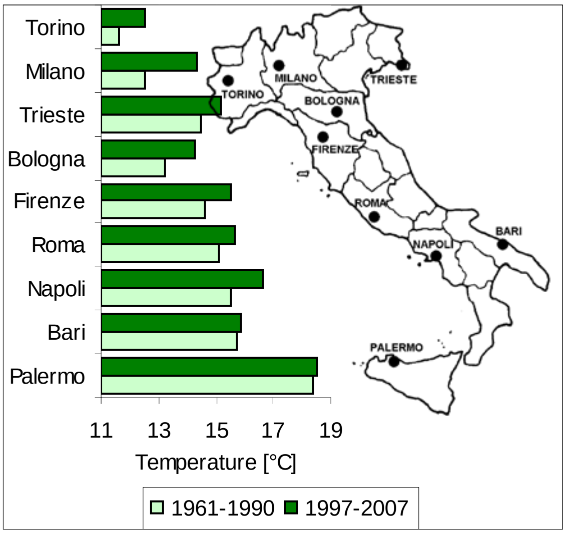

Figure 1 - Comparison between urban average temperatures relative to periods 1961-1990 and 1997-2007 (Source: Legambiente and Osservatorio Meteorologico Milano Duomo 2007).

The urban heat island effect has been observed in some locations, especially in Northern Italy in the Padana plain), for several years (Borghi 1980) (Bacci 1992) (Brunetti 2000) (Maugeri 2002).

The effect becomes more evident during the heat waves, like those of winter 2007 (Figure 2) and summer 2003 (Table 1).

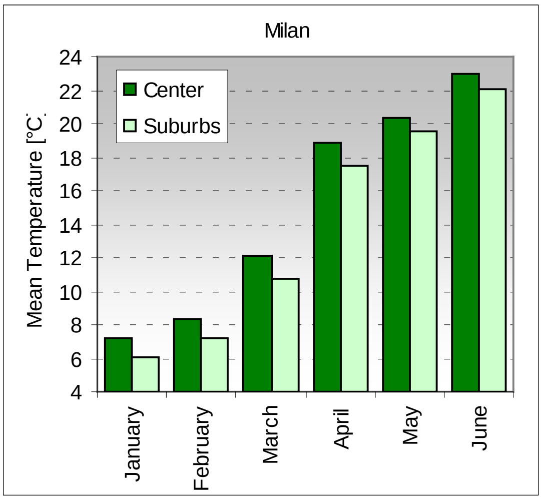

Figure 2- Heat wave of 2007 (January-June): temperature difference between the center of Milan and the rural area (Source: Legambiente and Osservatorio Meteorologico Milano Duomo 2007)

[°C]	Mean temperature in the center	Mean temperature in the suburbs	Temperature difference
Torino	26,6	24.3	2.3
Milano	28.2	27.3	0.9
Bologna	23.4	23	0.4
Firenze	23.3	23	0.3
Roma	28.2	27.1	1.1
Napoli	25.1	22.8	2.4
Bari	24	22	2
Palermo	28.1	26.9	1.3

Table 1– Heat wave of 2003 (June-August): temperature difference between city centres and surrounding rural zones (Source: Legambiente and Osservatorio Meteorologico Milano Duomo 2007).

Considering the daily scale, the major impacts of heat island occurs during the night, with the obvious consequence of limiting the cooling of urban structures. As showed in figure 3, the number of high temperature nights during the year has grown significantly: from 1961 to 2005, the number of nights when air temperature does not drop below 20°C has increased by 50%, mostly since 1981. In Rome, the hottest nights are all concentrated between 1994 and 2007, with some remarkable high levels, like on the night of july 23rd 2007, when the mimimum temperature has been 27,1 °C (4th highest value in record).

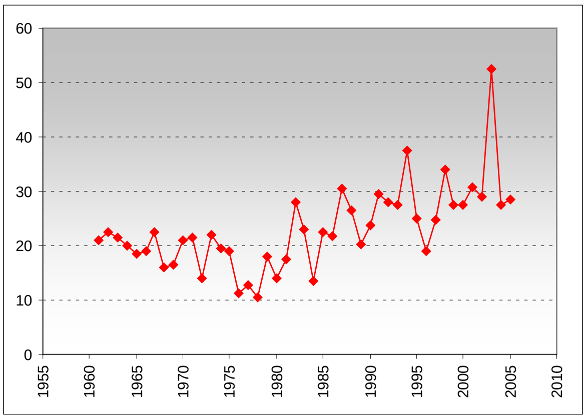

Figure 3 – Number of nights with minimum temperature higher than 20 °C in Italy between 1961 and 2005 (Source: Apat –OMS 2007).

3 Evolution of peak electric power demand in Italy and air conditioning market

During the last ten years, the electrical energy consumption in Italy has experienced a significant increase. The overload prevention system during the summer 2004 (with the programmed rolling blackout) and its continuation in the following years (Council of European Energy Regulators, 2008). were the most visible episodes showing a stress in matching offer and demand in the national electricity system.

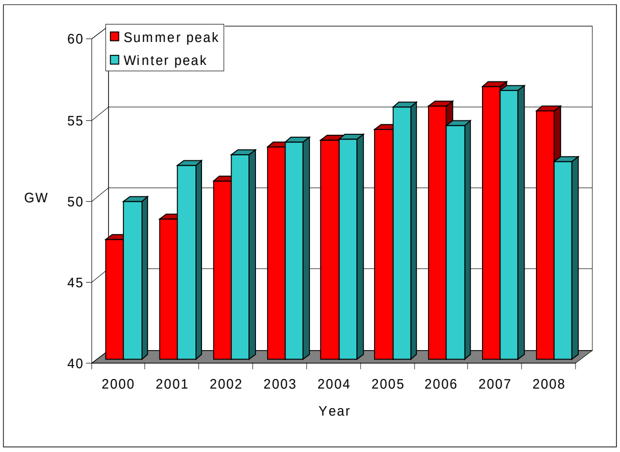

Figure 4 – Summer and winter peak power demand on the Italian electricity system, 2000 to 2008 (Source: Terna)

Terna SpA., the operator of the electricity transmission grids, publishes yearly the statistical analysis of the system evolution, summarized in figure 4. The analysis of the period 2000-2007 shows an average yearly growth of 2,7% in the summer peak load, one percentage point higher than the yearly growth of the winter peak demand. Total growth between 2000 and 2007 has been +14,3% in winter peak and +19,4% in summer peak. In 2006 and 2007 the summer peak has been higher than the winter one (GRTN and Terna 2002 to 2007). The data of 2008 are uncomplete but the complete results will be likely affected by the economic crisis and subsequent reduced economic activity starting in autumn 2008.

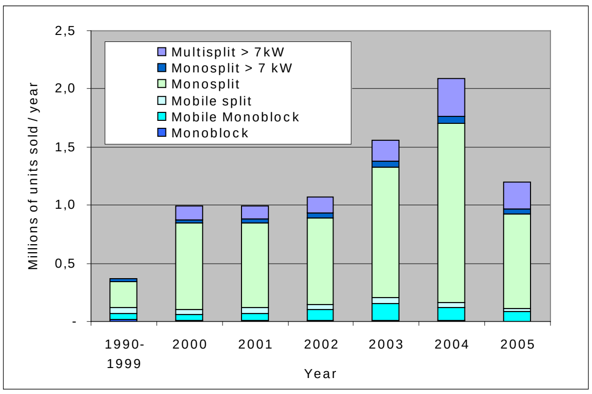

Figure 5 – Yearly sales of autonomous air conditioning units in Italy in the period 2000-2005 compared to average yearly sales in 1990-2000 (Ghielmi E. 2006).

Out of nearly 11,6 million units of autonomous air conditioning units sold between 1990 and 2005, more than 8 millions have been sold in the 2000-2005 period (figure 5). The President of the manufacturers association ANIMA/CoAer, Ghielmi states that : “Starting in 2000, this market… has had a spectacular development, largely unforeseen” (Ghielmi E. 2006). In 2003 and 2004, probably under the effect of the summer 2003 heat wave, yearly sales of autonomous air conditioning units in Italy have had a further growth.

Terna in its forecast 2008 to 2018 estimates that the summer peak will remain higher than the winter one and the distance between them will grow. The expectation for peak load in 2014 are 67,1 GW and 65,6 GW in summer and winter respectively. Terna estimates a need for installed electric capacity of about 91 GW in 2018 (Terna 2008).

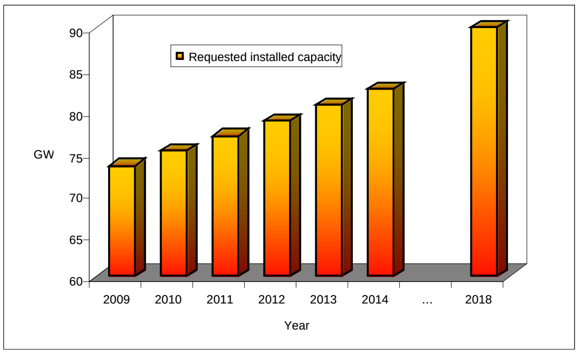

Figure 6 – Forecast of requested installed capacity up to 2018 by Terna (Terna 2008)

4 Legislative Framework on the Energy Performance of Buildings

Italian legislation on energy in buildings is undergoing revision, in the framework of the national implementation of the European

Directive 2002/91/EC on the energy performance of buildings.

The first step has been the Decreto Legislativo (Dlgs) 192/2005 which gave new legal values for maximum primary energy consumption for new or renovated buildings, with reference only to the end use space heating. It has established:

a) A set of maximum U-values for the various opaque and transparent components of the building envelope (the allowed value is lower for higher Degree Day zones);

b) minimum average seasonal efficiency of the heat generation system;

c) a set of values for maximum annual total primary energy consumption for space heating (higher values for high Surface/Volume ratios and in high degree days[2] climatic zones).

As for the end use cooling (Dlgs) 192/2005 only required that:

there should be effective solar protections (but the term “effective” was not defined in a quantitative way)

and superficial thermal mass of opaque components must be higher then 230 Kg/m^2 (or other techniques and materials, including innovative, which would have the same effect) in all zones excluding F and sites where monthly average solar irradiance on horizontal surface is higher then 290 W/m^2 in the month of maximum solar irradiation.

Dlgs 192/2005 was updated by the Dlgs 311/2006 which clarified a number of issues from Dlgs 192/2005 (including a clearer definition of when energy rating is mandatory in case of economic transaction, more in lime with the Directive) and proposes:

a) revised values for maximum U-values for the various opaque and transparent components of the building envelope, with improvements in 2008 and 2010;

b) maximum annual total primary energy consumption for space heating referred to heated net floor area for residential building, while to heated net volume for other building uses.

c) natural ventilation should be favoured by suitable design of the geometry of the building and sorroundings, or where this is not possible, mechanical ventilation may be used

In parallel there has also been the updating of technical standards.

As customary, many Italian norms (expressed through the acronym UNI) about energy in building consist of the adoption or transposition of European (EN) and/or International (ISO) standards.

In particular the UNI EN ISO 13790/2008 is the Italian version of the EN ISO 13790/2008 and it – in the revised version of 2008 – offers methods to calculate not only the energy need for heating but also the energy need for cooling.

A new set of four norms, called UNI TS 11300/2008, defines Italian modalities to use EN ISO 13790/2008 and EN 15316/2008.

At present the first two norms out of four are available and they propose:

a) methods to calculate energy need for heating, cooling and production of warm water for residential and non residential buildings;

b) data and methods to calculate the primary energy demand and efficiencies for space heating and production of warm water.

The last two norms, to be released, will be about:

c) data and methods to calculate the primary energy demand for space cooling;

d) how to use renewable energy sources and other methods the generate space heating and production of warm water.

On 24th February 2008, a new Decreto del Presidente della Repubblica (DPR) was published and came in force. It complements the Dlgs 192/2005, about those issues which were treated with little detail and in particular space cooling. Its requirements have to be applied for the construction of new buildings and for completely renovated buildings, both public and private.

It requires the use of UNI TS 11300/2008 norms to calculate energy performances of building.

In synthesis, issues from the last DPR about reduction of cooling demand and control of summer indoor temperatures are:

[2] Degree days for heating are calculated according the DPR 412/1993 and the base temperature is 18°C.

a) UNI TS 11300/2008 part 1 have to be used to calculate energy need for summer space cooling of building envelope;

b) The DPR gives – for the first time – maximum legal values of energy need for space cooling (see Table 1):

Type of building	Maximum legal value for cooling	Climatic zones[3]
Residential	40 kWh/m²	A - B
	30 kWh/m²	C - D - E - F
Non residential	14 kWh/m³	A - B
	10 kWh/m³	C - D - E - F

Table 2 - Maximum legal values of energy need for space cooling

c) The designer have to evaluate in a precise way the effectiveness of shading systems over glazed surfaces (i.e. according to UNI EN 13659/2009, UNI EN 13363-1/2008, UNI EN 13363-2/2006, ...);

d) In every site where monthly average solar irradiance on horizontal plane is higher then 290 W/m²:

   1. External opaque vertical walls, exposed from east to west, must have either a superficial thermal mass higher then 230 kg/m² or periodic thermal transmittance[4] lower then 0,12 W/m²K;
   2. External opaque horizontal component must have periodic thermal transmittance lower then 0,20 W/m²K;
   3. It is possible to reach previous values of periodic thermal transmittance also covering roof with vegetation ("coperture a verde");

e) Designers should favour natural ventilation of the whole building using in the best way the external ambient conditions and disposition of indoor spaces. If it is not possible, mechanical ventilation systems can be installed;

f) External shading systems are compulsory. If they are not cost-effective, they can be omitted if glazed surfaces are characterized by a solar factor not higher then 0,5. It has to be calculated according to UNI EN 410/2000.

The topic of thermal comfort is also present in Italian norms through the norms UNI EN ISO 7730/2006 and UNI EN 15251/2008.

UNI EN 15193/2008 is the new standard about lighting. Inter alia it gives information about the impact of lighting on space heating and cooling. It also gives maximum values of energy for lighting and the methodologies to calculate it for new or completely renovated buildings and to meter consumption in existing buildings.

4. Low Energy Cooling Technological and Behavioural Trends and Perspectives.

No general monitoring and evaluation programme (e.g. of the type of those ongoing in Germany like Solarbau) has been decided at national level. This even though in the last years some incentives and tax deductions have been introduced in order to finance new buildings and retrofits with a better energy efficiency focus and so there would be scope for monitoring the results and achieving a better insight on how to optimise passive cooling techniques to the specific Italian climatic features and building characteristics.

As a consequence monitoring and analysis exercises have been generally on a per building basis and without a general coordination framework.

Some service sector buildings have been monitored within e.g IEA tasks (e.g. hybrid ventilation); others are undergoing energy monitoring and comfort surveys in the frame of EU projects like Commonsense and ThermCo; some others within ad hoc monitoring projects. A common national database is at present lacking.

[3] Climatic zones are defined according to DPR 412/1993 and are based on ranges of degree days for heating.

[4] Periodic thermal transmittance is defined in UNI EN ISO 13796/2008. it is a complex quantity defined as the complex amplitude of the density of heat flow through the surface of the component adjacent to zone 1, divided by the complex amplitude of the temperature in zone 2.

Under the obligation to energy savings which has been established on electric and gas Distribution Companies in 2001 (taking effect in 2005 and renewed in 2008) energy efficiency certificates can be earned via actions on building envelope, including higher insulation, mass and solar protections. Even though these actions, based on comments e.g. by eERG have been endowed somehow larger recognition in the scheme than simpler actions like promotion of efficient appliances and compact fluorescent light bulbs, this has not been set sufficiently high to compensate for the higher initial capital costs to be recovered in a longer lifecycle; these type of actions have been up to now only a small part of the total energy savings.

In the last few years the Passivhaus technology has started to be applied in Italy mainly in the north as a replica of the technology adopted in center Europe. A EU IEE project (Passive-on, coordinated by Politecnico Milano- eERG, with the participation of the Passivhaus Institute and other EU research institutions) has developed a proposal for a new Passivhaus Standard for Warm European Climates, which includes specified comfort objectives and energy need limits both for winter and for summer:

- If cooling is provided by mainly passive means:
  - indoor comfort requirements: as defined by the adaptive model of the Annex A.2 ("Acceptable indoor temperatures for design of buildings without mechanical cooling systems") of the EN 15251;
  - energy needs for heating and cooling shall be lower than 15 kWh/m^2/year
  - total primary energy shall be lower than 120 kWh/m^2/year;
- If cooling is provided by active systems:
  - indoor comfort requirements: as defined by the Fanger's model of the EN 15251;
  - energy need for heating shall be lower than 15 kWh/m^2/year;
  - energy need for cooling: shall be lower than 15 kWh/m^2/year (this value may be updated and possibly reduced based on field studies);
  - total primary energy shall be lower than 120 kWh/m^2/year.

A few PassiveHaus are being built in Italy according to the revised standard and will be subject to monitoring in order to check the adaptations which have been proposed by the project (Zangheri P. 2009).

Specific passive cooling techniques which have a consolidated experience in centre and northern Europe, like air to ground and water to ground heat exchangers are somewhat gaining ground in Italy in the last years. A few large ground exchanger installations in commercial buildings have been and are being realised and some of them will be monitored and analysed.

In some cases free cooling, that is direct circulation of cool water from the ground in the building structures is being tested. Here again there would be a need of wider efforts of analysis and optimisation

After decades when the architectural trend has been towards largely glazed facades with no or little solar protections and a generally low focus on building envelope techniques for achieving low energy summer comfort, the legislation enacted in February 2009 might help to give again adequate relevance to this part of building design, and possibly allow to get more advanced passive cooling design being addressed and tested in the country.

Examples of a more explicit role of occupants in achieving low energy summer comfort

Since spring 2005 ENI (National Hydrocarbon Company) has allowed and encouraged all its employees to adopt an informal dress code called "energy-saving", that is without jacket and tie in summer, while keeping a style adequate to the work environment.

According the own evaluation of the Company, the initiative has given good results, by allowing to raise set point temperature of air-conditioning by 1°C, thus allowing a relevant reduction in the emissions into the environment and in the energy costs of the company.

ENI estimates that in summer 2007 the program has saved 243 000 kWh of electric energy, corresponding to 9% of electric consumption for cooling in the buildings affected. The CO2 emissions savings have been about 140 tons of CO_2.

At San Paolo Bank, a booklet has been produced and distributed in 2008, with suggestions for the employees on actions for reducing energy and materials waste.

As for containing energy consumption related to achieving summer comfort, it is suggested to:

keep windows closed and use blinds in such a way to protect windows from direct solar radiation

manage artificial lighting and office equipment correctly in order to achieve higher comfort and reduced energy costs.

If work tasks allow for it, adopt light dresses in summer, possibly avoiding to use a tie

adjust thermostat set point in such a way that the difference between internal set point and external temperature is not higher than 6 °C

turn off or lower the set point when leaving the office for a somewhat long period and in rooms which will not frequently be used

set the velocity of the fans in the fan coils at a medium level and keep it at that level through time

don't obstruct air distribution outlets

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Decreto Legislativo 19 agosto 2005, n. 192. "Attuazione della direttiva 2002/91/CE relativa al rendimento energetico nell'edilizia »

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The Air Infiltration and Ventilation Centre was inaugurated through the International Energy Agency and is funded by the following seven countries: Belgium, Czech Republic, France, Greece, the Netherlands, Norway and United States of America.

The Air Infiltration and Ventilation Centre provides technical support in air infiltration and ventilation research and application. The aim is to promote the understanding of the complex behaviour of the air flow in buildings and to advance the effective application of associated energy saving measures in the design of new buildings and the improvement of the existing building stock.

RECENT TRENDS AND DEVELOPMENTS REGARDING SUMMER COMFORT AND LOW ENERGY COOLING IN ITALY

end-use Efficiency Research Group (eERG) - Politecnico di Milano

Lorenzo Pagliano
Carlucci S. Roscetti A. Zangheri P.

Barcelona, March 31 - April 1, 2009

www.eerg.it

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end-use Efficiency Research Group
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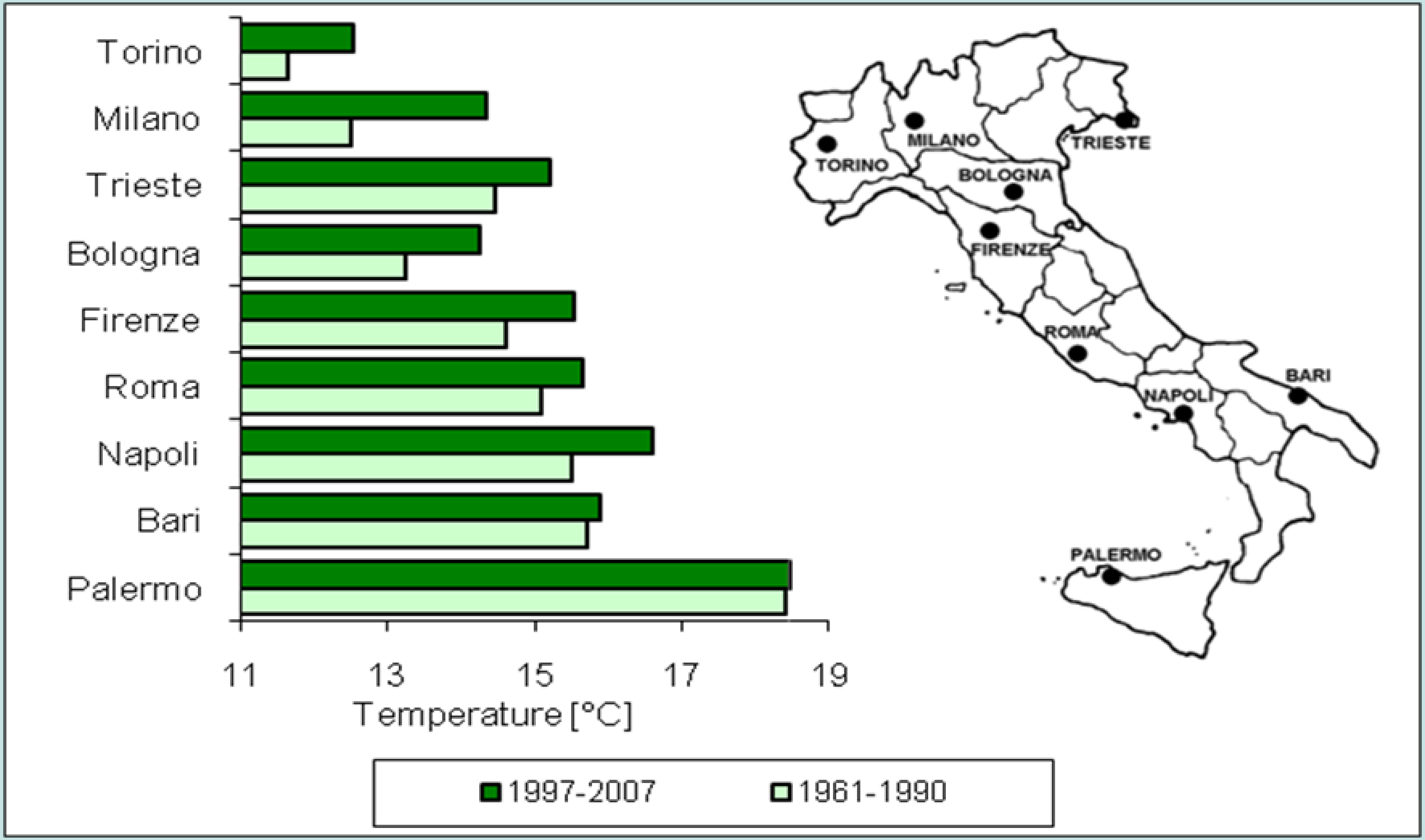
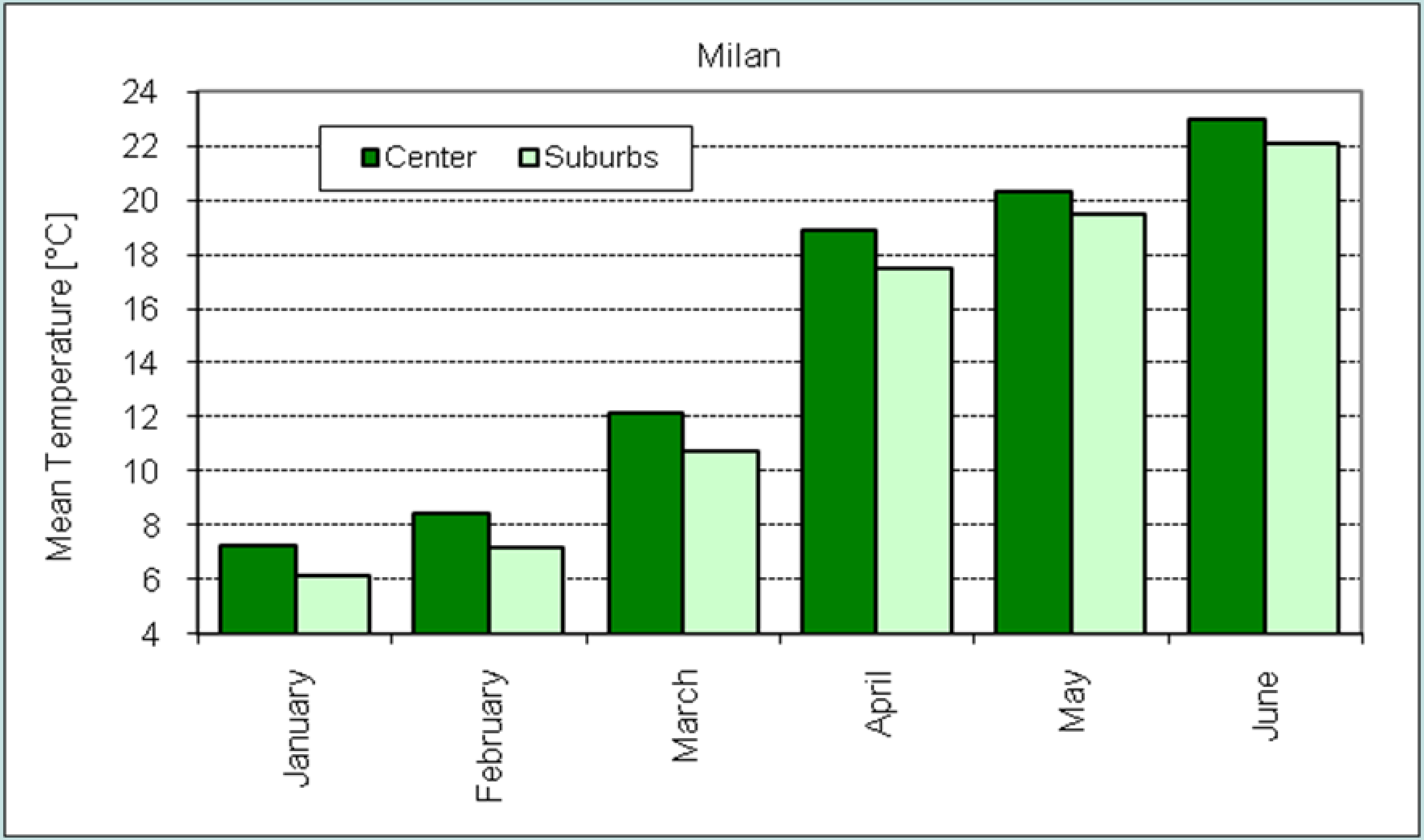
COMPARISON BETWEEN URBAN AVERAGE TEMPERATURES (1961-1990 / 1997-2007)



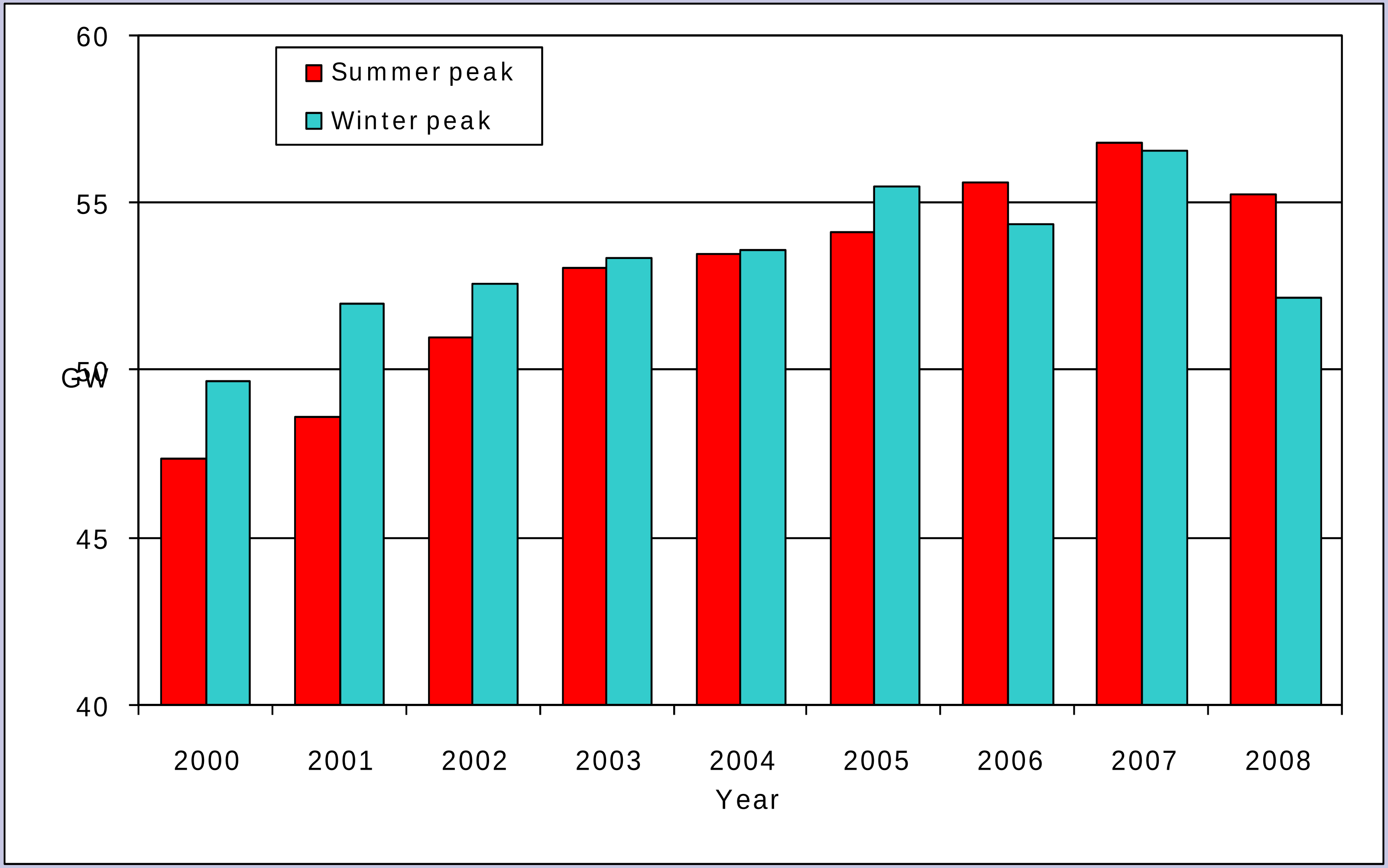
Source: Legambiente and Osservatorio Meteorologico Milano Duomo 2007

TEMPERATURE DIFFERENCE BETWEEN THE CENTER OF MILAN AND THE RURAL AREA - HEAT WAVE OF 2007



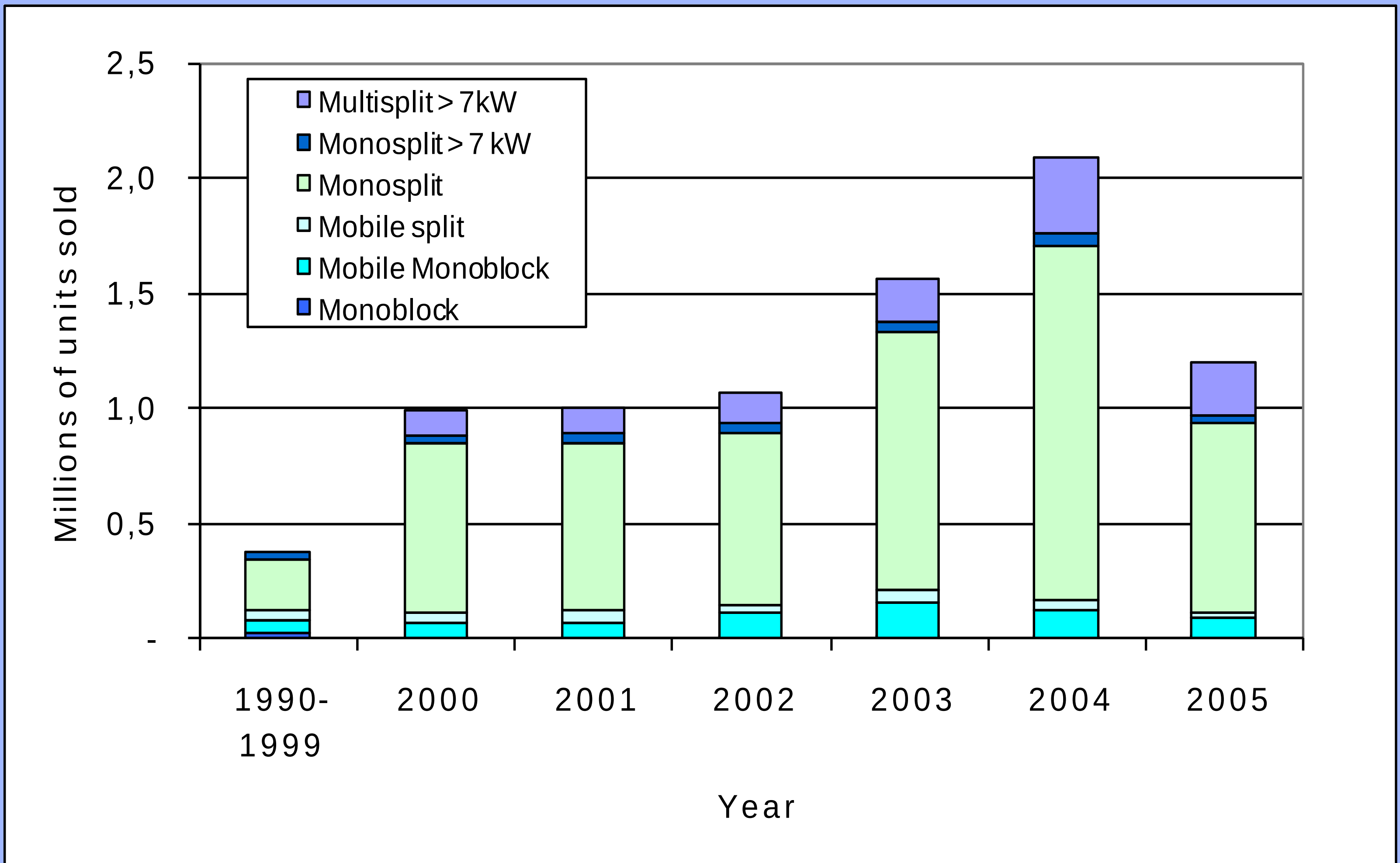
Source: Legambiente and Osservatorio Meteorologico Milano Duomo 2007

ELECTRIC POWER PEAK DEMAND IN ITALY (2000-2008)



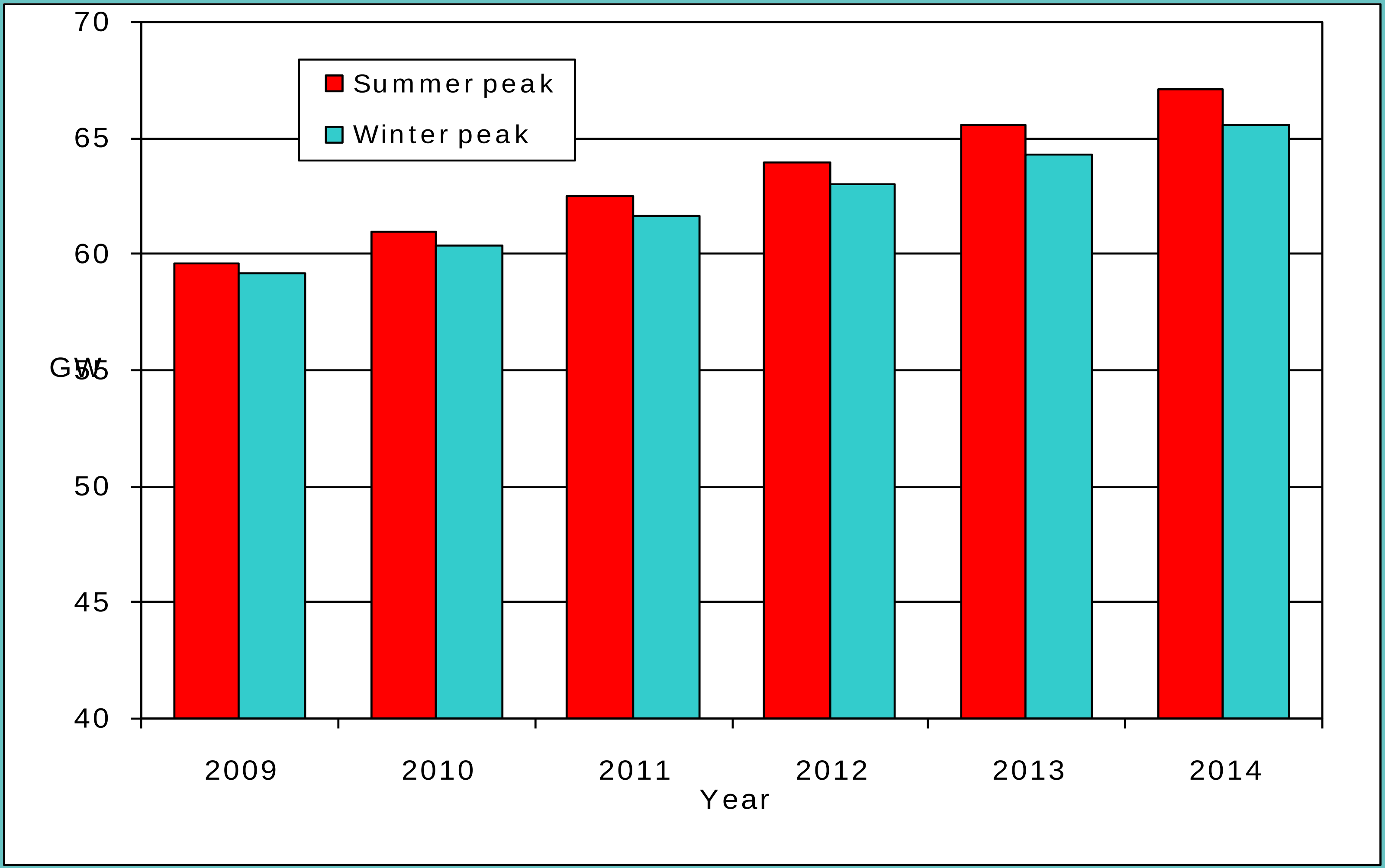
Source: Terna Spa

AUTONOMOUS AIR-CONDITIONING UNITS SOLD IN ITALY (1990-2005)



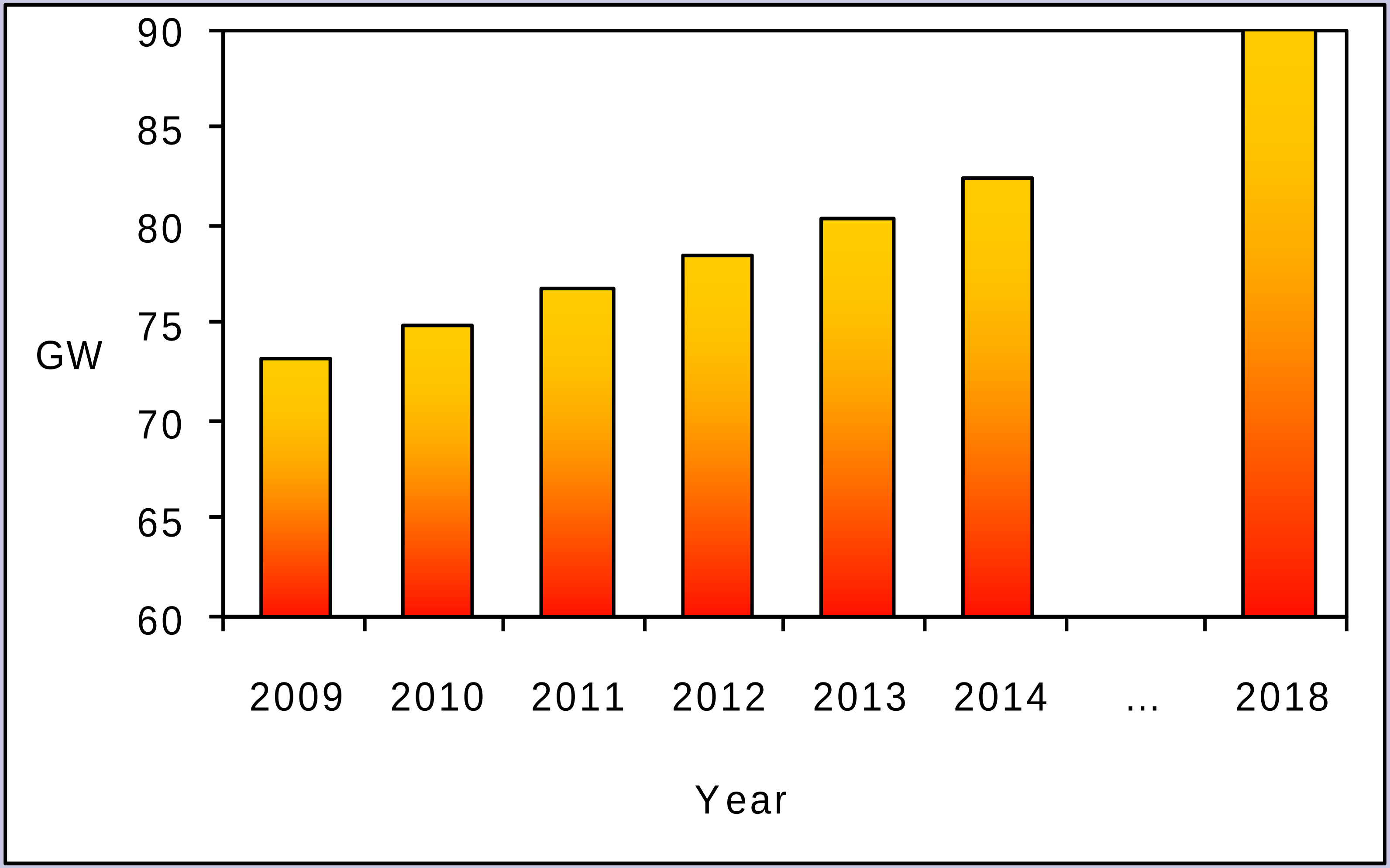
Source: Coaer

FORECAST for ELECTRIC POWER PEAK DEMAND in Italy: in case of normal winter and hot summer (2009-2014)



Source: Terna Spa

FORECAST OF INSTALLED CAPACITY REQUIREMENTS (2009-2018)



Source: Terna Spa

EVOLUTION OF ITALIAN LAWS AND NORMS ON ENERGY PERFORMANCE OF BUILDINGS

EUROPEAN LEGISLATION

DIRECTIVE 2002/91/EC ON ENERGY PERFORMANCE OF BUILDINGS

ITALIAN LEGISLATION

Legge 373/1976

Legge 10/1991

DPR 412/1993

DM 06/08/1994 transposition of CEN

Dlgs 192/2005 updated by Dlgs 311/2006

DPR 24/02/2009

ITALIAN TECHNICAL NORMATIVE

UNI 7357

UNI 10344 UNI 10348
UNI 10376 UNI 10379
UNI 10389 UNI 10345
UNI 10346 UNI 10347
UNI 10349 UNI 10351
...

UNI EN ISO 13790/2008
UNI EN ISO 15316/2008
UNI TS 11300/2008
UNI EN 15251/2008
UNI EN ISO 13659/2009
UNI EN 13363-1/2008
UNI EN 15193/2008
...

TIMELINE

HEATING DEGREE DAYS (DPR 412/1993)

Zone	HDD
Zona F	> 3000
Zona E	2101-3000
Zona D	1401-2100
Zona C	901-1400
Zona B	601 - 900
Zona A	< 600

Base temperature = 18 °C

MAIN APPLICATION FIELDS OF SOME OF CURRENT LAWS AND NORMS

ITALIAN LEGISLATION

Dlgs 192/2005 updated by Dlgs 311/2006

- Maximum U-values for opaque and transparent components of the building envelope (prescriptive);
- Minimum average seasonal thermal efficiency of the heat generation system (prescriptive);
- Maximum annual primary energy consumption for space heating expressed as a function of S/V ratio and HDD (performance)

DPR 24/02/2009

- Introduces NEW requirements on some building elements (prescriptive)
- Limits to the energy NEED for space cooling (performance)

DLGS 192/2005 UPDATED BY DLGS 311/2006

Maximum U-values according to the climate zone and the time regime
VERTICAL OPAQUE COMPONENTS OF THE BUILDING ENVELOPE

2. Trasmittanza termica delle strutture opache verticali

Tabella 2.1 Valori limite della trasmittanza termica U delle strutture opache verticali espressa in W/m²K

Zona climatica	Dall' 1 gennaio 2006 **U** (W/m²K)	Dall' 1 gennaio 2008 **U** (W/m²K)	Dall' 1 gennaio 2010 **U** (W/m²K)
A	0,85	0,72	0,62
B	0,64	0,54	0,48
C	0.57	0.46	0.40
D	0,50	0,40	0,36
E	0,46	0,37	0,34
F	0,44	0,35	0,33

DLGS 192/2005 UPDATED BY DLGS 311/2006

Maximum U-values according to the climate zone and the time regime
HORIZONTAL or TILTED OPAQUE COMPONENTS

3. Trasmittanza termica delle strutture opache orizzontali o inclinate

3.1 Coperture

Tabella 3.1 Valori limite della trasmittanza termica U delle strutture opache orizzontali o inclinate di copertura espressa in W/m^2K

Zona climatica	Dall' 1 gennaio 2006 U (W/m^2K)	Dall' 1 gennaio 2008 U (W/m^2K)	Dall' 1 gennaio 2010 U (W/m^2K)
A	0,80	0,42	0,38
B	0,60	0,42	0,38
C	0,55	0.42	0.38
D	0,46	0,35	0,32
E	0,43	0,32	0,30
F	0,41	0,31	0,29

3.2 Pavimenti verso locali non riscaldati o verso l'esterno.

Tabella 3.2 Valori limite della trasmittanza termica U delle strutture opache orizzontali di pavimento espressa in W/m^2K

Zona climatica	Dall' 1 gennaio 2006 U (W/m^2K)	Dall' 1 gennaio 2008 U (W/m^2K)	Dall' 1 gennaio 2010 U (W/m^2K)
A	0,80	0,74	0,65
B	0,60	0,55	0,49
C	0,55	0,49	0.42
D	0,46	0,41	0,36
E	0,43	0,38	0,33
F	0,41	0,36	0,32

DLGS 192/2005 UPDATED BY DLGS 311/2006

Maximum U-values according to the climate zone and the time regime
TRANSPARENT COMPONENTS (WHOLE WINDOW & CENTRAL GLASS)

4. Trasmittanza termica delle chiusure trasparenti

Tabella 4a. Valori limite della trasmittanza termica U delle chiusure trasparenti comprensive degli infissi espressa in W/m^2K

Zona climatica	Dall' 1 gennaio 2006 U (W/m^2K)	Dall' 1 gennaio 2008 U (W/m^2K)	Dall' 1 gennaio 2010 U (W/m^2K)
A	5,5	5,0	4,6
B	4,0	3,6	3,0
C	3,3	3,0	2.6
D	3,1	2,8	2,4
E	2,8	2,4	2.2
F	2,4	2,2	2.0

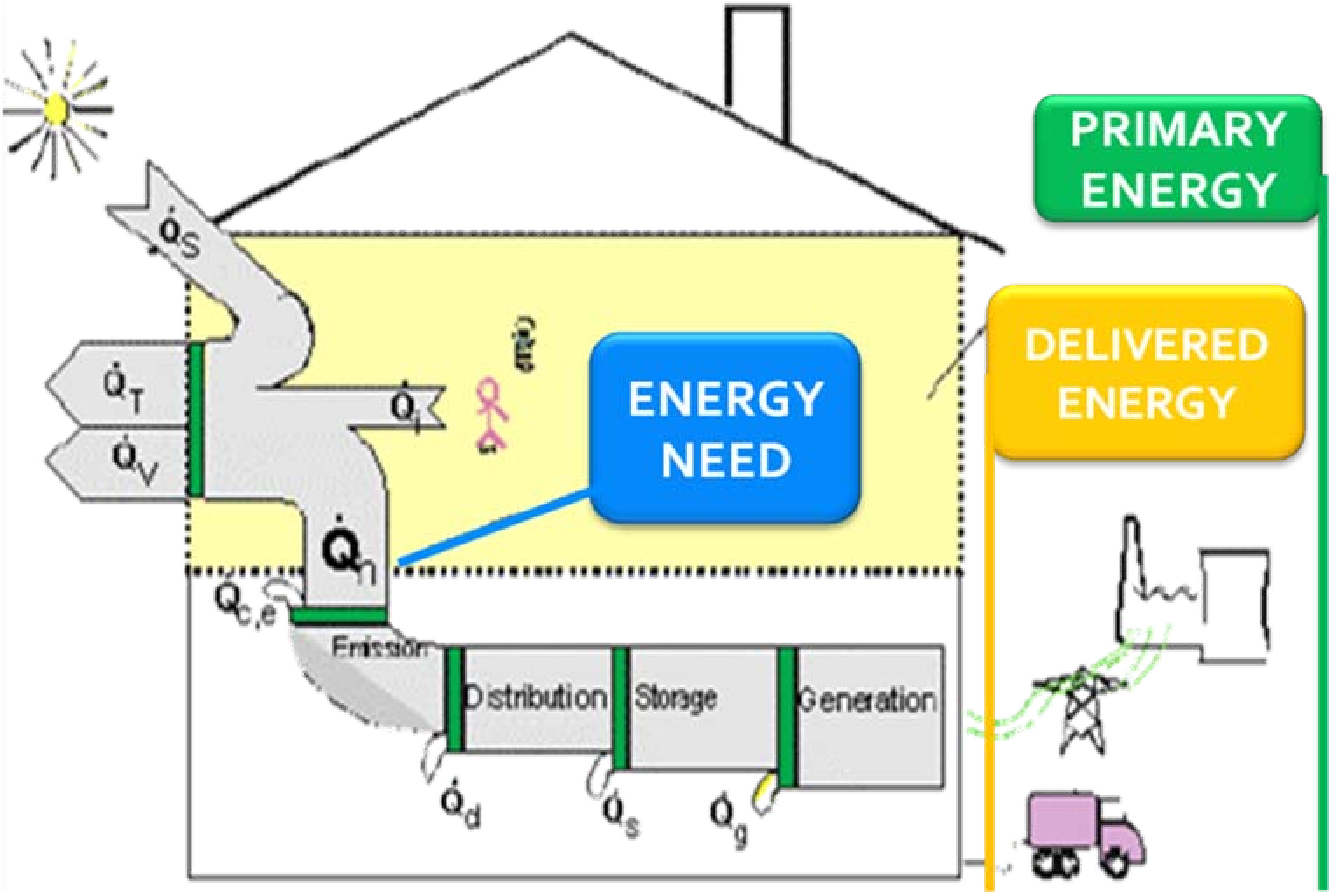
Tabella 4b. Valori limite della trasmittanza centrale termica U dei vetri espressa in W/m^2K

Zona climatica	Dall' 1 gennaio 2006 U (W/m^2K)	Dall' 1 luglio 2008 U (W/m^2K)	Dall' 1 gennaio 2011 U (W/m^2K)
A	5,0	4,5	3,7
B	4,0	3,4	2,7
C	3,0	2,3	2,1
D	2,6	2,1	1,9
E	2,4	1,9	1,7
F	2,3	1,7	1,3

DLGS 192/2005 UPDATED BY DLGS 311/2006

Minimum global average seasonal efficiency of heating system
GENERATION + STORAGE + DISTRIBUTION + EMISSION + REGULATION

$$\eta_g = (65 + 3 \log Pn)\ \%$$



DLGS 192/2005 UPDATED BY DLGS 311/2006

Maximum annual primary energy for space heating as function of S/V ratio and HDD
RESIDENTIAL BUILDING (EXCLUDED SPECIAL USES I.E. COLLEGES, PRISONS, ...)

Tabella 1.1 Valori limite dell'indice di prestazione energetica per la climatizzazione invernale, espresso in kWh/m² anno

Rapporto di forma dell'edificio S/V	**Zona climatica**									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	**10**	**10**	**15**	**15**	**25**	**25**	**40**	**40**	**55**	**55**
≥0,9	**45**	**45**	**60**	**60**	**85**	**85**	**110**	**110**	**145**	**145**

Tabella 1.2 Valori limite, **applicabili dal 1 gennaio 2008**, dell'indice di prestazione energetica per la climatizzazione invernale, espresso in kWh/m² anno

Rapporto di forma dell'edificio S/V	**Zona climatica**									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	**9,5**	**9,5**	**14**	**14**	**23**	**23**	**37**	**37**	**52**	**52**
≥0,9	**41**	**41**	**55**	**55**	**78**	**78**	**100**	**100**	**133**	**133**

Tabella 1.3 Valori limite, **applicabili dal 1 gennaio 2010**, dell'indice di prestazione energetica per la climatizzazione invernale, espresso in kWh/m² anno

Rapporto di forma dell'edificio S/V	**Zona climatica**									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	**8,5**	**8,5**	**12,8**	**12,8**	**21,3**	**21,3**	**34**	**34**	**46,8**	**46,8**
≥0,9	**36**	**36**	**48**	**48**	**68**	**68**	**88**	**88**	**116**	**116**

DLGS 192/2005 UPDATED BY DLGS 311/2006

Maximum annual primary energy for space heating as function of S/V ratio and HDD
ALL OTHER BUILDINGS

Tabella 2.1 Valori limite dell'indice di prestazione energetica per la climatizzazione invernale espresso in kWh/m^3 anno

Rapporto di forma dell'edificio S/V	Zona climatica									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	2,5	2,5	4,5	4,5	7,5	7,5	12	12	16	16
≥0,9	11	11	17	17	23	23	30	30	41	41

Tabella 2.2 Valori limite, applicabili dal 1 gennaio 2008, dell'indice di prestazione energetica per la climatizzazione invernale espresso in kWh/m^3 anno

Rapporto di forma dell'edificio S/V	Zona climatica									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	2,5	2,5	4,5	4,5	6,5	6,5	10,5	10,5	14,5	14,5
≥0,9	9	9	14	14	20	20	26	26	36	36

Tabella 2.3 Valori limite, applicabili dal 1 gennaio 2010, dell'indice di prestazione energetica per la climatizzazione invernale espresso in kWh/m^3 anno

Rapporto di forma dell'edificio S/V	Zona climatica									
	A	B		C		D		E		F
	fino a 600 GG	*a 601 GG*	*a 900 GG*	*a 901 GG*	*a 1400 GG*	*a 1401 GG*	*a 2100 GG*	*a 2101 GG*	*a 3000 GG*	*oltre 3000 GG*
≤0,2	2,0	2,0	3,6	3,6	6	6	9,6	9,6	12,7	12,7
≥0,9	8,2	8,2	12,8	12,8	17,3	17,3	22,5	22,5	31	31

MAIN APPLICATION FIELDS OF SOME OF CURRENT LAWS AND NORMS

ITALIAN LEGISLATION

Dlgs 192/2005 updated by Dlgs 311/2006

- Maximum U-values for opaque and transparent components of the building envelope (prescriptive);
- Minimum average seasonal thermal useful efficiency of the heat generation system (prescriptive);
- Maximum annual total primary energy consumption for space heating expressed as a function of S/V ratio and HDD (performance)

DPR 24/02/2009

- Introduces NEW requirements on some building elements (prescriptive)
- Limits to the energy NEED for space cooling (performance)

DPR 24/02/2009 : FIRST REQUIREMENTS EVER ON SPACE COOLING IN ITALY

1. It gives maximum legal values of ENERGY NEED FOR SPACE COOLING (for the first time ever)

2. UNI TS 11300/2008 part 1 have to be used to calculate energy need for space cooling

3. The designer have to evaluate in a precise way the effectiveness of SHADING SYSTEMS over glazed surfaces (i.e. according to UNI EN 13659/2009, UNI EN 13363-1/2008, UNI EN 13363-2/2006, …);

DPR 24/02/2009 : FIRST REQUIREMENTS ON SPACE COOLING IN ITALY

4. In every site where monthly average solar irradiance on horizontal plane is higher then 290 W/m^2:
   i. External opaque vertical walls, exposed from east to west, must have or a thermal mass per unit of front area higher then 230 kg/m^2 or periodic thermal transmittance (or transfer admittance) lower then 0,12 W/m^2K $$Y_{ie} = -\left.\frac{\varphi_i}{\theta_e}\right|_{\theta_i=0}$$
   ii. External opaque horizontal component must have periodic thermal transmittance (or transfer admittance) lower then 0,20 W/m^2K

5. It is possible to reach periodic thermal transmittance limits covering roof with vegetation

DPR 24/02/2009 : FIRST REQUIREMENTS ON SPACE COOLING IN ITALY

6. to favour natural ventilation of the whole building using in the best way the external ambient conditions and disposition of indoor spaces. If it is not possible, mechanical ventilation systems can be installed

7. External shading systems are compulsory. If they are not cost-effective, they can be omitted if glazed surfaces are characterized by a solar factor not higher then 0,5

DPR 24/02/2009 : FIRST REQUIREMENTS EVER ON SPACE COOLING IN ITALY – maximum energy need

TYPE OF BUILDING	MAXIMUM LEGAL VALUE FOR SPACE COOLING	CLIMATIC ZONES
Residential	40 kWh/m^2	A - B
	30 kWh/m^2	C - D - E - F
Non residential	14 kWh/m^3	A - B
	10 kWh/m^3	C - D - E - F

MAIN APPLICATION FIELDS OF SOME OF CURRENT LAWS AND NORMS

ITALIAN TECHNICAL NORMATIVE

UNI EN ISO 13790/2008
UNI TS 11300-1/2008

- Calculation of energy need for space heating and cooling

UNI TS 11300-2/2008
UNI TS 11300-3/2008(NR)

- Calculation of primary energy performance for heating (cooling not yet released) and production of warm water

UNI EN 15251/2008
UNI EN ISO 7730/2006

- Use of comfort models

UNI EN 15193/2008

- Methodology to evaluate energy for lighting and relations with space heating and cooling

THE NEW PASSIVHAUS STANDARD: ENERGY AND COMFORT

- If cooling is provided by mainly passive means:
  - indoor comfort requirements: as defined by the adaptive model class II of the Annex A.2 ("Acceptable indoor temperatures for design of buildings without mechanical cooling systems") of the EN 15251;
  - energy needs for heating and cooling shall be lower than 15 kWh/m2/year
  - total primary energy shall be lower than 120 kWh/m2/year;

- If cooling is provided by active systems:
  - indoor comfort requirements: as defined by the Fanger's model of the EN 15251;
  - energy need for heating shall be lower than 15 kWh/m2/year;
  - energy need for cooling: shall be lower than 15 kWh/m2/year (this value may be updated and possibly reduced based on field studies);
  - total primary energy shall be lower than 120 kWh/m2/year.

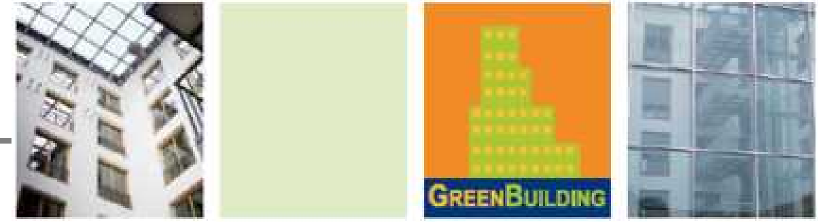
Low Energy Cooling Technological and Behavioural Trends and Perspectives.

• Behaviour:

- Since spring 2005 ENI (National Hydrocarbon Company) informal dress code without jacket and tie in summer, to raise set point temperature of air-conditioning by 1°C,
- in summer 2007 the program saved 243 000 kWh of electric energy, 9% of electric consumption for cooling
- S. Paolo Bank: keep windows closed and use blinds
- adopt light dresses in summer, possibly avoiding to use a tie
- difference between internal set point and external temperature is not higher than 6 °C

• Technology:

- No national monitoring and evaluation programme (e.g. of the type of those ongoing in Germany like Solarbau)
- only "per building" exercises apart…



H) Energy Summary

H2) Primary energy balance of building

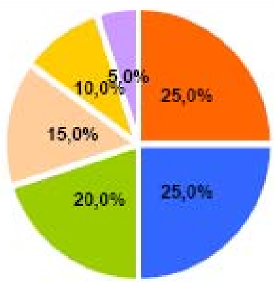
Primary Energy (PE) disaggregation according to EN 15603		Planned performance	Baseline	Savings in percentage	Data source
PE for heating	(kWh)	5.000	8.000	-37,5%	Not available
PE for cooling & dehumidification	(kWh)	5.000	6.000	-16,7%	Data from EN norm calculation
PE for ventilation & humidification	(kWh)	4.000	4.000		Data from dynamic simulation
PE for SHW production	(kWh)	3.000	4.400	-31,8%	Metered data
PE for lighting	(kWh)	2.000	2.000		Not available
PE for other electric uses	(kWh)	1.000	1.000		Data from EN norm calculation

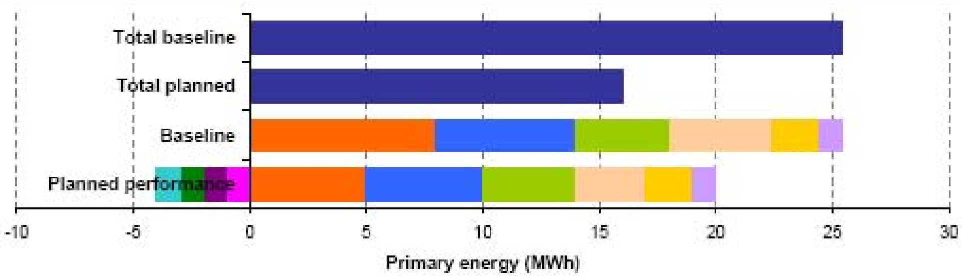
Equivalent Primary Energy generated by renewables		Planned performance
PE from solar thermal plant	(kWh)	1.000
PE from photovoltaic plant	(kWh)	1.000
PE from wind generation system	(kWh)	1.000
PE from hydroelectric generator	(kWh)	1.000

PRIMARY ENERGY SUMMARY

Total PE before interv. or legal value	(kWh)	25.400
Total PE after interv. or in actual status	(kWh)	20.000
Total PE from renewables	(kWh)	4.000
Total primary energy saved	(kWh)	-9.400
	(%)	37,0%

Planned performance

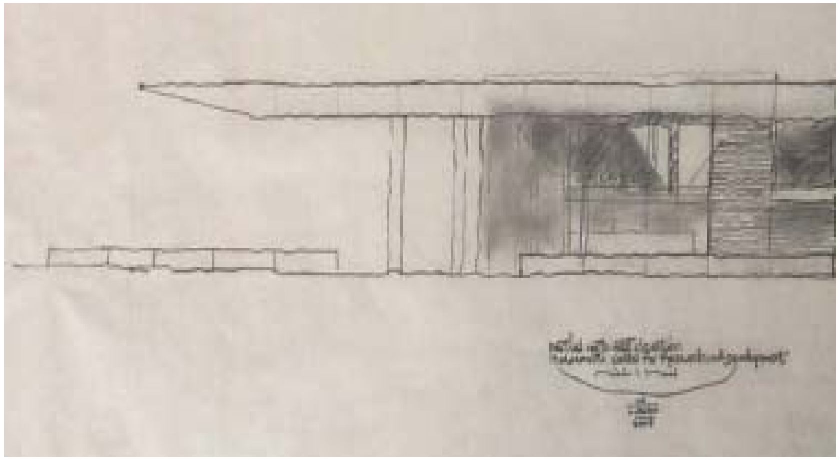


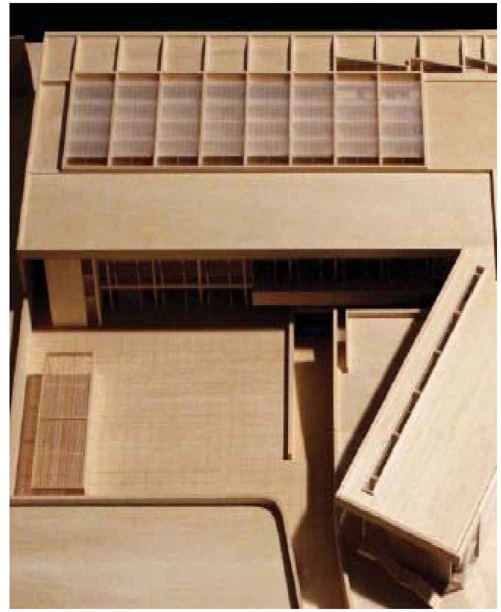


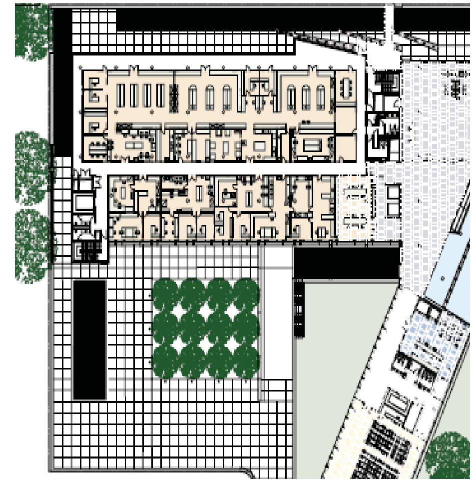
PE for heating | PE for cooling & dehumidification | PE for ventilation & humidification | PE for SHW production
PE for lighting | PE for other electric uses | PE from solar thermal plant | PE from photovoltaic plant
PE from wind generation system | PE from hydroelectric generator | Total Primery Energy

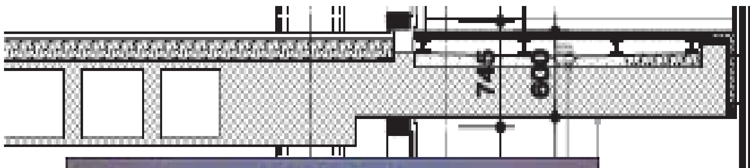
OFFICE AND LABORATORY BUILDING

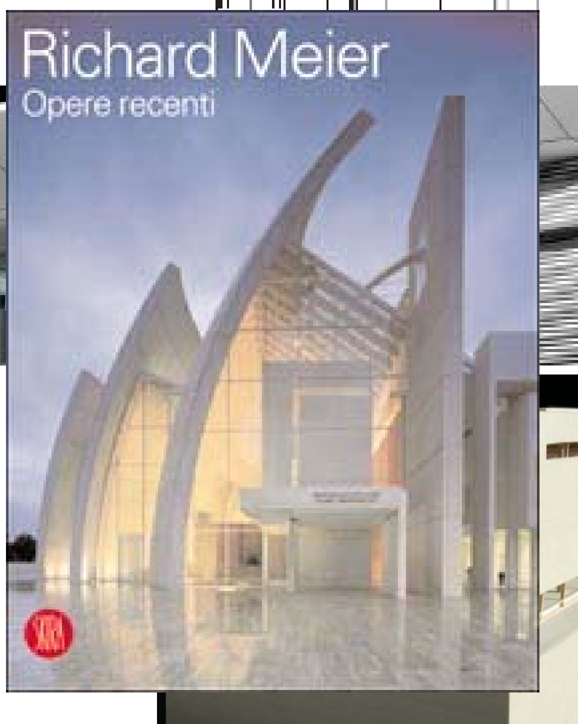
- Architect: Richard Meier & Partners, New York
- Energy analysis glazing, solar protections and ground exchanger: eERG
- Monitoring support and analysis: eERG

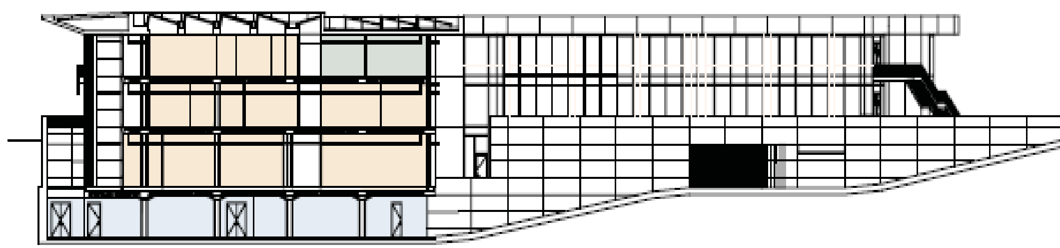







745
600


Richard Meier
Opere recenti



OPAQUE ENVELOPE

- The flat concrete **roof has an important thermal mass exposed to internal air** that ensures a large inertial behaviour.
- The roof, which has large overhang projections provides ample shading on the façade.
- This component of the building envelope includes **skylights (16% of roof area)** which direct natural light into offices of the second floor.
- **GB supported** the reduction **of thermal transmittance values**, the introduction and optimization of **shading systems** for the skylights, the **introduction and optimization of a ground exchanger used in free cooling for part of summer**

Type of technical component	M.u.	U-Value
External walls (maximum)	W/(m²K)	0,258
External walls (minimum)	W/(m²K)	0,104
Flat roof	W/(m²K)	0,140
Floor above untreated spaces	W/(m²K)	0,400
Skylights (total)	W/(m²K)	1,82 - 2,38

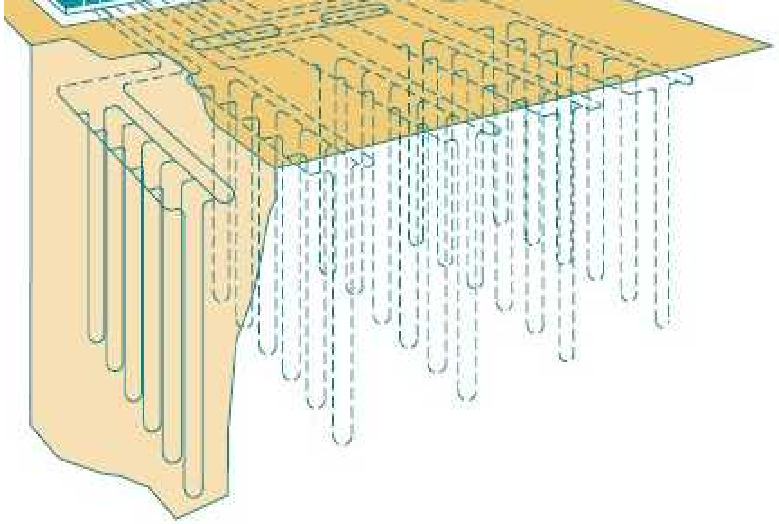
TRANSPARENT ENVELOPE

The vertical exterior skin of the building is mainly realized by glazed façades with high-performance, **low-e**, glass systems. Façade systems consist of pre-cast concrete, aluminium and glass cladding, extending from the building base to the roof.

Property of north façades	M.u.	Value
U-value at centre of glazing	W/(m²K)	0,62
U-value of entire glazing system	W/(m²K)	1,30
Light transmission	%	47%

Property of other façades	M.u.	Value
U-value at centre of glazing	W/(m²K)	1,08
U-value of entire glazing system	W/(m²K)	1,74
Solar factor	%	32%
Light transmission	%	52%

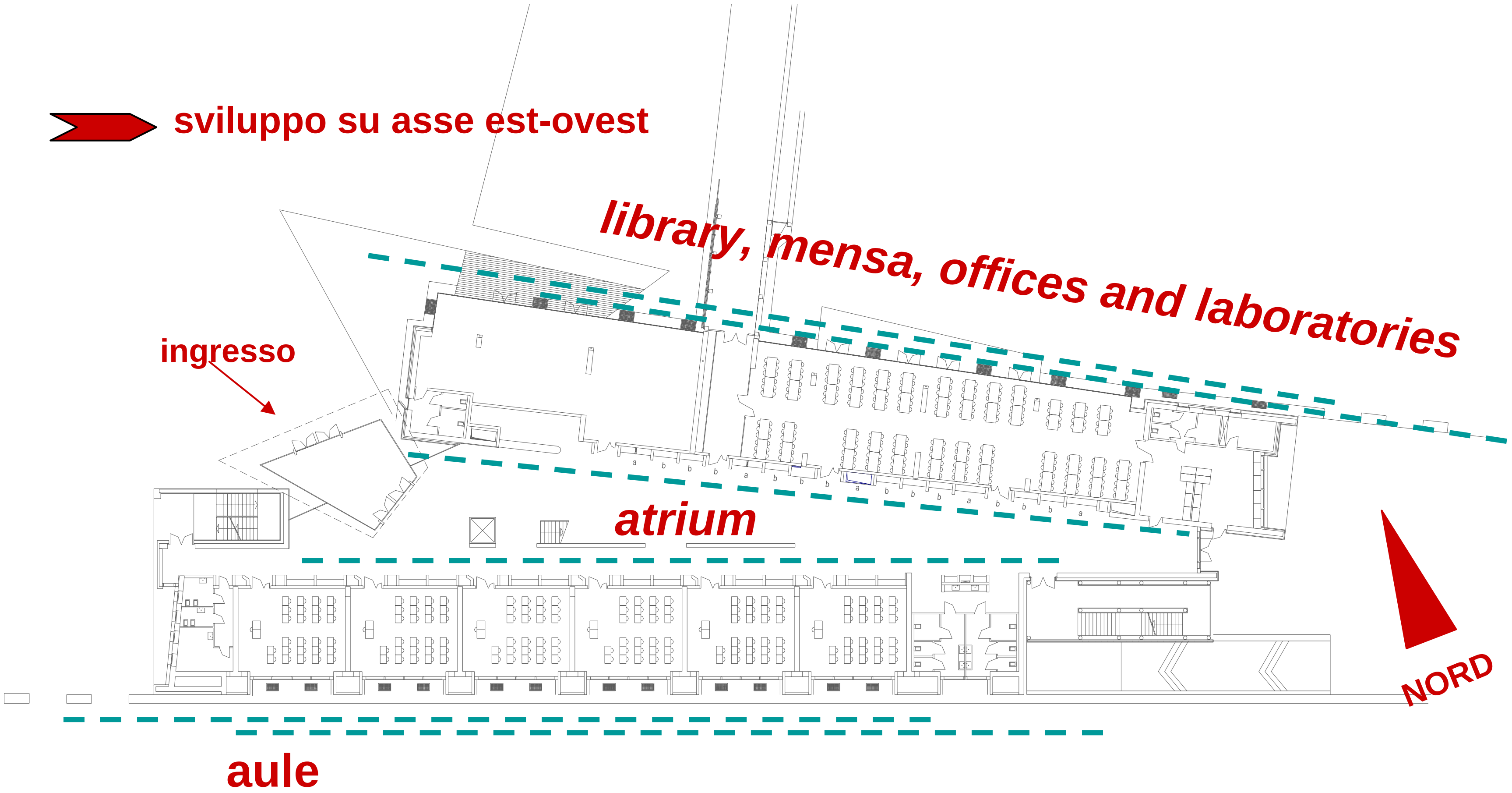
GEOTHERMAL SYSTEM



- The **geothermal system** consists of:
  - **48 boreholes (100 m long)** arranged in two full rectangular configuration;
  - **3 reversible heat pumps**, each connected to **16 ground exchangers**, with total thermal power of 312 kW and minimum COP of 4,1 in heating mode;
  - the monitoring and control system.
- In warmer periods, if the free-cooling strategy is not enough to comfort achievement, the geothermal heat pumps (with a nominal COP of 5) can be used to increase the cooling capacity.
- For ITCLab, the **primary energy requirement limit for heating**, according to Italian Dlgs 192/2005, is **57,2 kWh/m^2 per year**.
- Since **primary energy demand of ITCLab is less than 40 kWh/m^2 per year**, it results that there is an **energy saving** of slightly **over 30%** (GB Target = -25%).

Raffrescamento ventilativo strutturale: esempio applicativo

SCUOLA MEDIA PEDAGNA - IMOLA

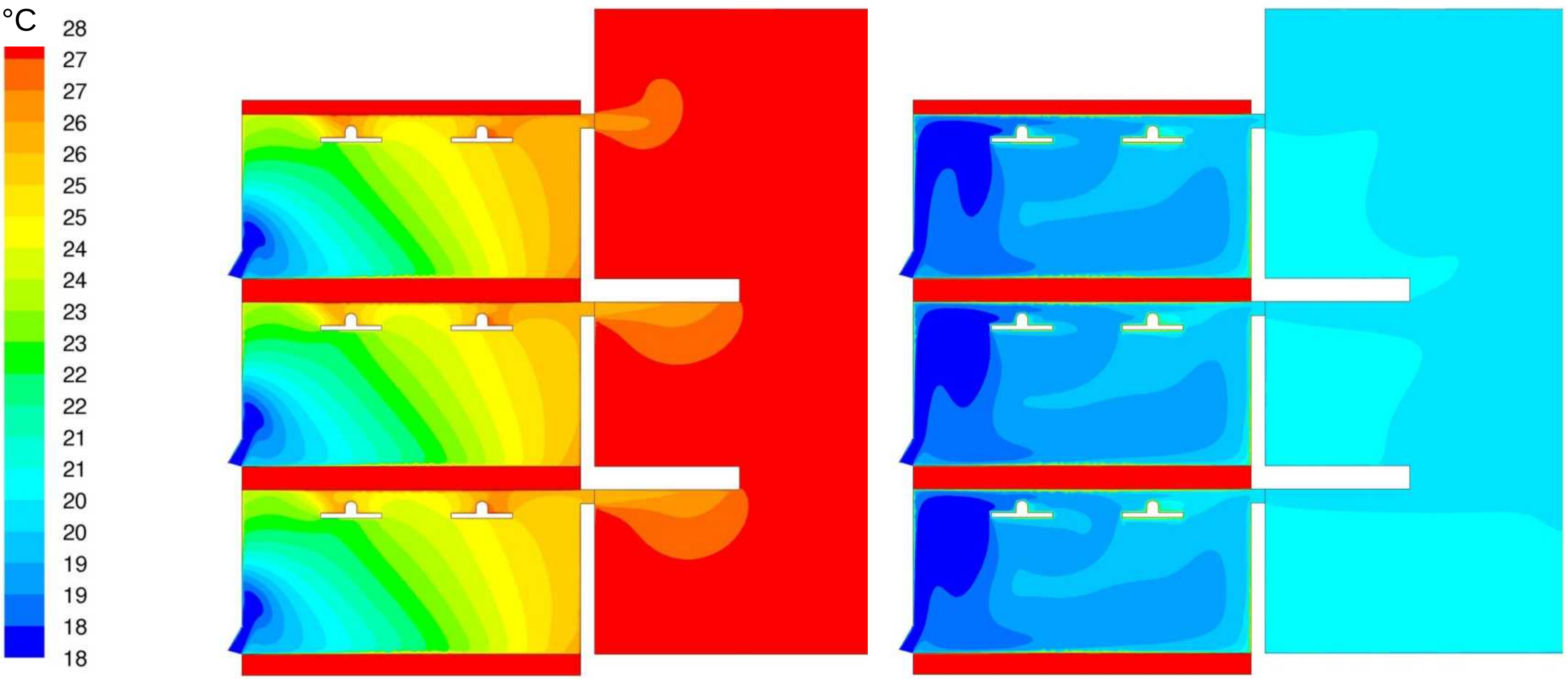


Raffrescamento ventilativo strutturale: esempio applicativo

SCUOLA MEDIA PEDAGNA - IMOLA

Analisi dei flussi d'aria condotta da Marco Simonetti, con la supervisione del Prof. G.V. Fracastoro, utilizzando il programma FLUENT

simulazioni CFD 2-D dei flussi d'aria per effetto camino tra esterno, aule sud e atrio, per una differenza di temperatura di 10 °C: *zone di temperatura dell'aria – flusso bilanciato*



dopo 1 minuto **dopo 10 minuti**

THANK YOU

www.eerg.it

end-use Efficiency Research Group (eERG) - Politecnico di Milano

Lorenzo Pagliano
Carlucci S. Roscetti A. Zangheri P.

Barcelona, March 31 - April 1, 2009

www.eerg.it

eERG
end-use Efficiency Research Group
Gruppo di ricerca sull'efficienza negli usi finali dell'energia

Building Performance Simulation
in a Changing Environment

- changing environment
- traditional vs simulation
- quality assurance
- software and use
- our work
- IBPSA

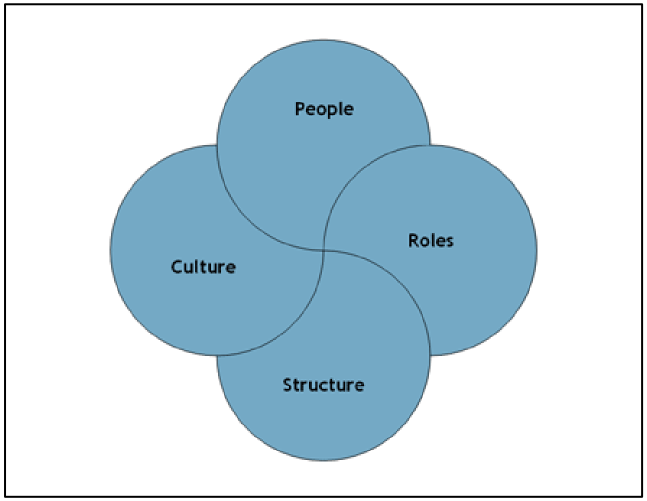
prof.dr.ir. Jan Hensen
unit Building Physics & Systems

TU/e Technische Universiteit Eindhoven University of Technology

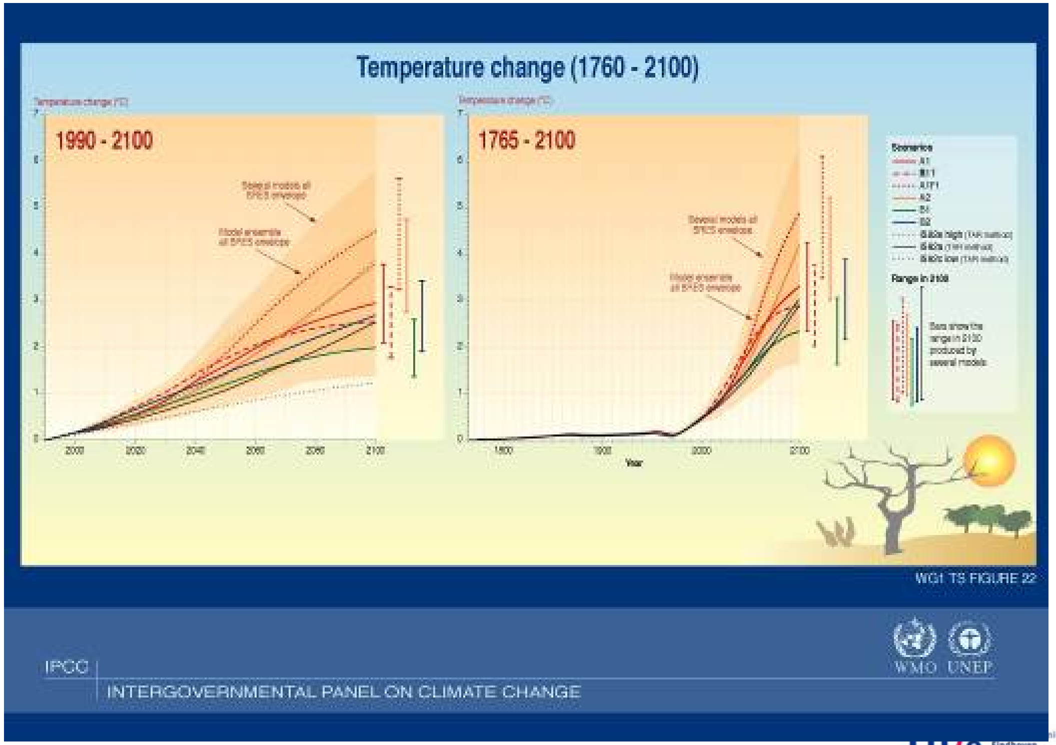
Changing Environment

Flexibility & robustness

Organizations change continuously



source: www.futuresense.com



Green design “guidance”

Voluntary “best green” performance of some buildings

More complex tools are accepted

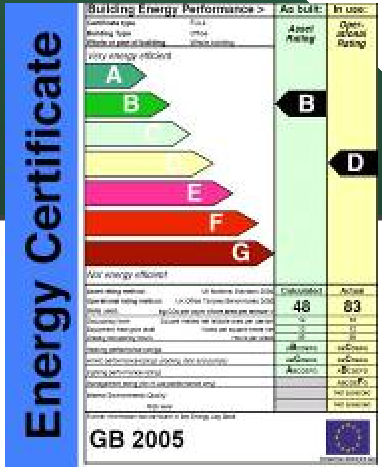
LEED, GBTool, CASBEE, ……

performance

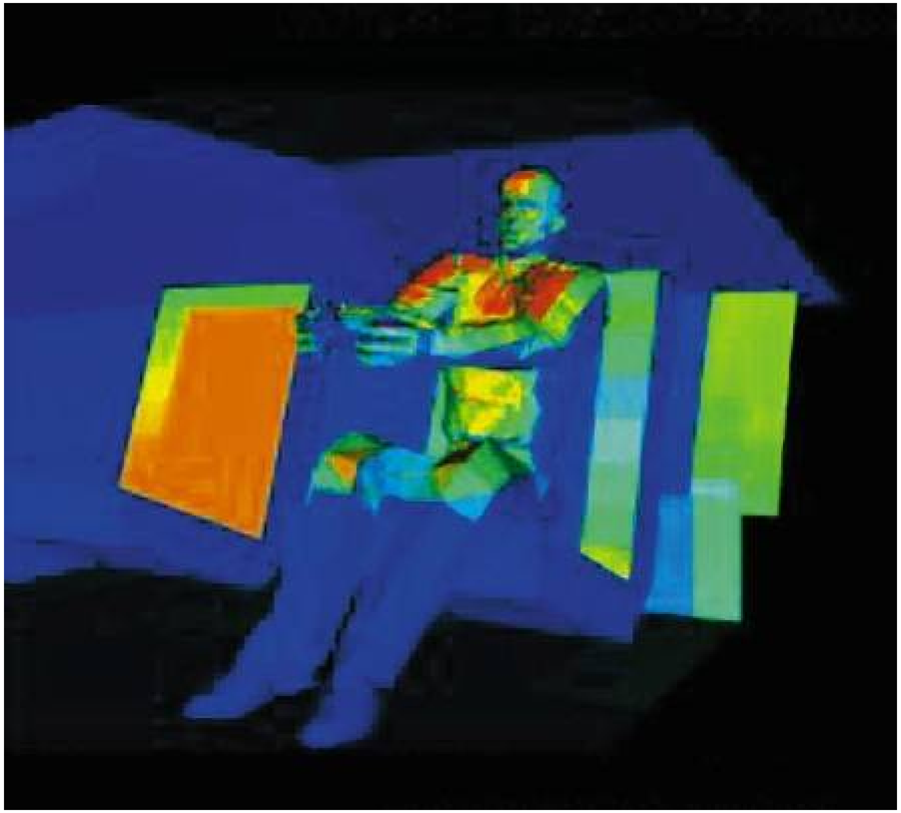
Mandatory minimum energy performance of every building

Tools must be as simple as possible

EPBD



Higher comfort demands



source: www.automotiveworld.com

source: www.learn.londonmet.ac.uk

Indoor quality vs. productivity

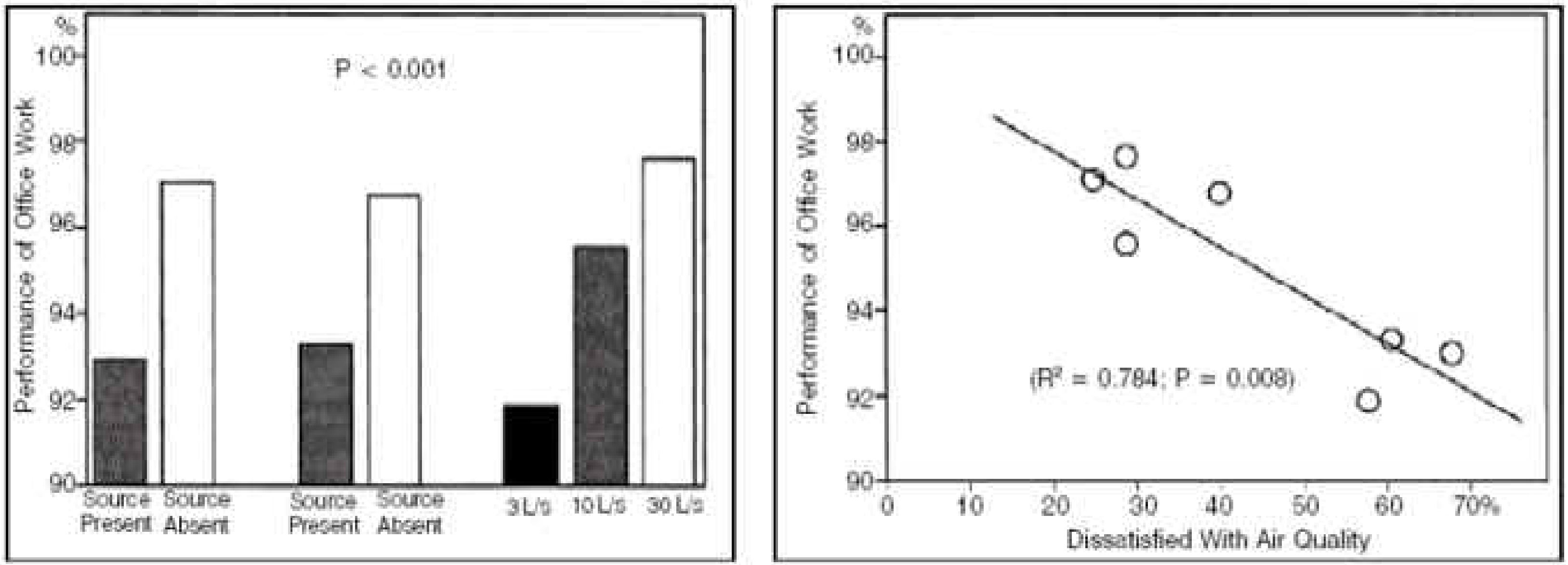
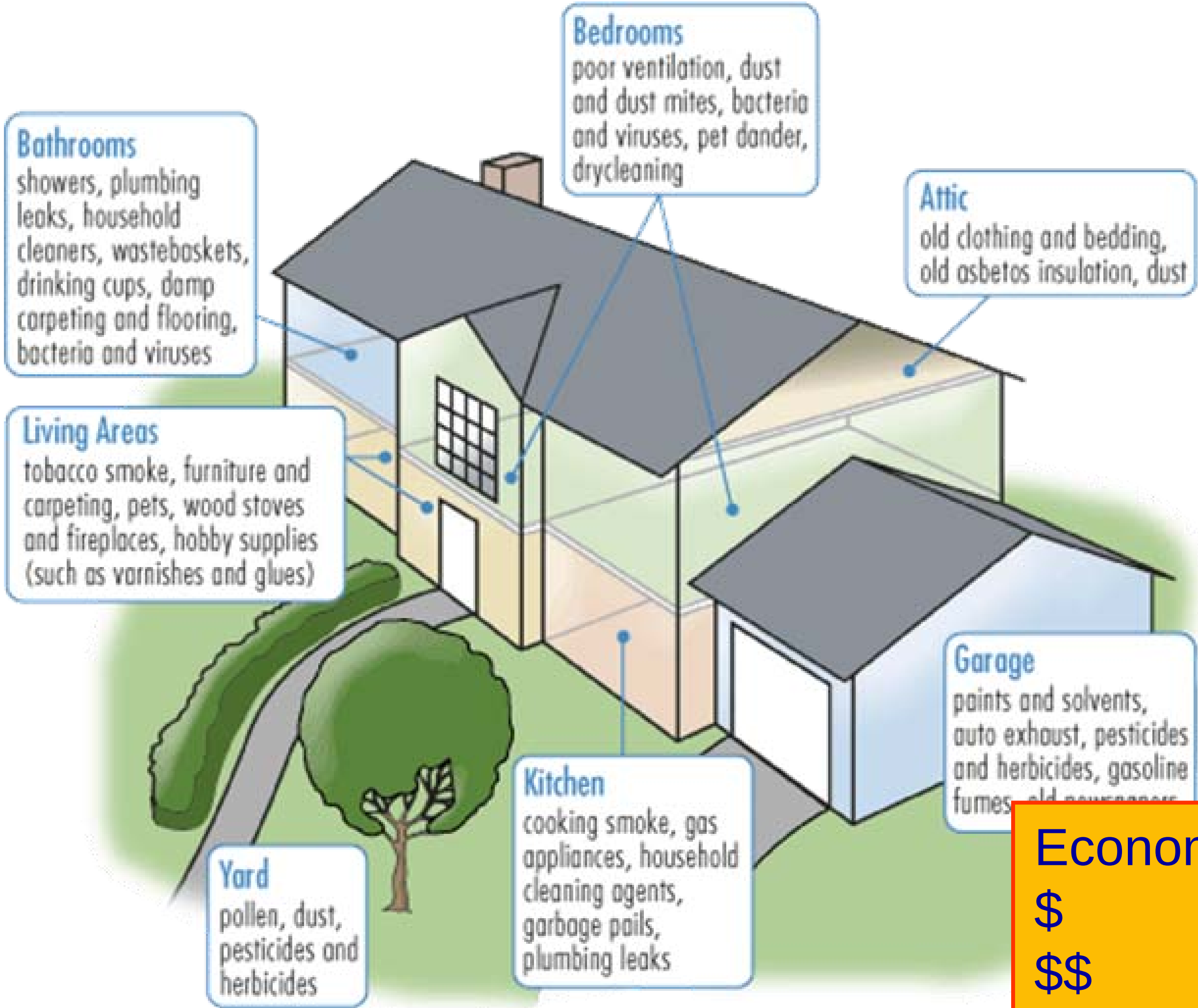


Figure 1 (left): Performance of office work as a function of the presence or absence of the pollution source, or the outdoor air supply rate. Figure 2 (right): Performance of office work as a function of the perceived air quality.

source: Wargocki, P 2002 "Making the Case For IAQ", ASHRAE IAQ Applications

Indoor quality vs. health

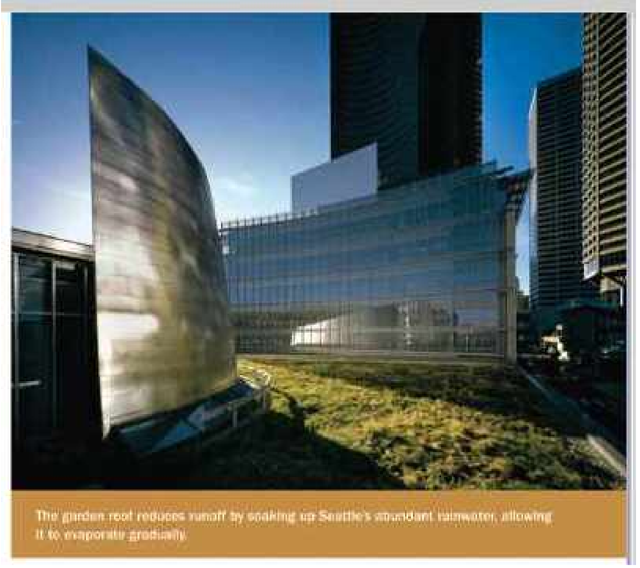


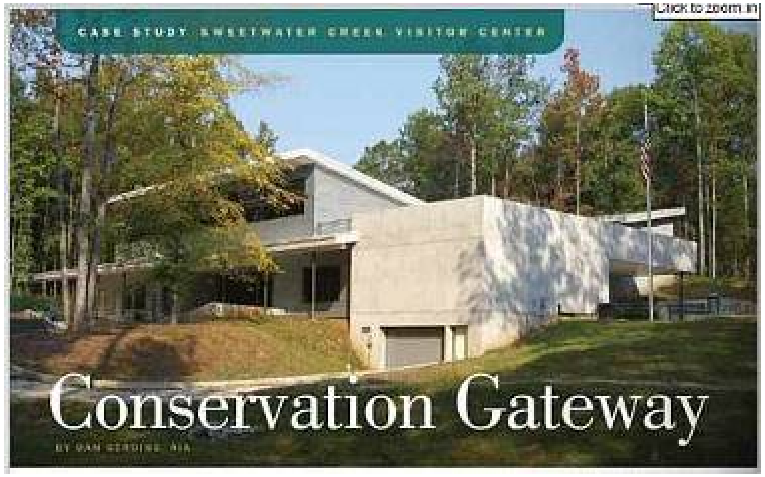
source: AirAdvice 2004-2005 http://www.airadvice.com/homeowners/sou

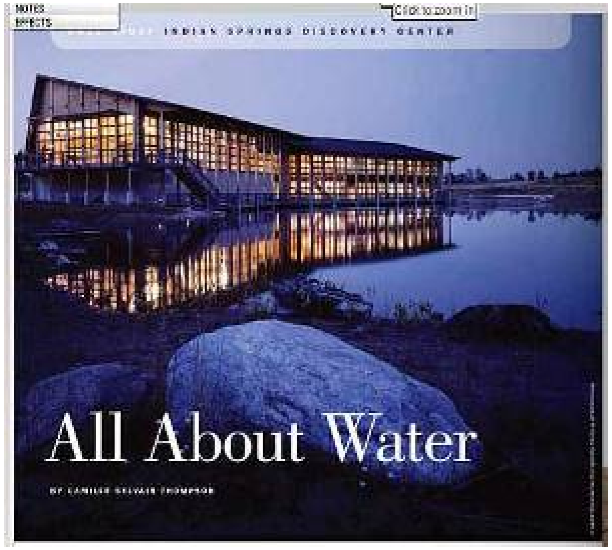
Economic impact:
$ energy
$$ productivity
$$$ health

TU/e Technische Universiteit Eindhoven University of Technology

Increasing real world complexity







source: High Performing Buildings, spring 2008

Increasing real world complexity

Increasing need for future performance prediction by computational simulation

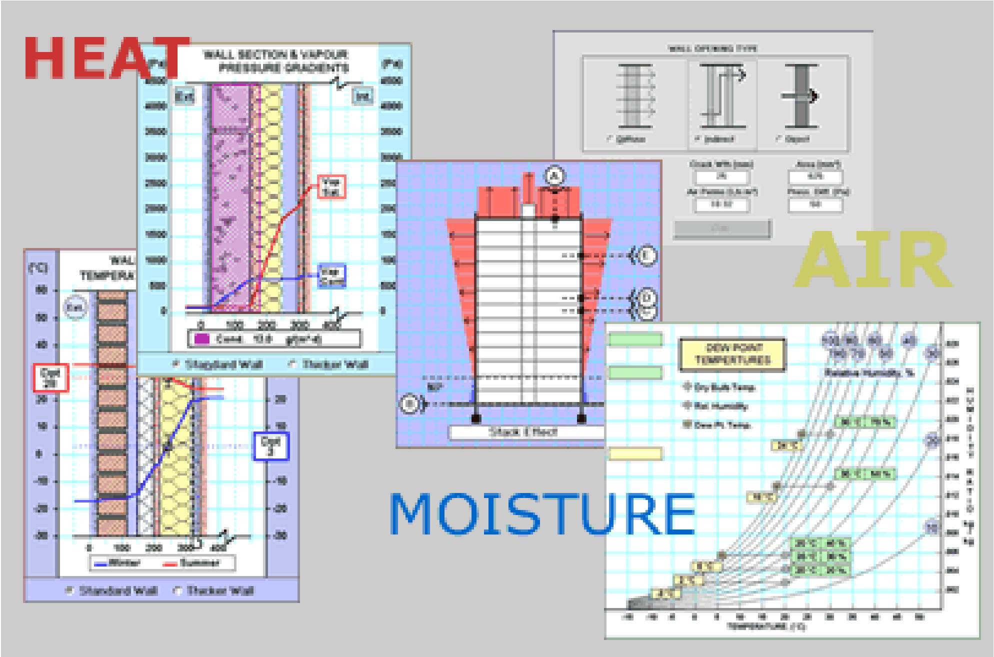
http://www.wired.com/culture/design/magazine/15-08/st_greenmuseum/

CALIFORNIA ACADEMY OF SCIENCES
Renzo Piano

Traditional vs. Simulation Tools

Traditional design tools

- ➲ mono-disciplinary
- ➲ solution oriented
- ➲ narrow in scope
- ➲ static
- ➲ extreme conditions
- ➲ analytical methods (exact solution of very simplified modelof reality)

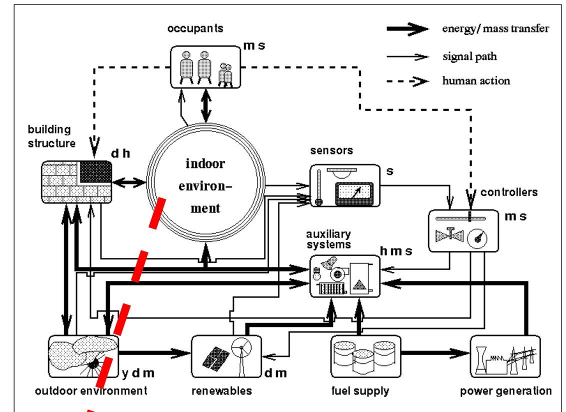


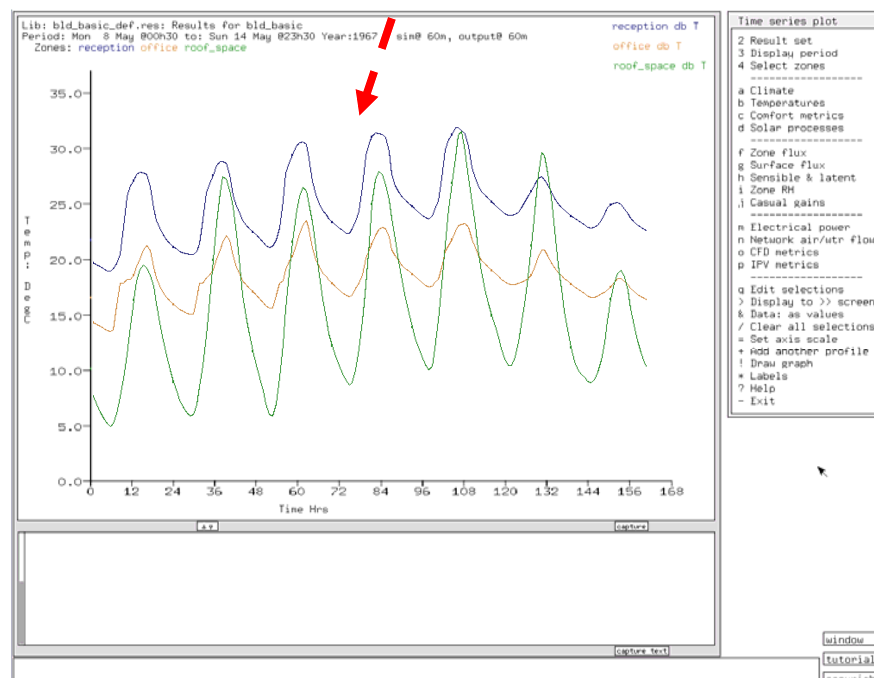
source: www.virtual-north.com

Simulation tools

> The best way to predict the future is to create it

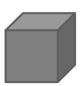
- multi-disciplinary
- problem oriented
- wide application scope
- dynamic
- all conditions
- numerical methods (approximate solution of realistic model of reality)





What is the difference?

fundamental difference between traditional and simulation tools is in the **complexity**



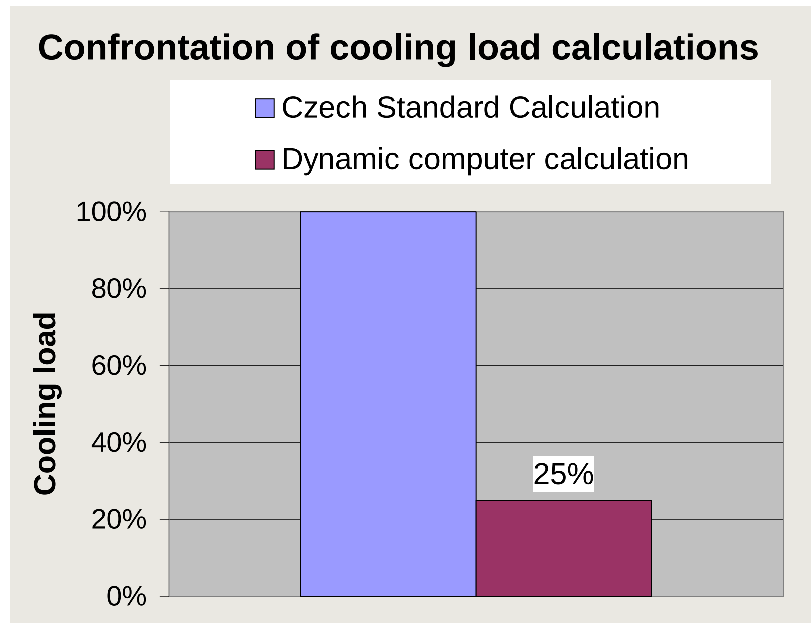
traditional models
– perhaps 10 variables

therefor much more need for:
- quality assurance
- knowledge / skills
- resources

computer simulation
– often > 10,000 variables

source: IBPSA-USA

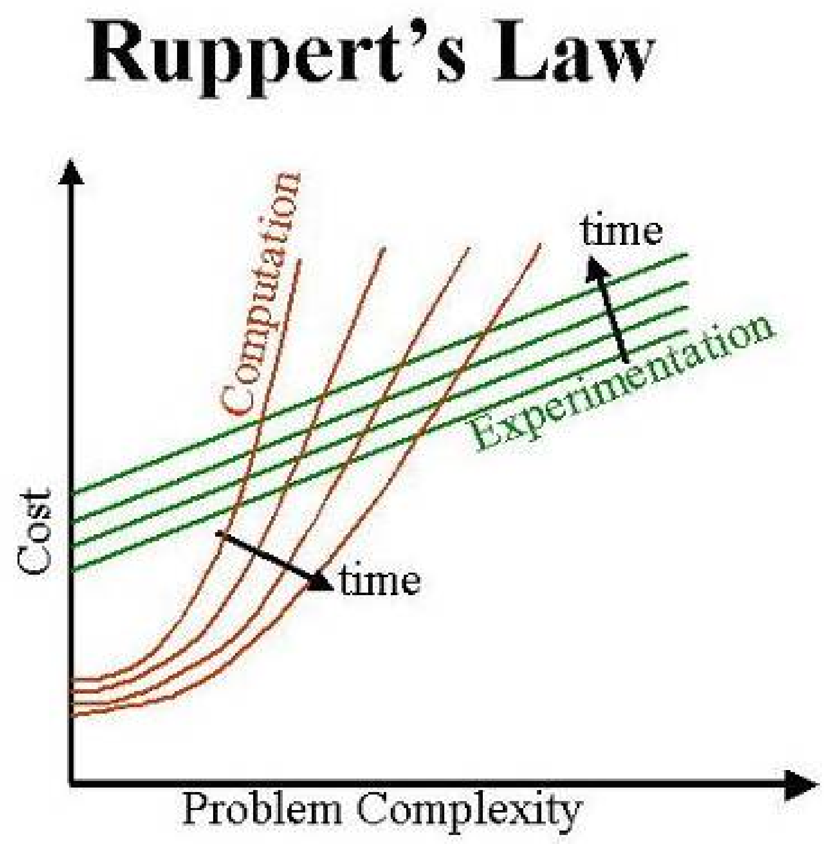
Is difference important?



source: M Lain et al. 2002

Quality Assurance

Simulation vs. measurements



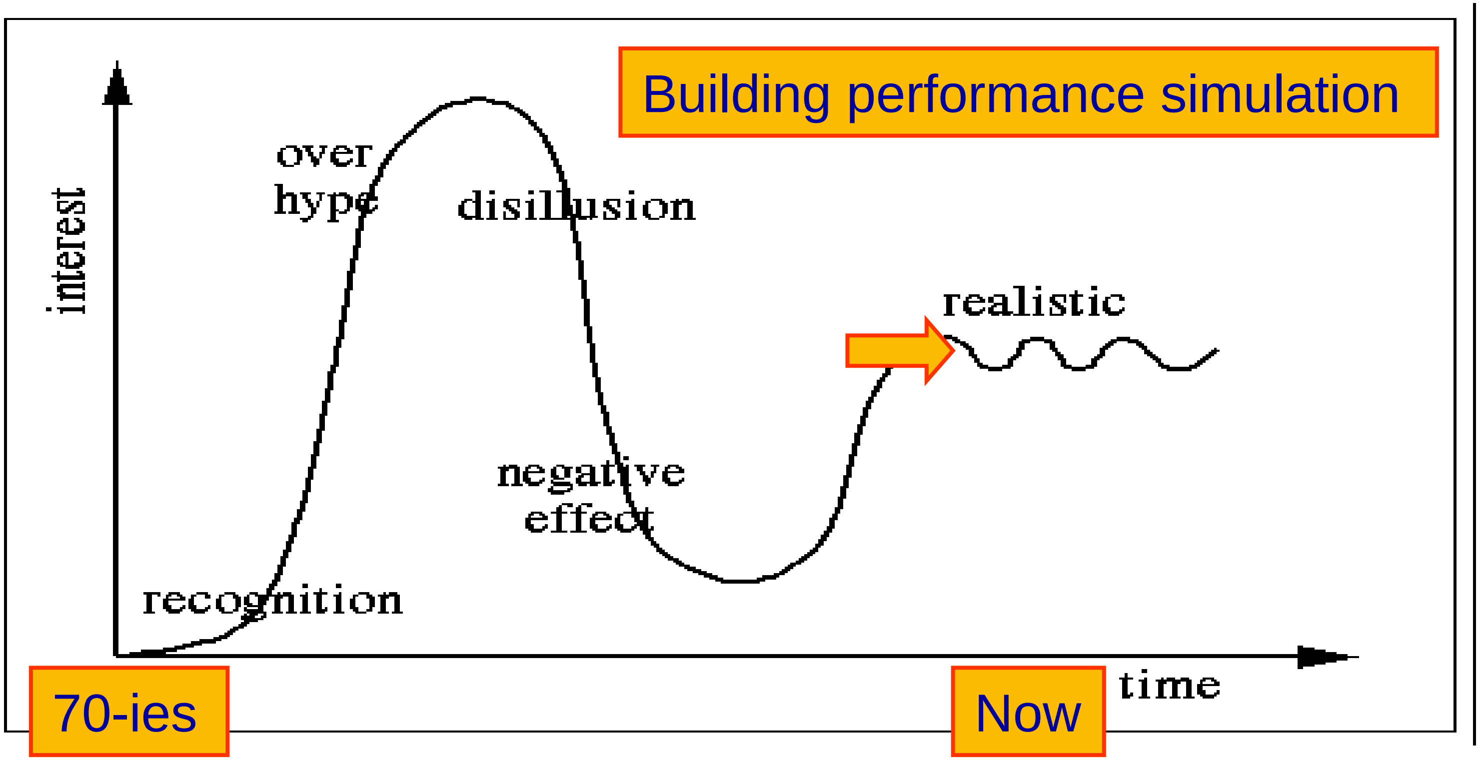
Measurements essential for verification, validation and calibration !

Don’t simulate when

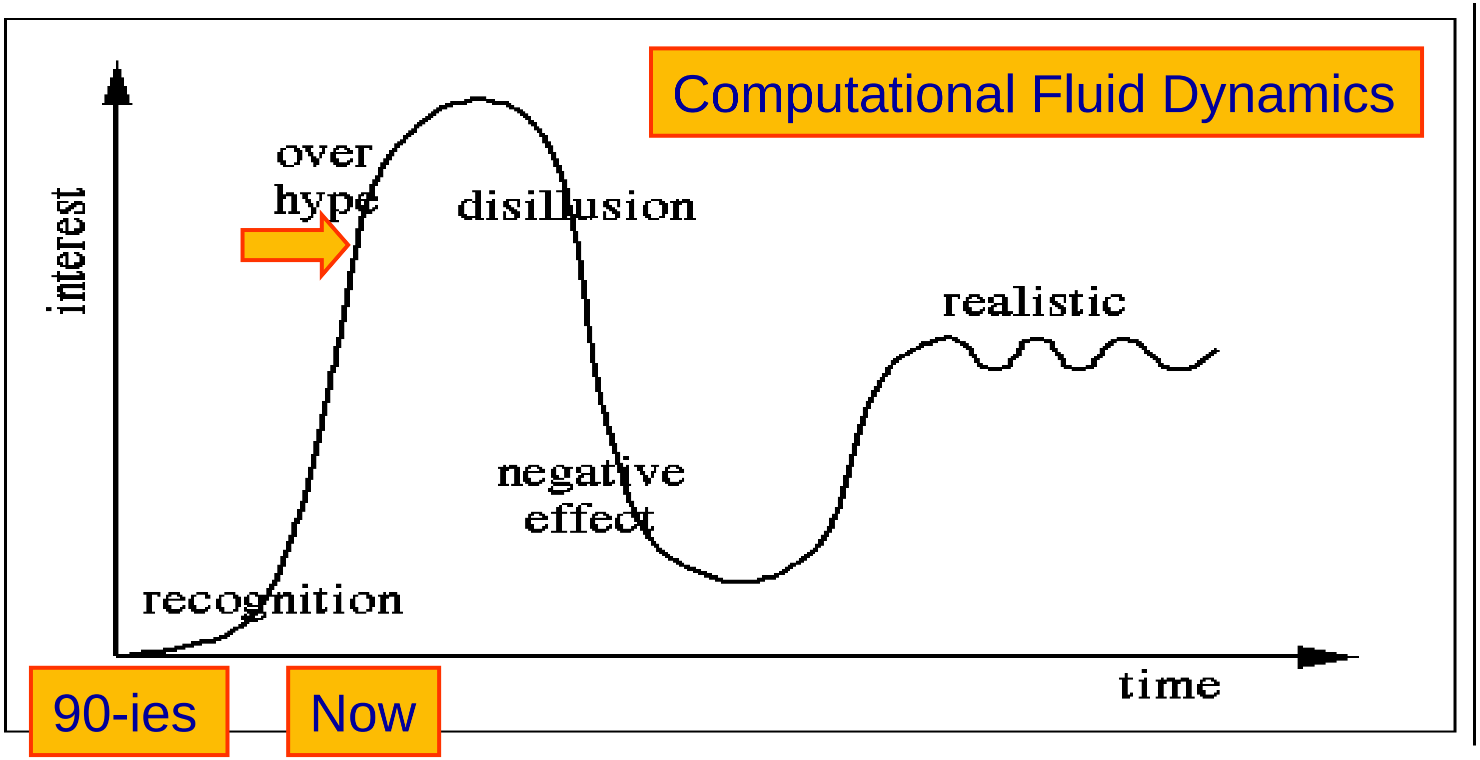
1. the problem can be solved using "common sense analysis“
2. the problem can be solved analytically (using a closed form)
3. it's easier to change or perform direct experiments on the real
4. the cost of the simulation exceeds possible savings
5. there aren't proper resources available for the project
6. there isn't enough time for the model results to be useful
7. there is no data – not even estimates
8. the model can't be verified or validated
9. project expectations can't be met
10. system behavior is too complex, or can't be defined

Banks & Gibson, 1997

Technology hype cycle



Technology hype cycle

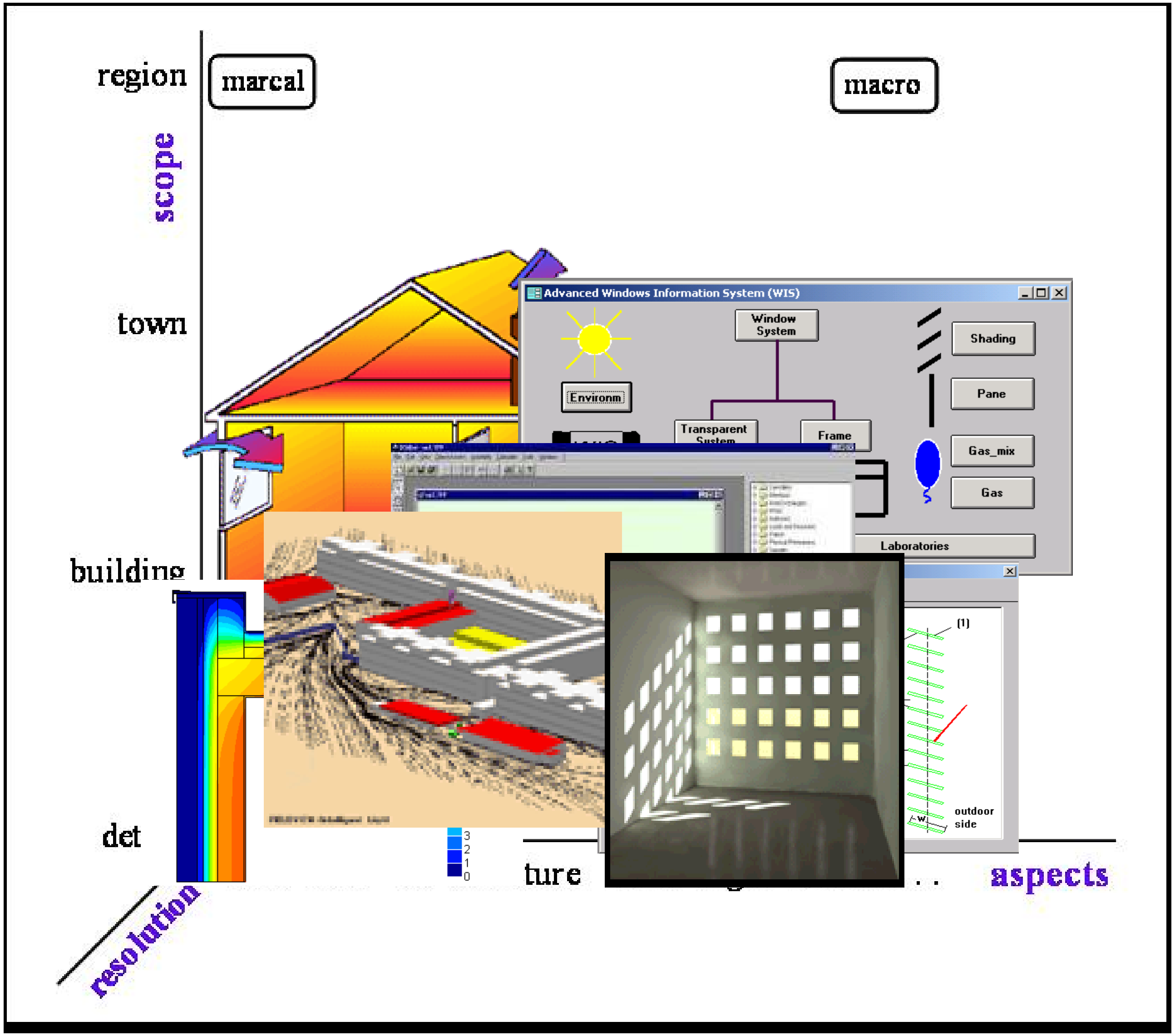


Quality assurance needs

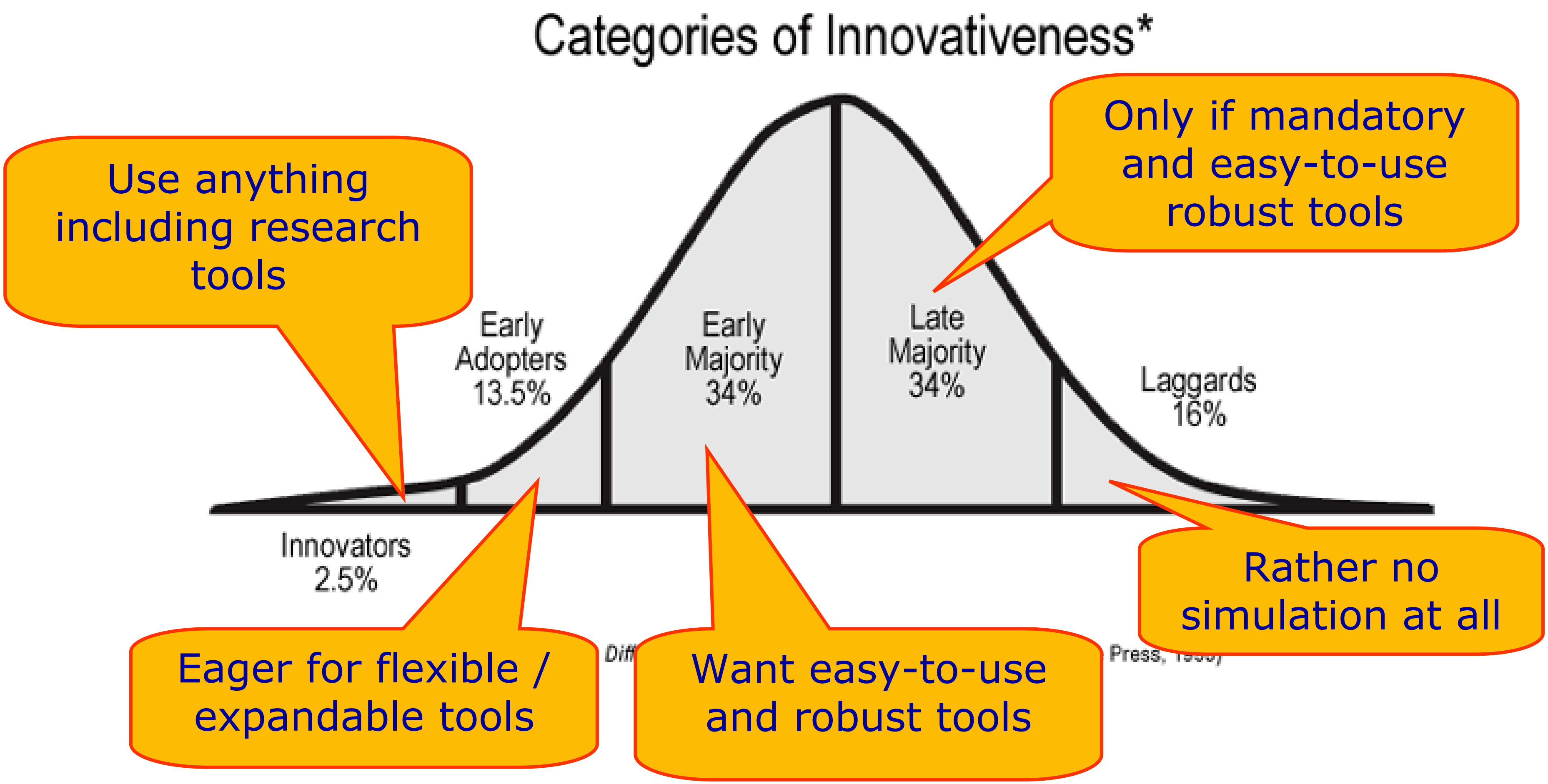
- simulation needs to be learned
  - sufficient domain knowledge
  - modeling and simulation skills and knowledge (eg awareness of limitations)
- quality control
  - appropriate model (scale, resolution, complexity)
  - validation, verification and calibration
  - proper application methodology

Simulation Software & Use

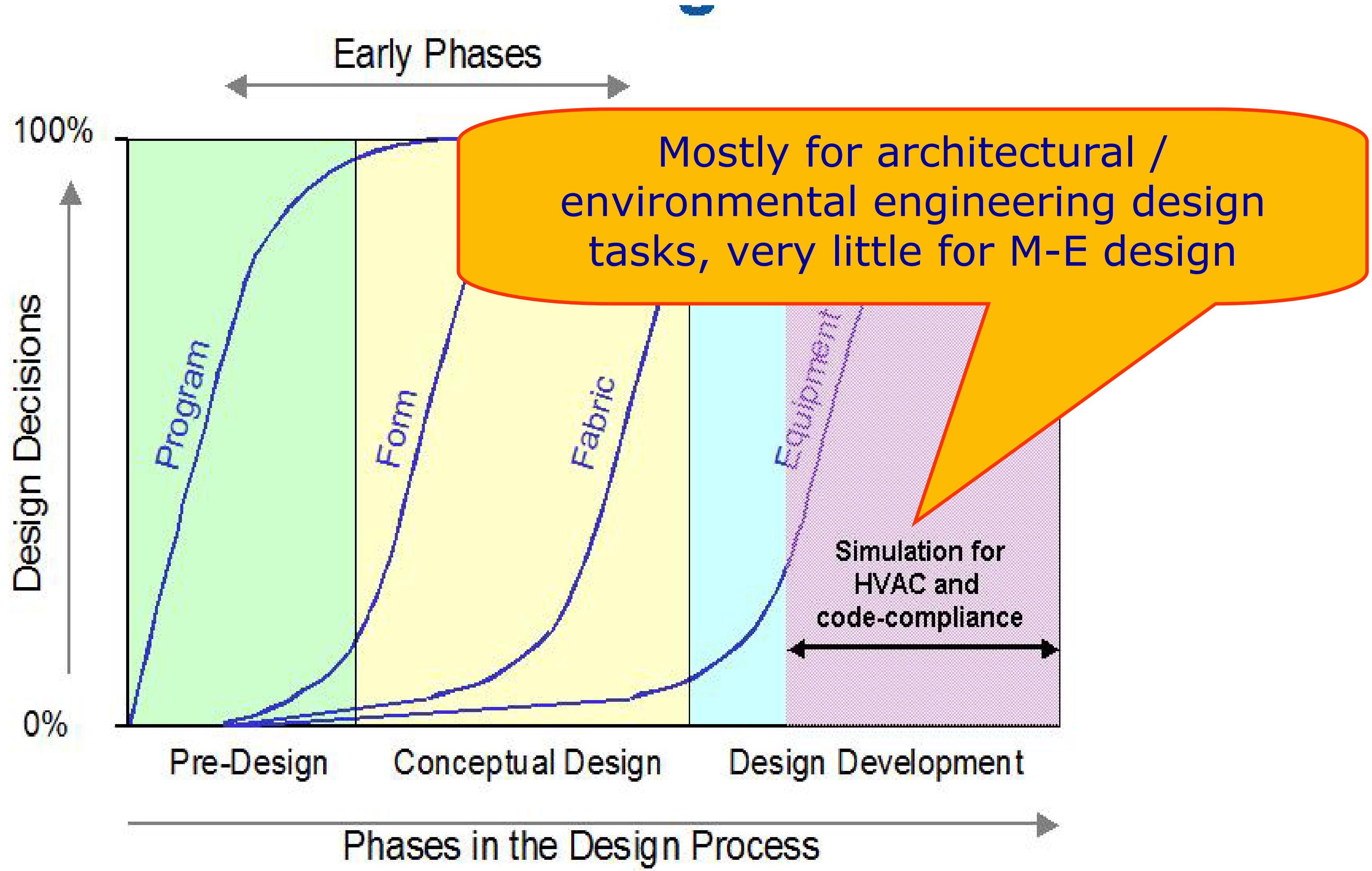
Simulation software



Simulation users



Simulation tasks



source: P Torcellini / P Ellis

Simulation task - example

A.C. van der Linden et al. / Energy and Buildings xxx (2005) xxx–xxx

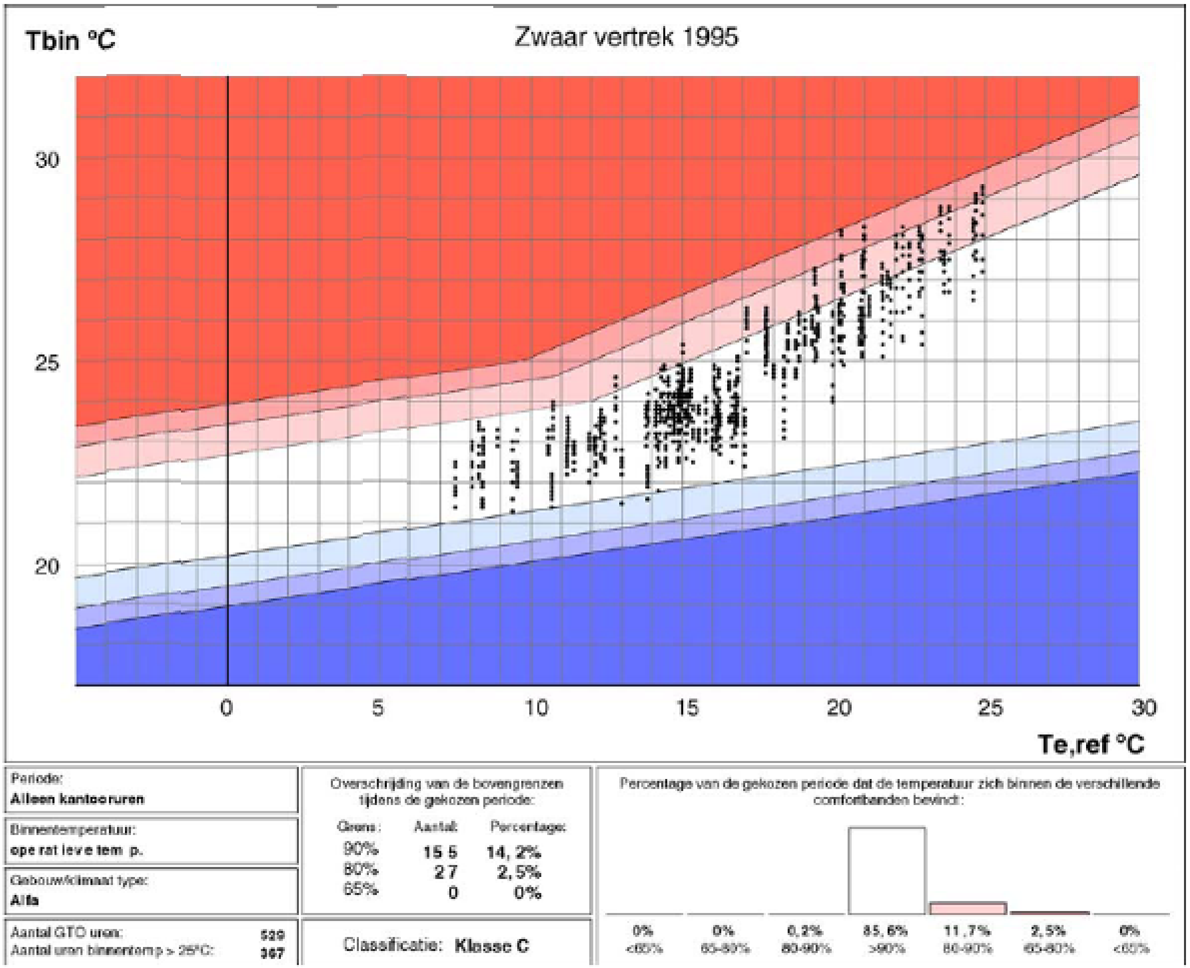
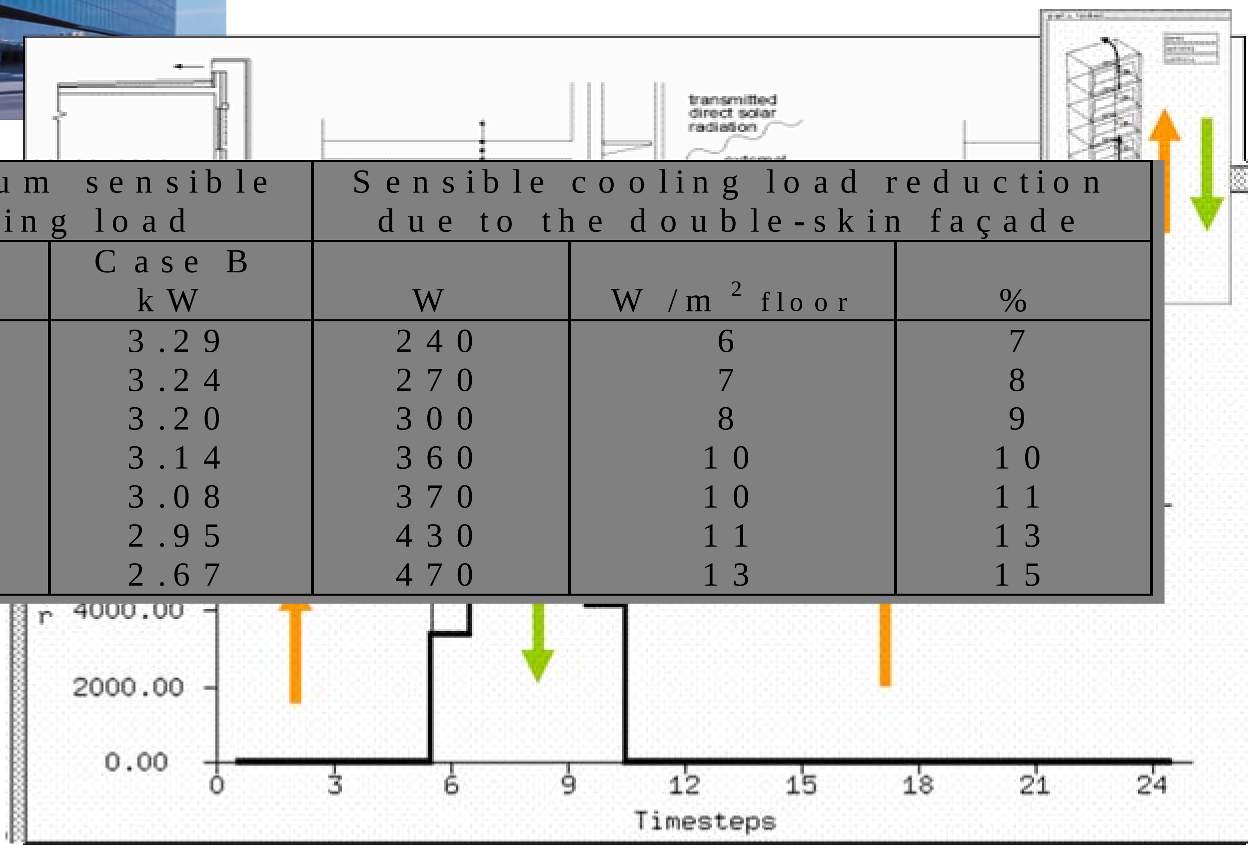


Fig. 6. The situation (medium–heavy building) of Fig. 4 now calculated for the months May–September 1995.

Simulation task - example



Floor level	Maximum sensible cooling load		Sensible cooling load reduction due to the double-skin façade		
	Case A kW	Case B kW	W	W/m^2 floor	%
8th	3.53	3.29	240	6	7
7th	3.51	3.24	270	7	8
6th	3.50	3.20	300	8	9
5th	3.50	3.14	360	10	10
4th	3.45	3.08	370	10	11
3rd	3.38	2.95	430	11	13
2nd	3.14	2.67	470	13	15

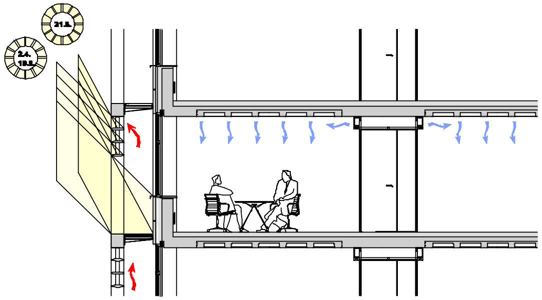
Simulation task - example

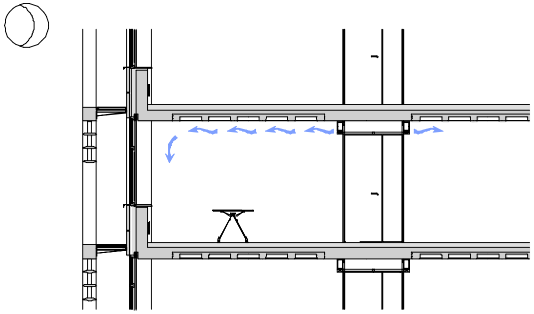
Passive cooling

- External shading
- High thermal mass
  (exposed floor / ceiling, ribs)

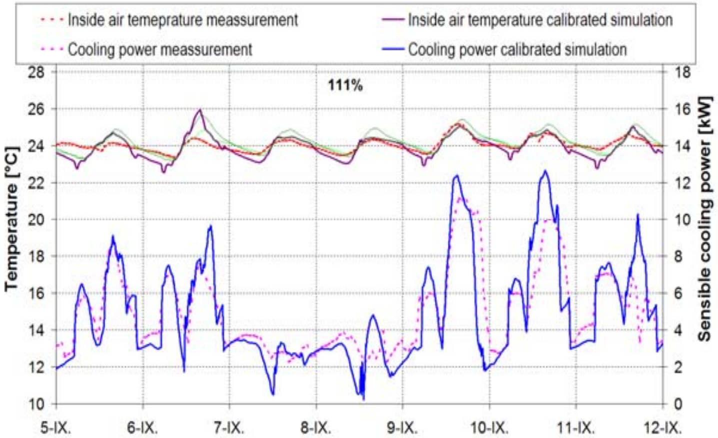
Low energy cooling

- All air system
- Night ventilation
- Top cooling
- Heat recovery

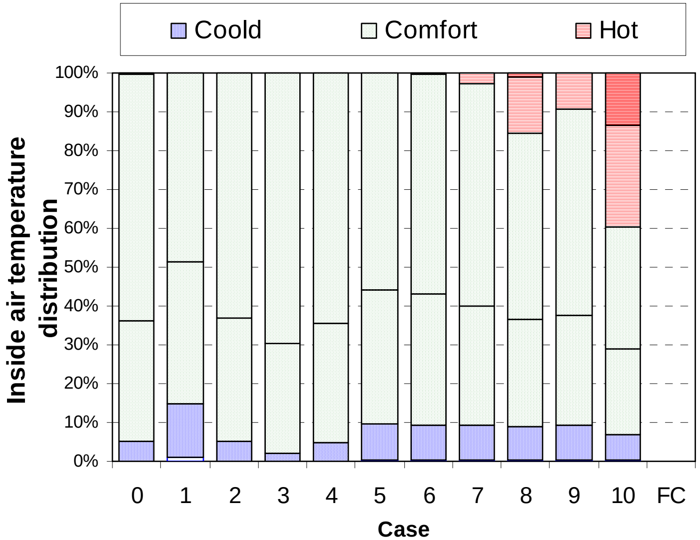


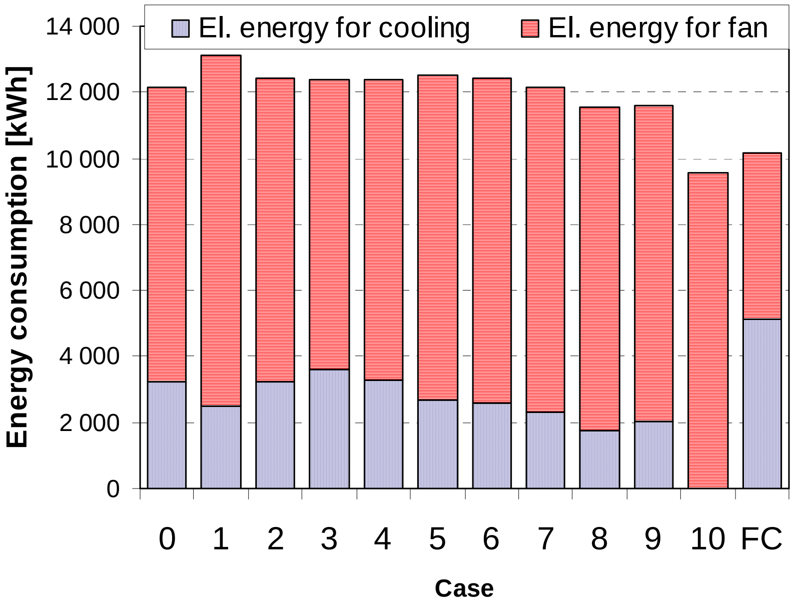


Simulation task - example



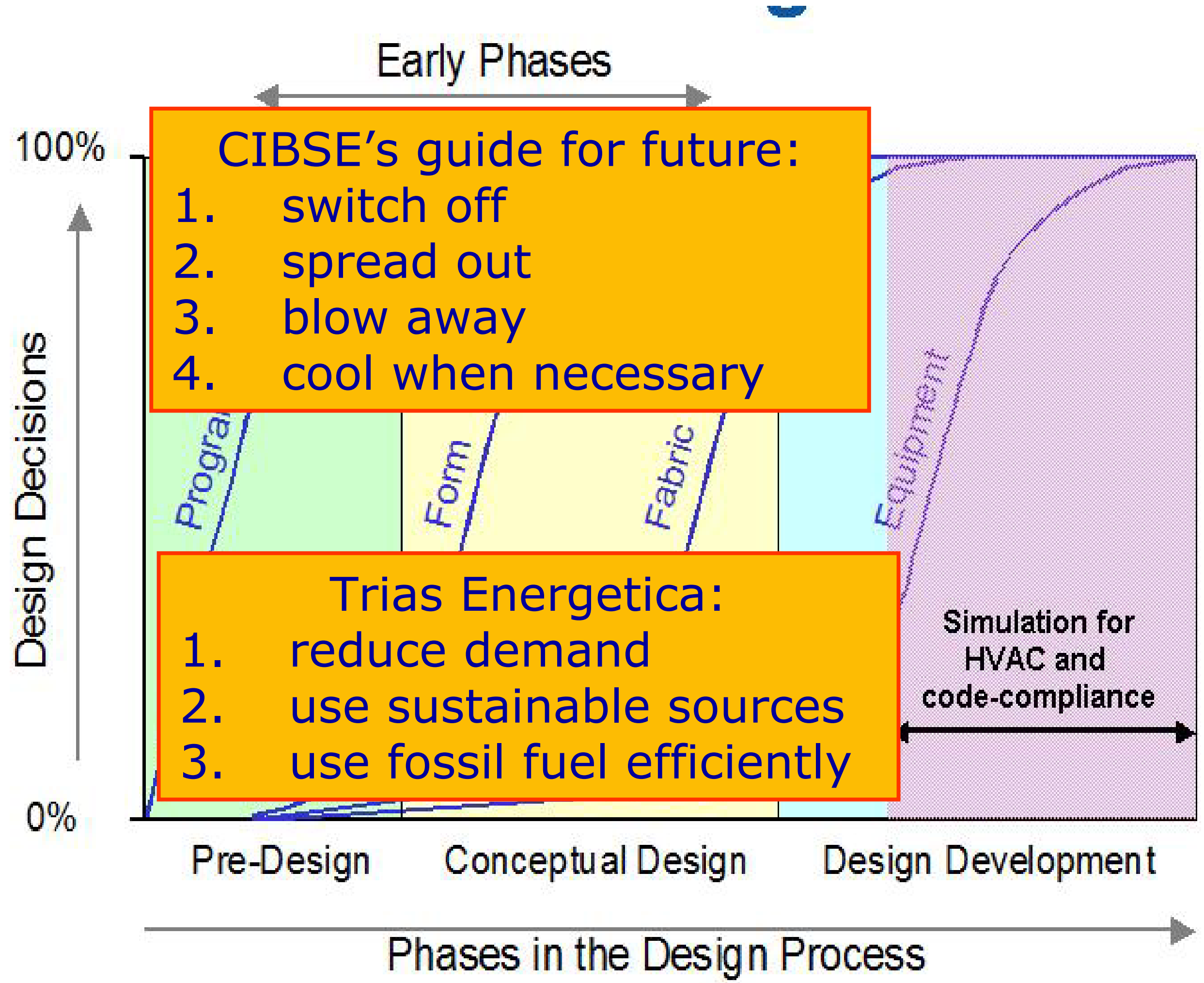
➲ Using calibrated building + systems model, 10 operation scenarios were simulated: 6 scenarios with various combinations of flow rates and control periods, 5 scenarios with reduced cooling coil capacity





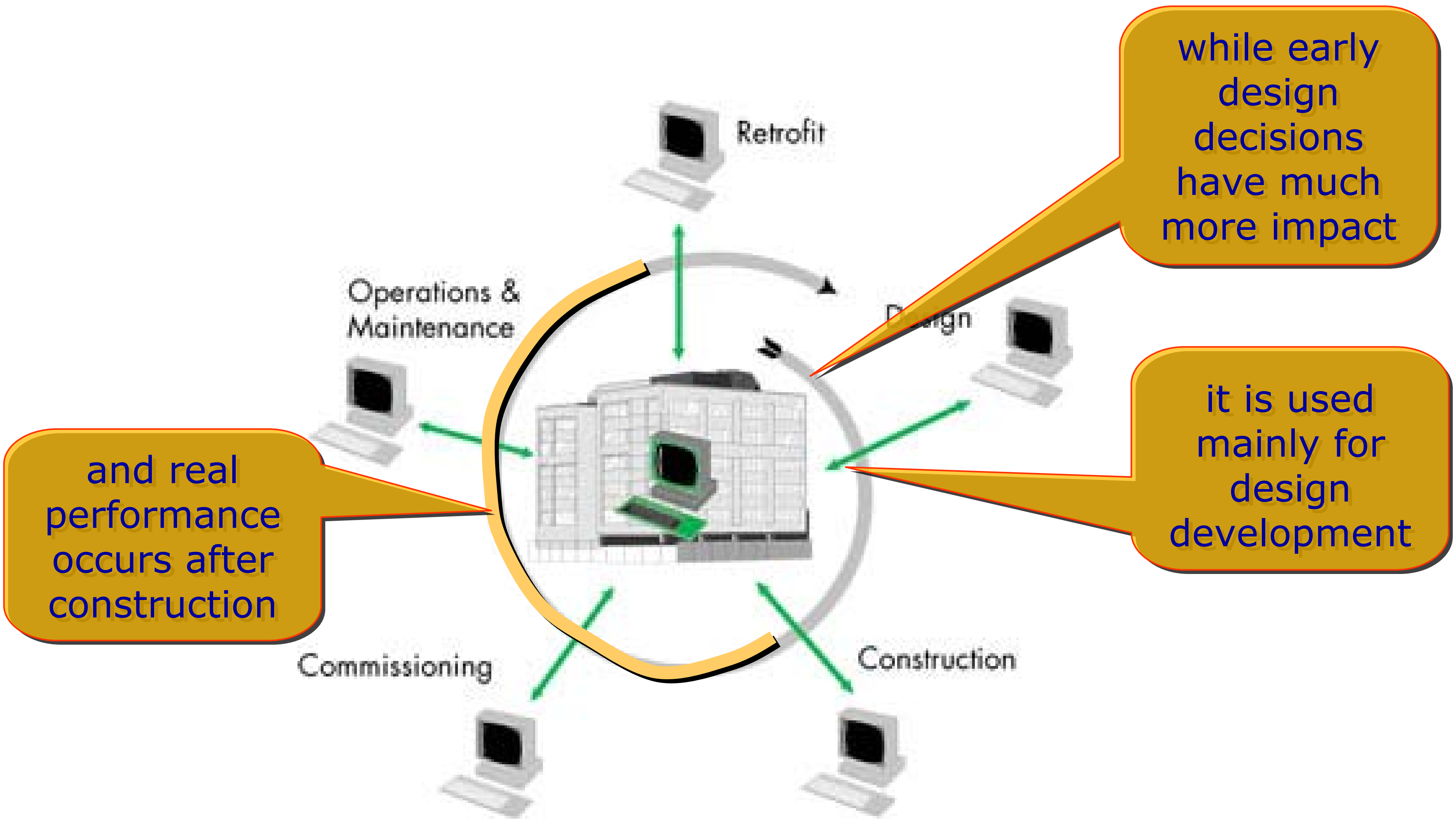
source: Milos Lain

Simulation in design



source: P Torcellini / P Ellis

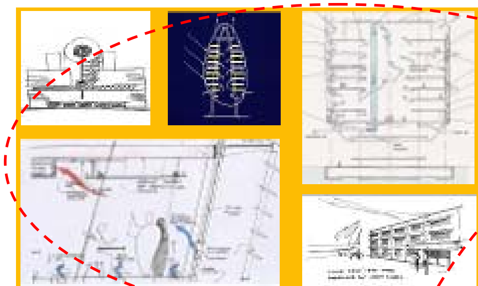
Simulation for design, but ...

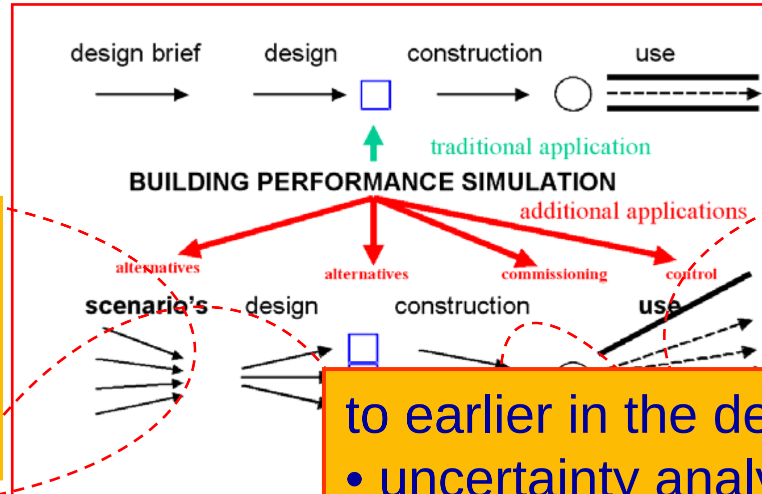


source: eetdnews.lbl.gov

Our Work

Expanding simulation scope

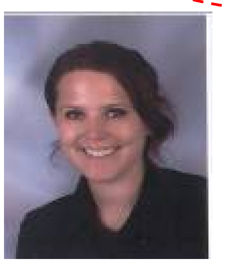


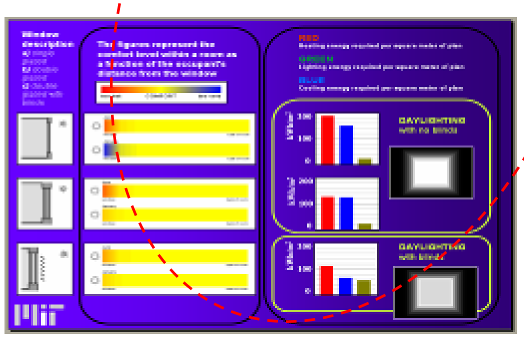


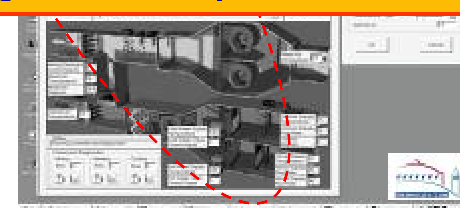
to earlier in the design process by:

- uncertainty analysis
- sensitivity analysis

- multi-objective decision making
- genetic algorithm optimization

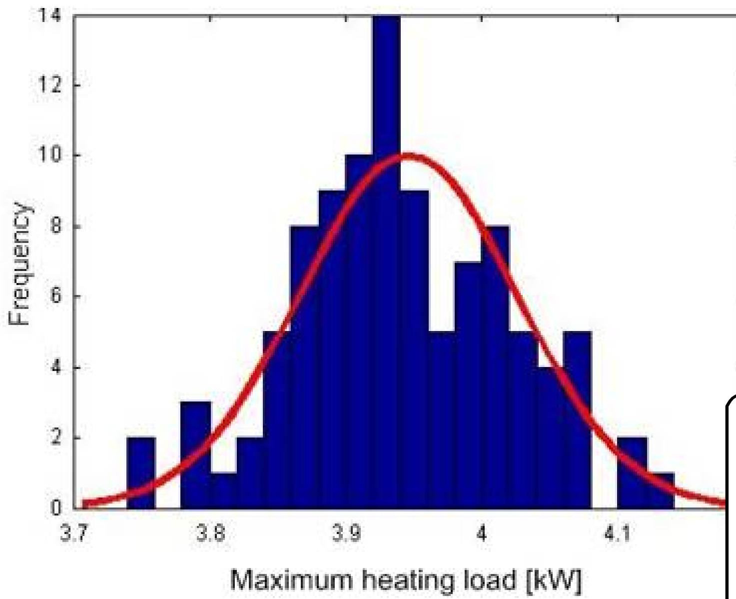


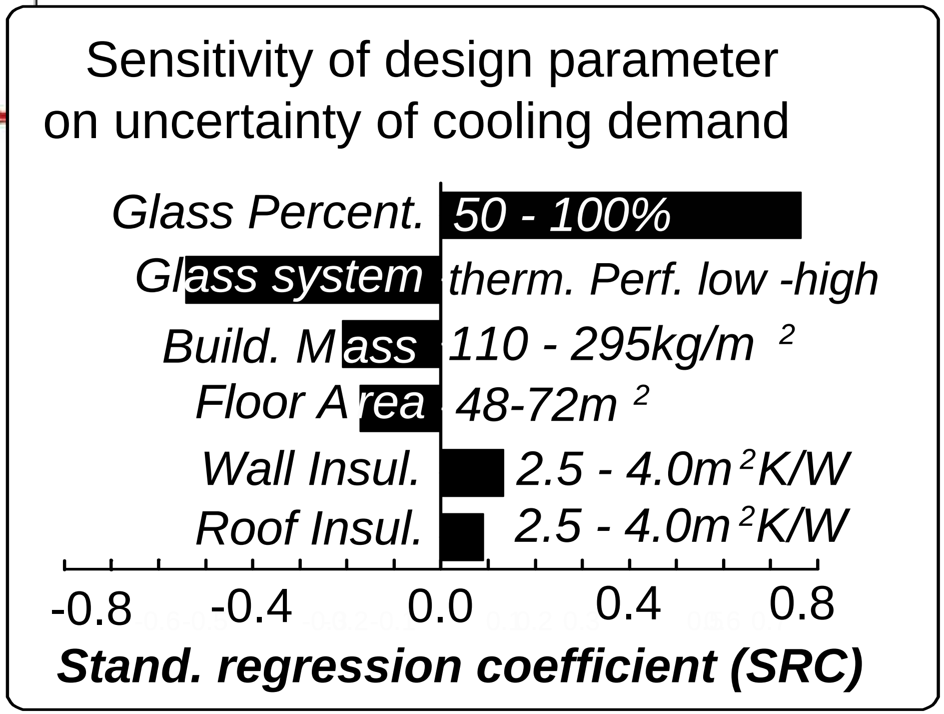




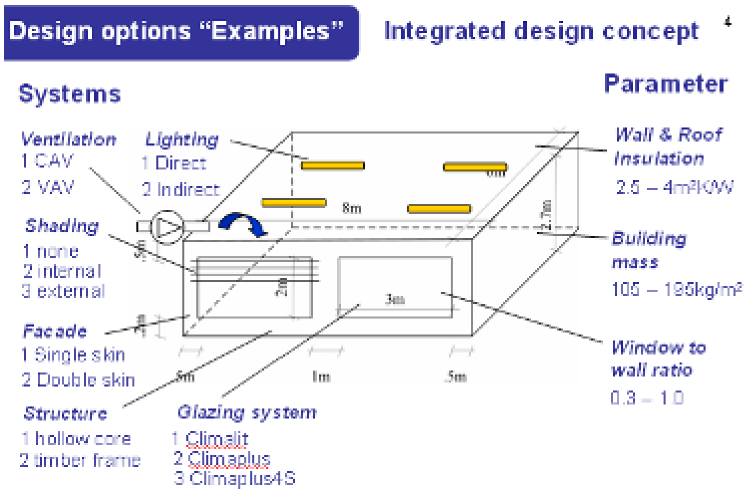
ZKU Turkey

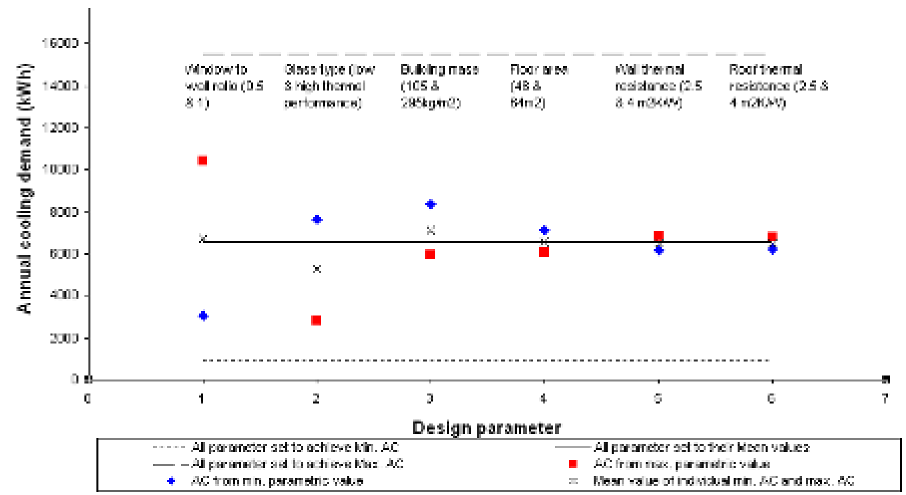
Uncertainty & sensitivity

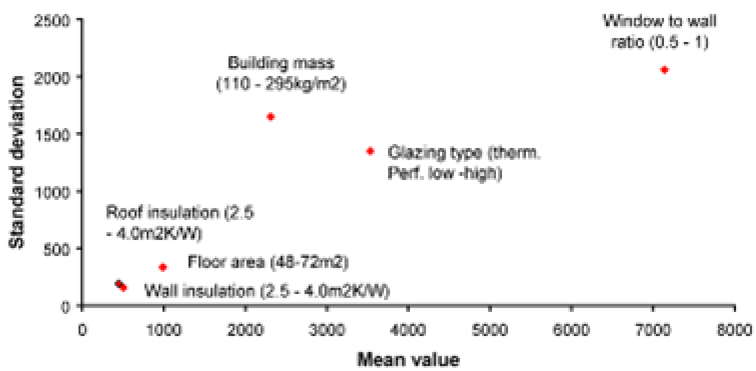


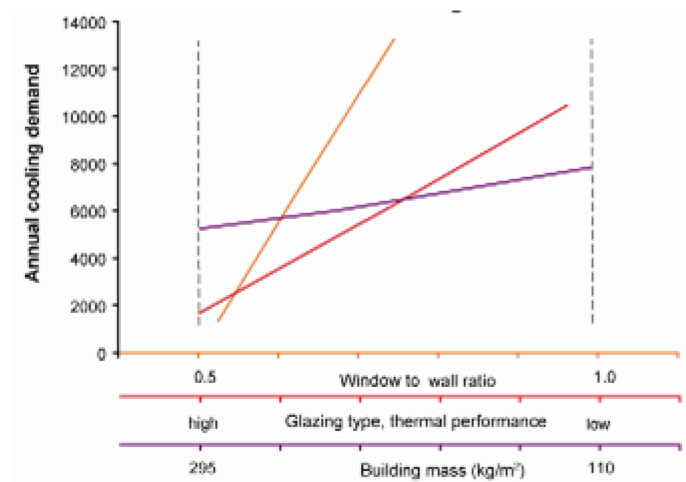


Uncertainty & sensitivity





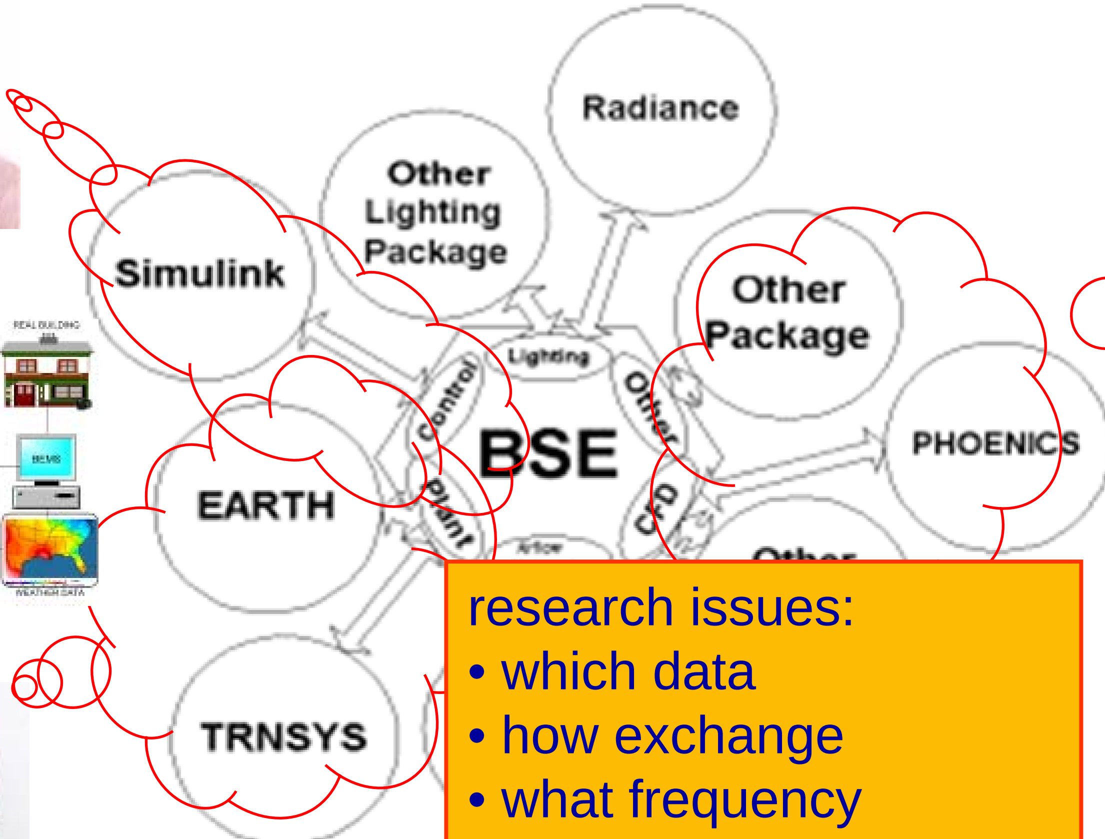




Source: Christian Struck

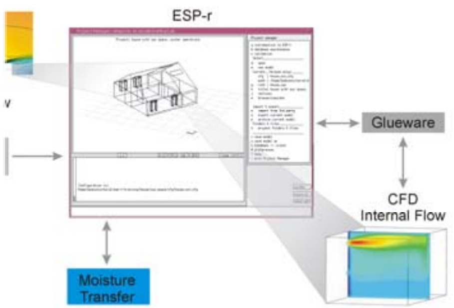
TU/e Technische Universiteit Eindhoven University of Technology

Co-simulation (by run-time coupling)

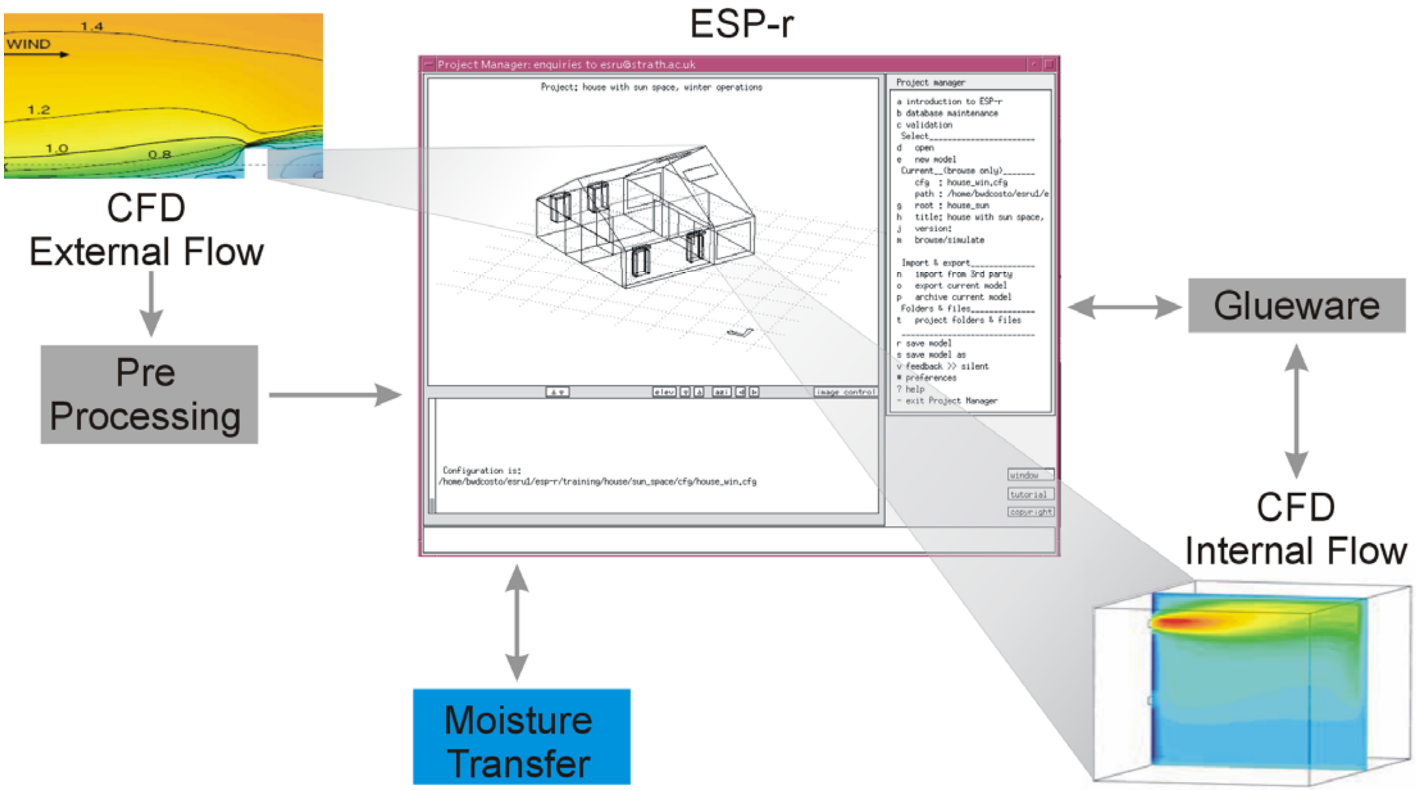


research issues:
- which data
- how exchange
- what frequency

- speed
- stability
- accuracy



Heat, air and moisture



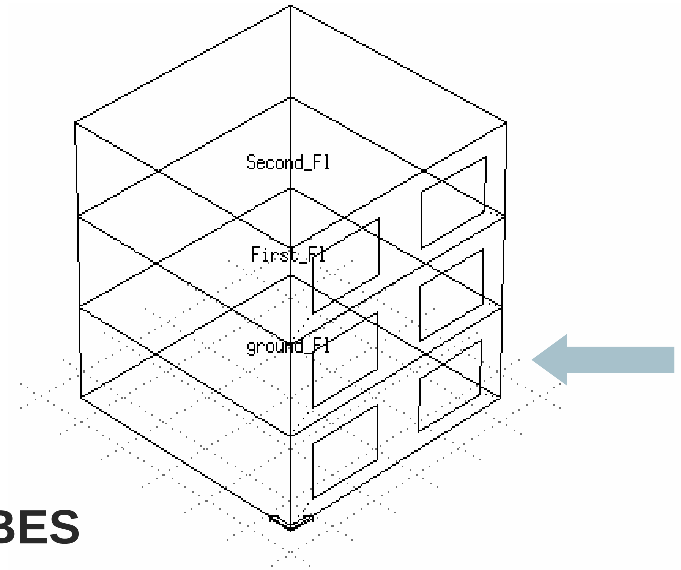
deliverables:

- prototype software
- coupling procedure
- coupling validation

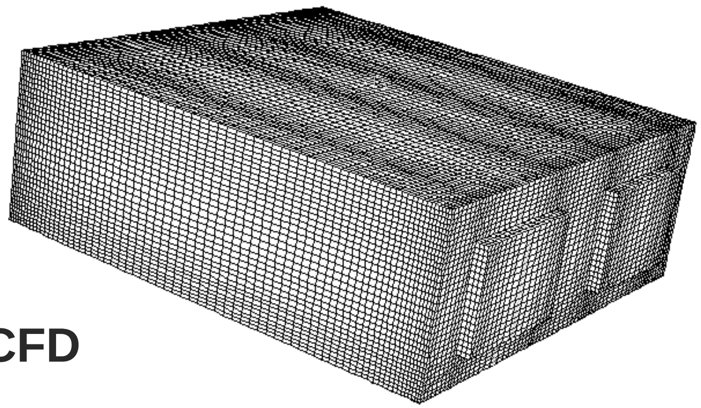
HAMPE – case study 1

Model

- ➢Volume: 10 (m) *10 (m) * 3.33 (m)
- ➢12 surfaces
- ➢Duration = 1 day (31st of March)
- ➢2 time steps per hour
- ➢Location: Brussels
- ➢Free floating temperature

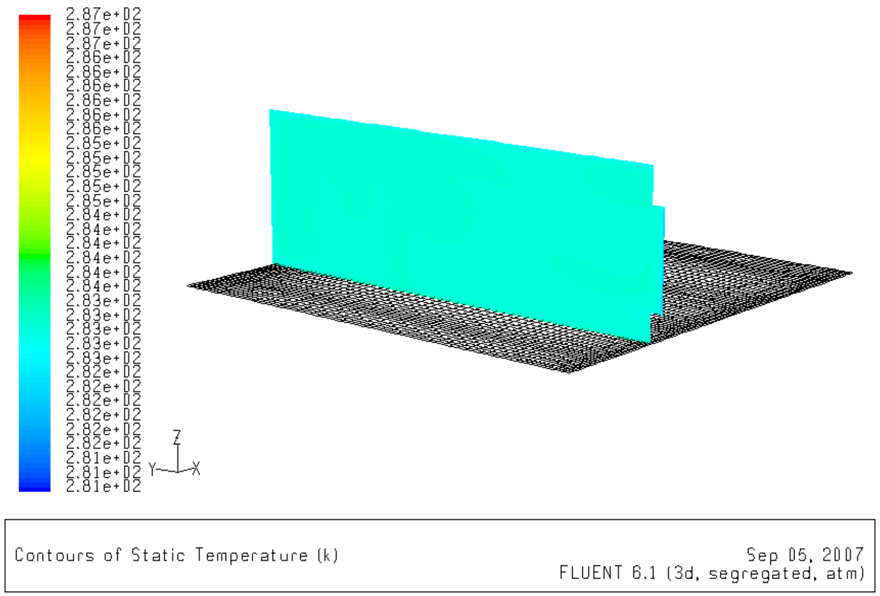


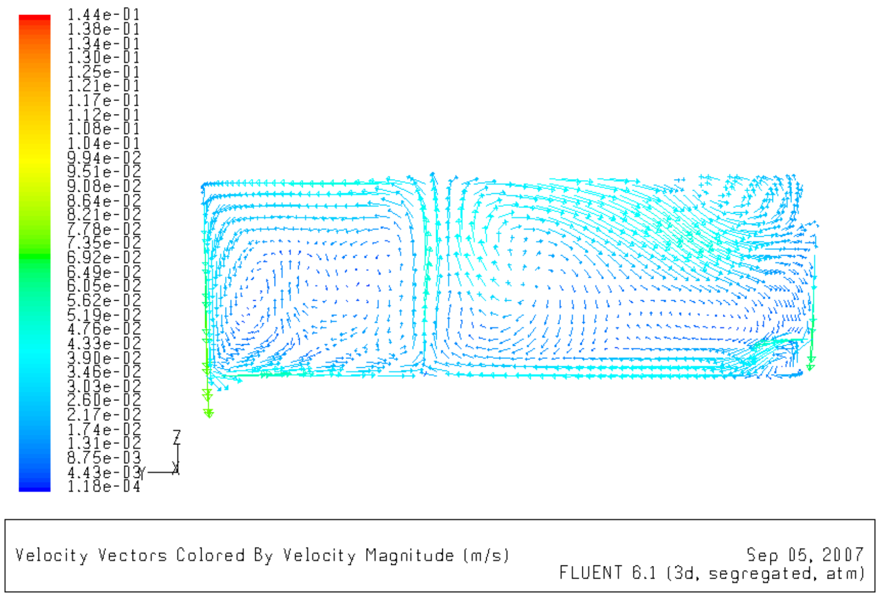
BES

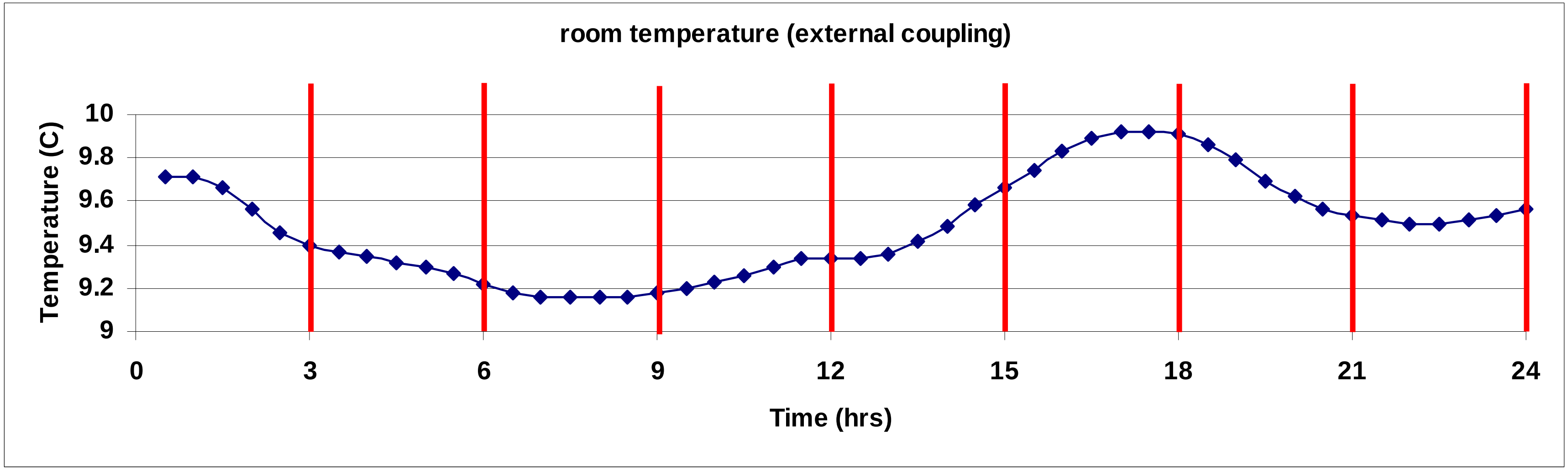


CFD

HAMPE – case study 1



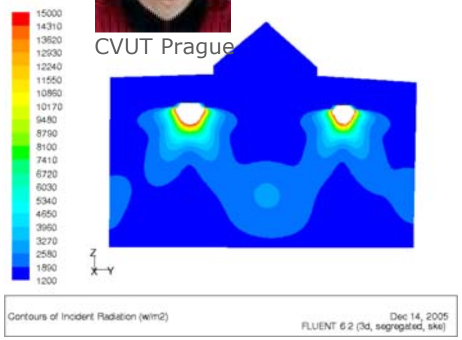




Source: Daniel Costola + Mohammad Mirsadeghi

Application oriented

CVUT Prague



CVUT Prague

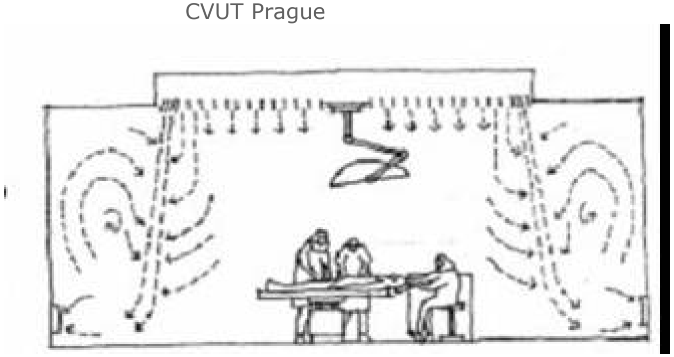
CVUT Prague

CVUT Prague

CVUT Prague

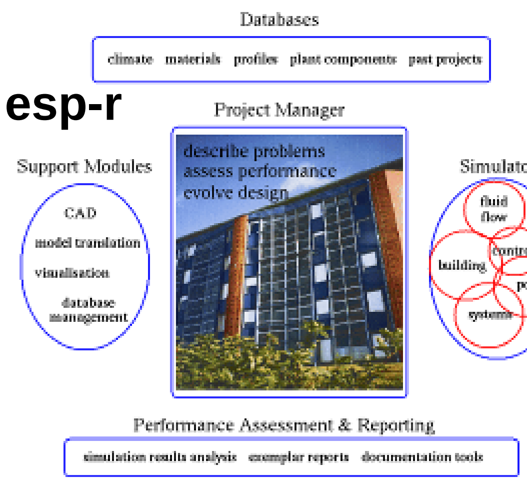
CVUT Prague

CVUT Prague



Identifies shortcomings and barriers to be addressed in our more general research

International co-operation



TNO

IWT

ALBAN

TVVL

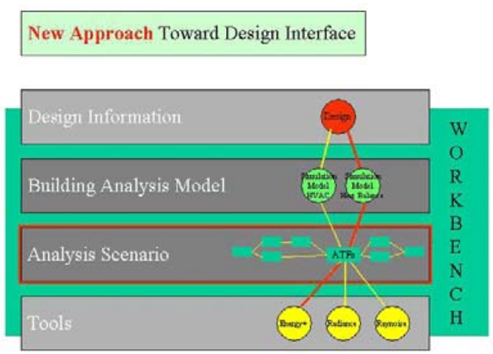
IBPSA - NVL

Stichting Promotie Installatietechniek (PIT)

vabi software

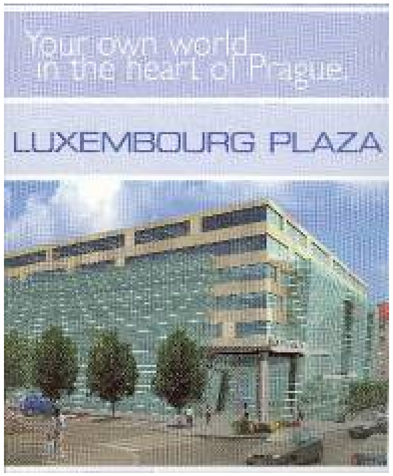
COPERNICUS ERB IC15 CT98 0511
Integrated Design Optimization of building energy performance and indoor environment

Deerns



SMARTHOMES

An e-box

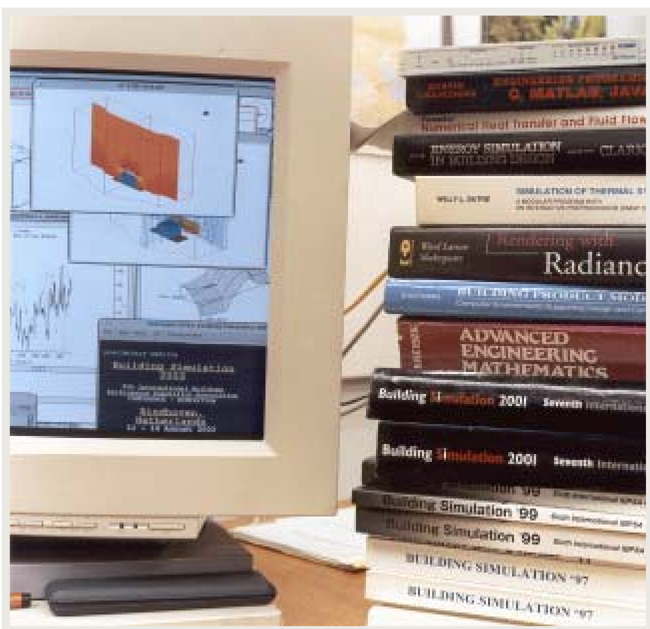


Consultancy

- AED Project s.r.o., Prague
- AND spol. s.r.o., Prague
- Allan Cumming Associates, Edinburgh
- Blyth & Blyth Associates, Edinburgh
- City of Glasgow
- College Bouw Ziekenhuisvoorzieningen, Utrecht
- Florida Solar Energy Center, Cocoa
- Frauenhofer-Institute for Solar Energy Systems, Freiburg
- Ian Hunter Partnership, Edinburgh
- Jiri Petlach Vzduchotechnika, Prague
- Korea Institute of Energy Research, Daejon
- McLaren, Murdoch & Hamilton, Perth
- Metroprojekt Praha a.s., Prague
- Miller Partnership, Glasgow
- Ove Arup & Partners International Ltd, London
- ORCO Property a.s., Prague
- PRelude, Arcen
- Scotsman Publications Ltd., Edinburgh
- Sipral a.s., Prague
- VABI, Delft

Teaching

- Introduction
- State-of-the-art
- Capita Selecta



Generation 2020 ?

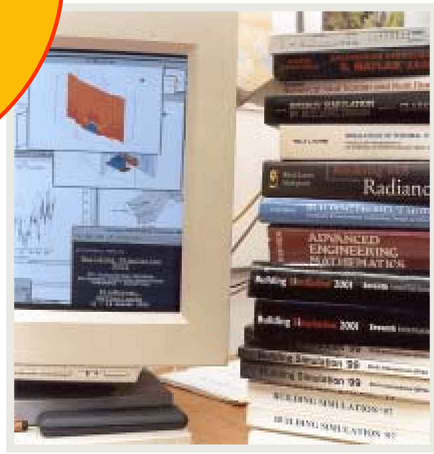
In Conclusion

In conclusion

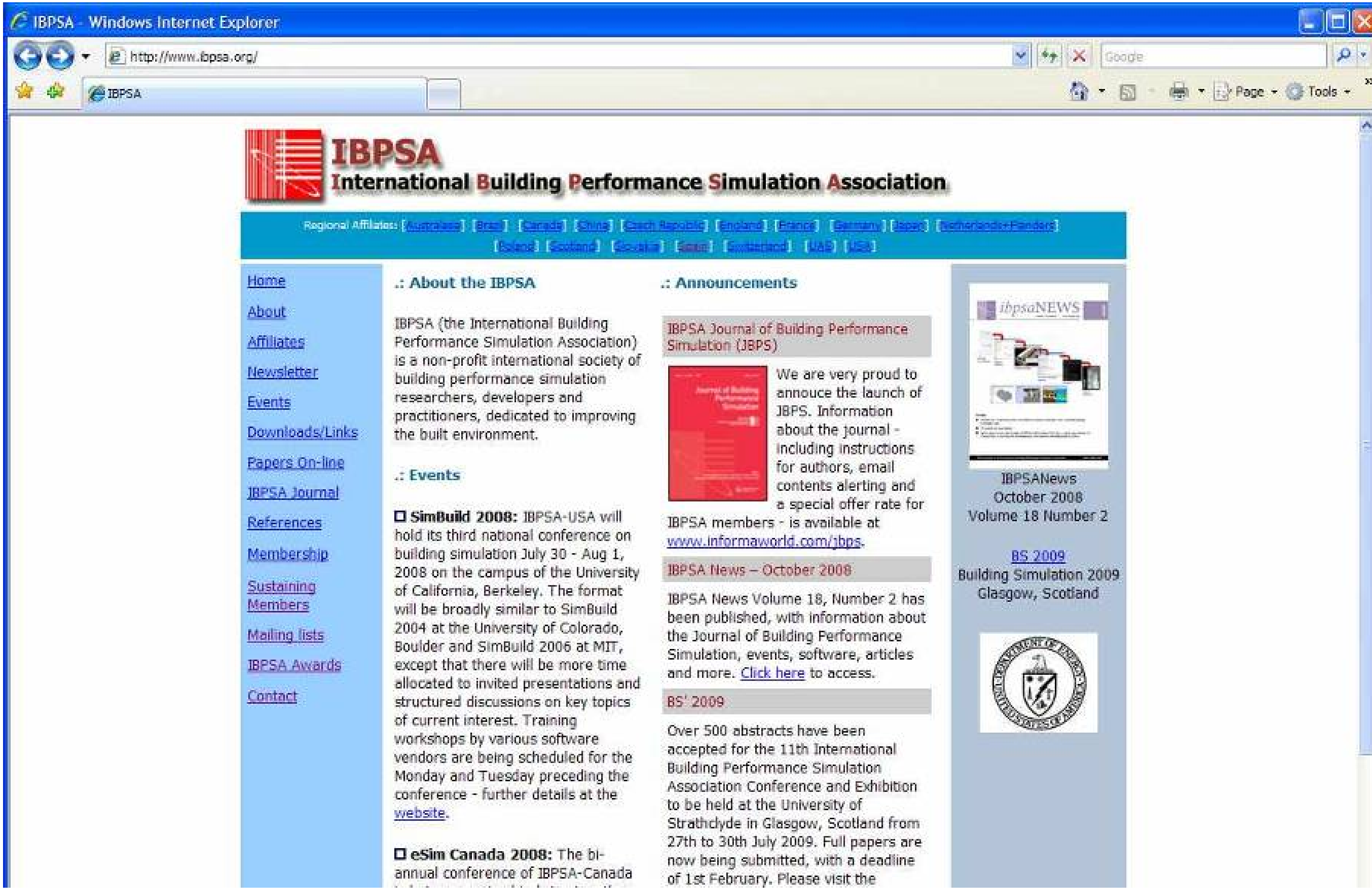
- Increasing real w ld co y
- Qu
- g
- opments

Poses major challenges to us (practitioners, researchers, educators, …), and is background of

IBPSA, a global network / community of practice



www.ibpsa.org



Thank You !

www.bwk.tue.nl/bps/hensen

Summer Comfort and Energy Savings through Solar Shading

EUROPEAN SOLAR-SHADING ORGANIZATION

Energy Savings & Comfort

ASIEPI workshop on
Summer Comfort and Cooling,
Barcelona, 1 April 2009

Wouter Beck
(Hunter Douglas Europe)

EUROPEAN SOLAR-SHADING ORGANIZATION
Energy Savings & Comfort

Agenda

- ES-SO
- Solar shading
- Market trends and developments
- Barriers and opportunities
- Recommendations

ES-SO: the European Solar-Shading organization

- umbrella org of the solar shading industry in EU
- 15 member countries
- thousands of SME's all over Europe
- internal, external solar shading and roller shutters
- demonstrate energy savings at the EU level
- more than an item left to the tenant

EUROPEAN SOLAR-SHADING ORGANIZATION

Energy Savings & Comfort

Where can solar shading help?

Summer

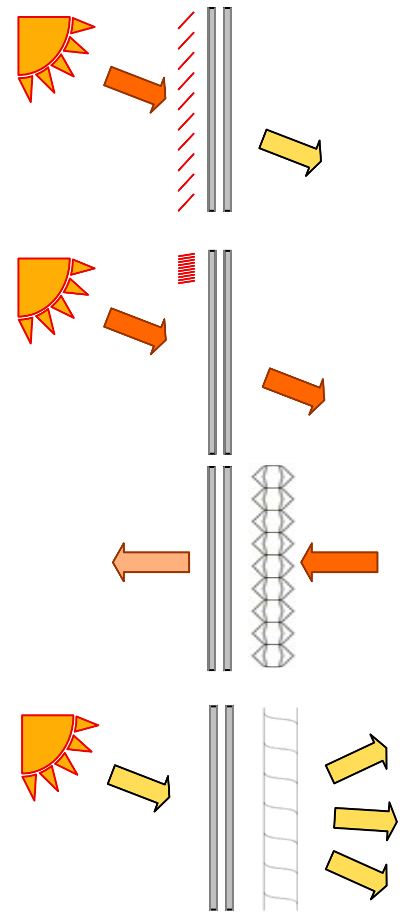
- keep out heat to avoid mechanical cooling

Winter

- use solar gains for passive heating
- improve insulation of windows

All seasons

- use natural daylight to avoid artificial lighting and associated cooling loads



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Energy Savings & Comfort

And what does that mean...

At building level:

- Save energy for heating, cooling and lighting
- Reduce the required cooling capacity

At regional level:

- Reduce peak loads (MW) and reactive loads (MVAr)

To help avoiding ...

Market trends

no solar shading

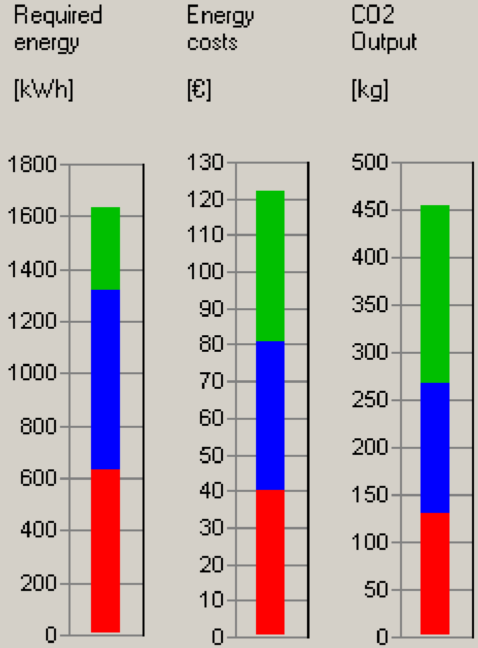
Conversion data

Cost of gas
0.44 €/m3

Cost of electricity
0.13 €/kWh

CO2 emission gas
1.8 kg/m3

CO2 emission electricity
0.6 kg/kWh



	Required energy [kWh]	Energy costs [€]	CO2 Output [kg]
Heating	635	40	130
Cooling	684	41	137
Lighting	313	41	188
Total	1632	122	455

with solar shading

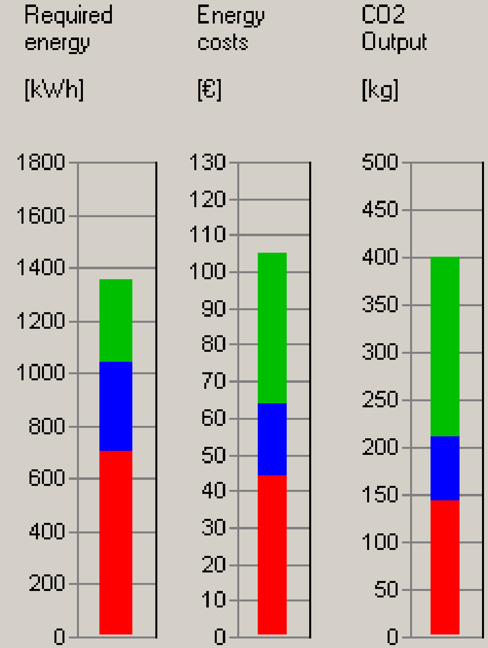
Conversion data

Cost of gas
0.44 €/m3

Cost of electricity
0.13 €/kWh

CO2 emission gas
1.8 kg/m3

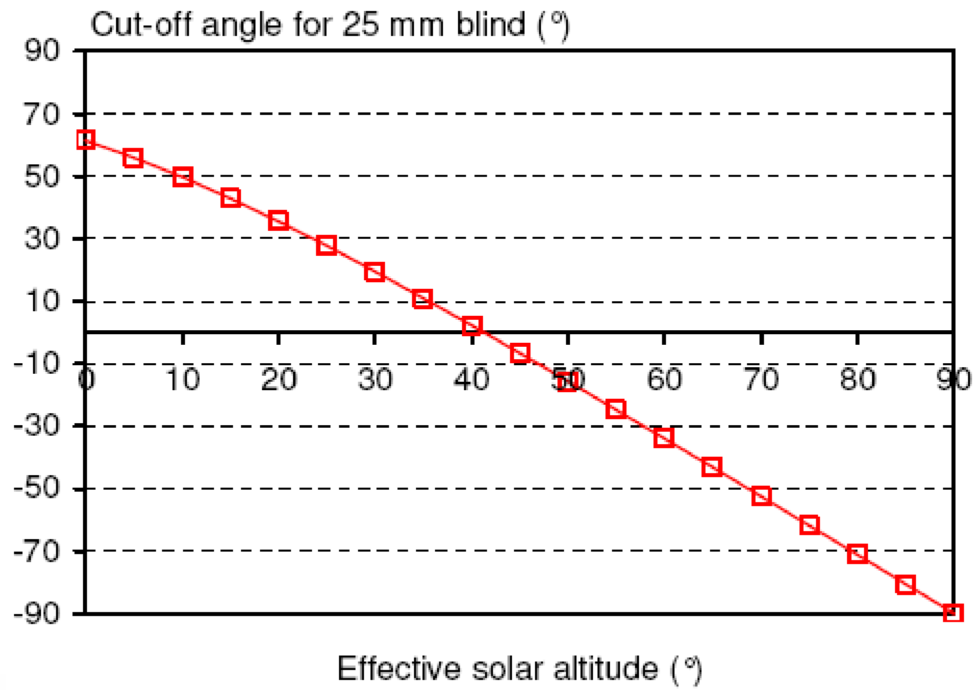
CO2 emission electricity
0.6 kg/kWh



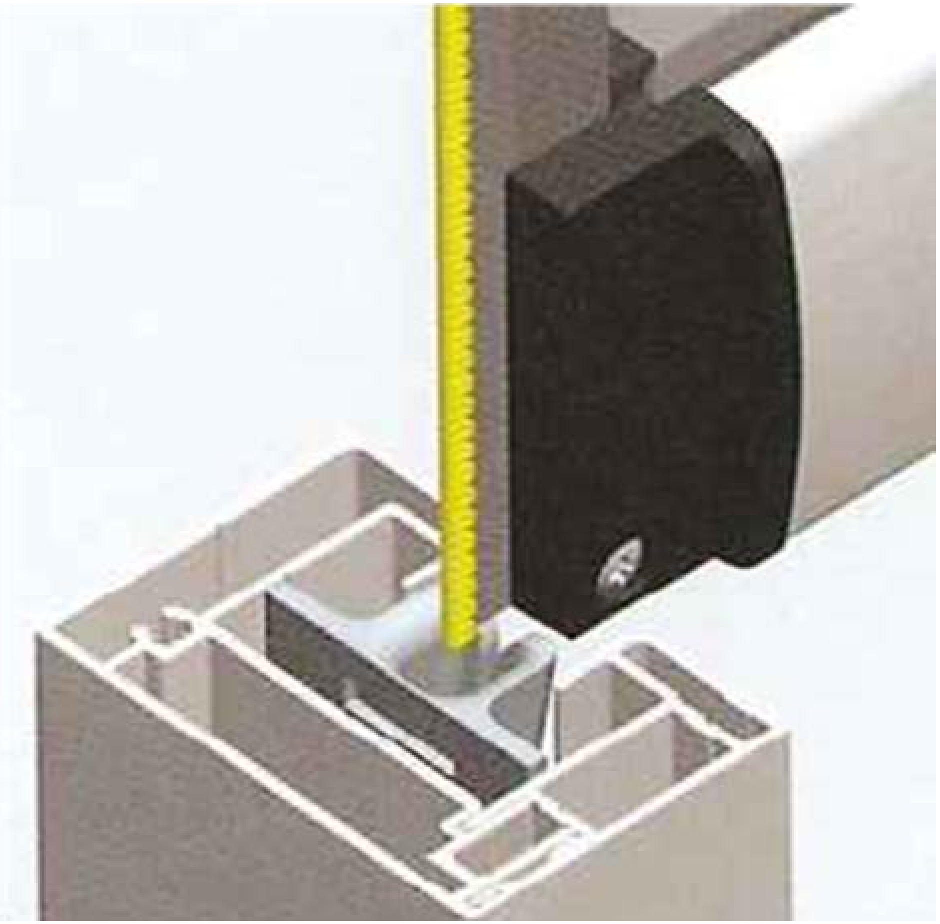
	Required energy [kWh]	Energy costs [€]	CO2 Output [kg]
Heating	701	44	144
Cooling	337	20	67
Lighting	313	41	188
Total	1351	105	399

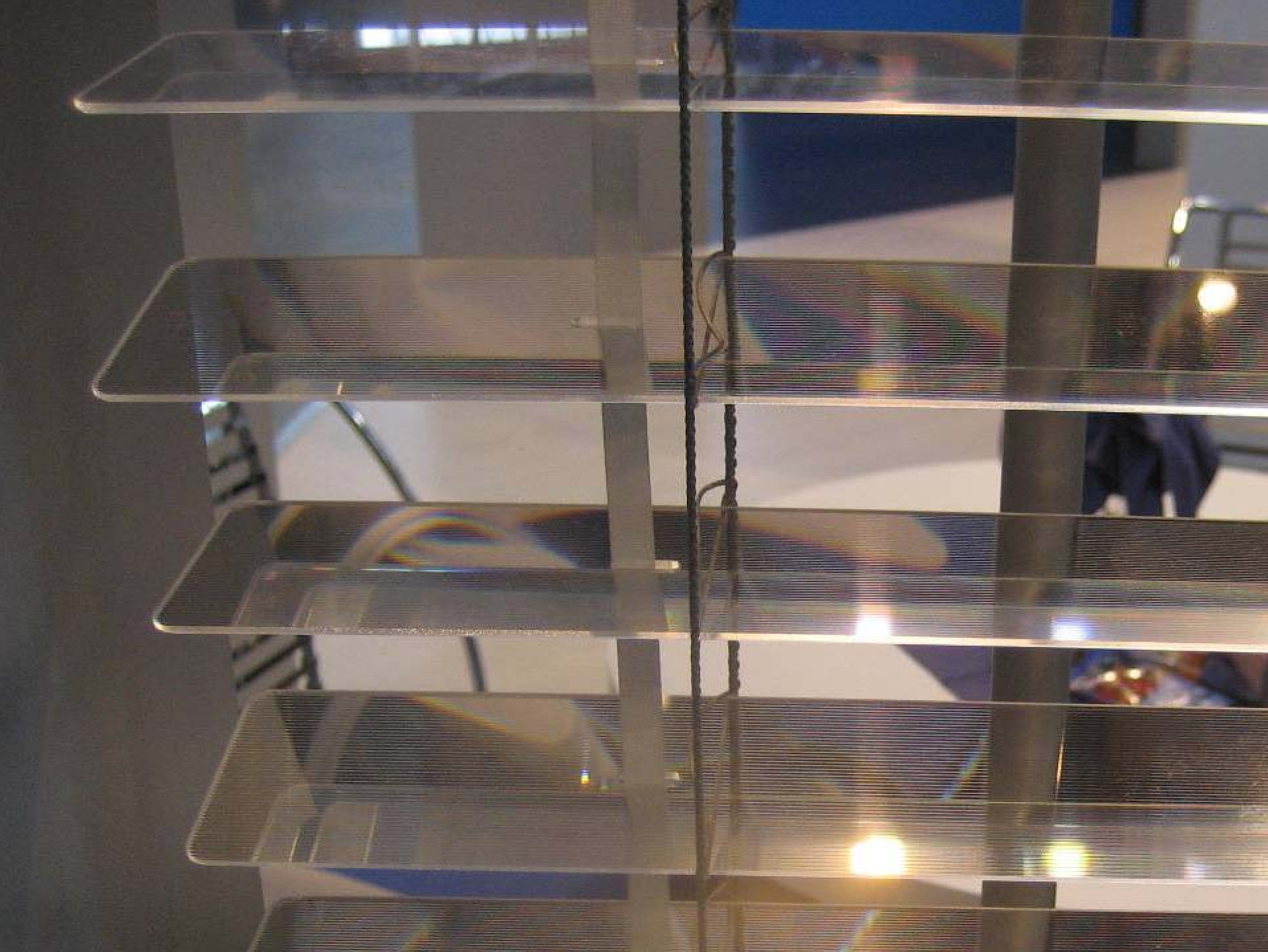
Developments

- Automation and integration with BMS
  - Steering on irradiance level
  - Steering of slat angles on solar elevation




Km/h





Barriers and opportunities (1)

- The full effects of solar shading are more difficult to convey
  - Impact on cooling, heating, lighting
  - Effects depend on location, orientation, fenestration, internal gains, ventilation

Policy makers like ‘one dimensional’ measures

EUROPEAN SOLAR-SHADING ORGANIZATION
Energy Savings & Comfort

Barriers and opportunities (2)

Design process

- Glazing, shading, daylighting and HVAC require a holistic approach
  - Architects deal with the concept and structural aspects
  - Installation specialists deal with IEQ

Result: often a HVAC-only solution

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Barriers and opportunities (3)

- Energy savings in national EPBD implementations through solar shading appear to be moderate and not consistent with today's automation
  - Belgium: unfavorable default g-value
  - Germany: conservative static shading coefficients
  - UK: solar shading does not affect SAP rating, penalty in winter
  - Netherlands: somewhat conservative (a.o. 300 W/m^2 criterion, default parameters)

→ **Hard to get a complete and factual overview**

The industry has to play its part…

- Industry and architects (often) perceive regulations as fixed
  - Various mechanisms for appeal
  - These mechanisms are hardly ever used by the shading industry
  - Provide factual evidence of effectiveness
- Make sure the rationale doesn't get lost during the lifetime of the system

Recommendations

National regulations:

- reward passive first
- use actual product values (g-value, Fc, ...) and take automation into account
- promote a holistic approach:
  shading, glazing, lighting, HVAC in concert

Recommendations

Industry must play its role:

- Quantify and communicate effects
- Better explain the workings -
- Challenge defaults in regulations by providing factual evidence on the state of the art

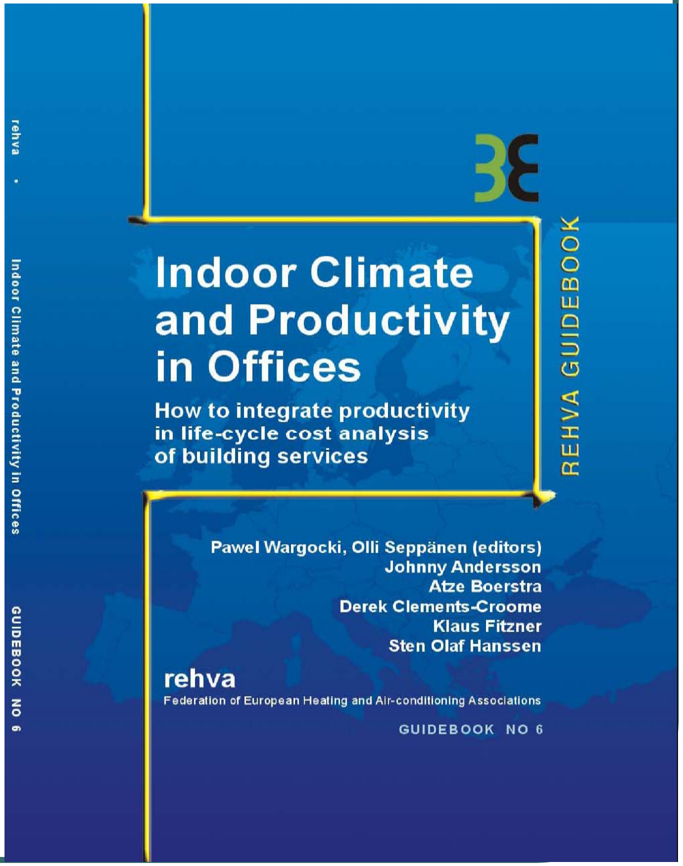
Design:

- Consider solar shading in concept phase

And what is ES-SO doing?

REHVA/ES-SO guidebook on Solar Shading

- Actionable information for designers in the building trade
- State-of-the-art information on the possibilities of solar shading
- Integration with other building services, in particular HVAC
- Effects on energy use of buildings



EUROPEAN SOLAR-SHADING ORGANIZATION
Energy Savings & Comfort

Influencing the EPBD recast

EUROPEAN COMMISSION

Directorate-General for Energy and Transport

⬇ 2002/91 recital 10 (adapted)
⇨ new

(9) The energy performance of buildings should be calculated on the basis of a methodology, which may be differentiated at ⌦ national and ⌫ regional level, ⌦ and ⌫ that includes, in addition to thermal ⌦ characteristics ⌫ ~~insulation~~, other factors that play an increasingly important role such as heating and air-conditioning installations, application of renewable energy sources, ⌦ passive heating and cooling elements, shading, indoor air-quality, adequate natural light ⌫ and design of the building. ⌦ The methodology for calculating energy performance should not only be based on the season where heating is required, but should cover the annual energy performance of a building. ⌫

From the Commission's EPBD Recast

EUROPEAN SOLAR-SHADING ORGANIZATION
Energy Savings & Comfort

More about ES-SO

www.es-so.org

EUROPEAN SOLAR-SHADING ORGANIZATION

Energy Savings & Comfort

Thank you for your attention!

Thermal comfort in buildings with low-energy cooling – Establishing an annex for EPBD-related CEN-standards for buildings with high energy efficiency and good indoor environment

Summer Comfort and Cooling ThermCo Project

Doreen Kalz | Jens Pfafferott

31 March – 1 April 2009, Barcelona Spain

Fraunhofer Institut Solare Energiesysteme

Intelligent Energy Europe

Project Summary

ThermCo provides consistent design guidelines and legal certainty for low-energy cooling:

- **ThermCo** evaluates low-energy cooling concepts all-over Europe using a standardised method based on existing monitoring data from good and best practice examples.
- **ThermCo** provides design guidelines for typical building concepts in the European climate zones.
- **ThermCo** collects the knowledge available and transfers it into a REHVA Guidebook on Low-Energy Cooling in Europe which acts as a commonly accessible knowledge pool for passive and low-energy cooling techniques.
- The proposed approach is applied to eight demonstration projects in different climatic zones of Europe.
- **ThermCo** contains a strong dissemination strategy. A strong dissemination tool for enhanced building concepts is a REHVA Guidebook which is accepted by the European and the national federations of HVAC engineers and architects.

Background

Directive 2002/91on the energy performance of buildings states: “Priority should be given to strategies which enhance the thermal performance of buildings during the summer period.”

- Although low-energy cooling concepts are highly-developed and have been realised successfully in many projects in all European climate zones, we experience a continued growth in the use of air-conditioning in Europe, not only in Southern Europe but also in the moderate summer climates and even in North European countries with cool summers.
- Unfortunately, there is a strong uncertainty among all persons concerned with building design due to conflicting requirements and standards. Conflicting requirements can be found not only on the European level but also in the member states.
- A design guideline for comfortable low-energy buildings and consistent evaluation criteria for the indoor environment will be applied to different climate zones and, hence, will contribute to a consistent quality assessment of energy and comfort.

Objectives and main steps

The **ThermCo** project contains five project related work packages:

- **Data evaluation**: Compilation, acquisition and evaluation of existing monitoring data from typical, low-energy and high-performance office buildings in Europe.
- **Application**: Identification and evaluation of different measures for low energy demand and high indoor environmental quality in different European climate zones.
- **Regulatory measures**: Collection of available knowledge and transferring it into a guideline which acts as a commonly accessible knowledge pool for passive and low-energy cooling techniques.
- **Demonstration**: The proposed approach is applied to eight demonstration projects in different climatic zones of Europe in order to test, to validate and, if necessary, to revise the evaluation procedure.
- **Dissemination**: Preparation of appropriate information material for the different target groups involved in the design and planning process of buildings.

Expected results

The implementation plan shows the methodology and the expected results.

The main result is a REHVA Guidebook on Low-Energy Cooling in Europe, related to the European Energy Performance of Buildings Directive (EPBD).

Data Evaluation	Application	Regulatory Measures	Demonstration	Dissemination
Data acquisition: energy and comfort	Application in South-European countries	Thermal comfort standards	Project Greece	Website, guidelines and translation
Adaptive models for thermal comfort	Application in North-European countries	Best practice and design examples	Project Germany	Workshops
Overall user satisfaction and thermal comfort votes in passively cooled buildings	Application in Mid-European countries		Project Romania	Professional journals
Comfort and productivity	Generalisation and application in different climate zones		Project France	
	Impact of new low-energy technologies on thermal comfort		Project Italy	
	Barriers to the implementation of low-energy coling		Project Finland	
			Project Denmark	
			Project Czech Republic	
How can we achieve good indoor environment in summer with low energy supply?		Implementation of an annex for CEN standards	Summary of case studies →	**Annex for CEN standards related to EPBD**

Fraunhofer Institut Solare Energiesysteme

Partners & Contact

N°	Participant name	Short name	Country	Main Role in Consortium
1 (CO)	Fraunhofer ISE	ISE	DE	Passive cooling
2 (CR)	PSE GmbH	PSE	DE	Management support
3 (CR)	University of Karlsruhe	UniKarl	DE	Data evaluation
4 (CR)	Technical University of Denmark	DTU	DK	Comfort models
5 (CR)	Helsinki University of Technology	TKK	FI	Regulatory measures
6 (CR)	University of La Rochelle	ULR	FR	Calculation methods
7 (CR)	University of Athens	NKUA	GR	Case studies
8 (CR)	Czech Technical University	CTUP	CZ	Application of standards
9 (CR)	Politecnico di Milano	eERG	IT	Climatic issues
10(CR)	Technical University of Civil Engineering - Bucharest	TUCEB	RO	Implementation

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E-mail: jens.pfafferott@ise.fraunhofer.de, Tel: +49(0)761/4588-5129

Fraunhofer Institut Solare Energiesysteme

Intelligent Energy Europe

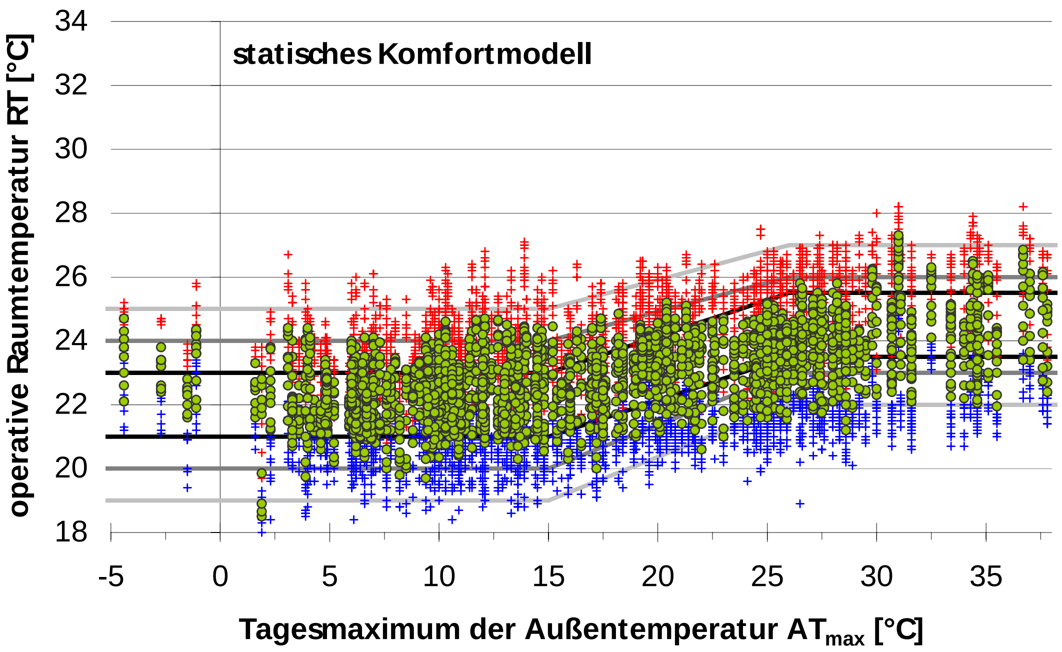
Results: Long-term monitoring and spot measurements

Fraunhofer Institut Solare Energiesysteme

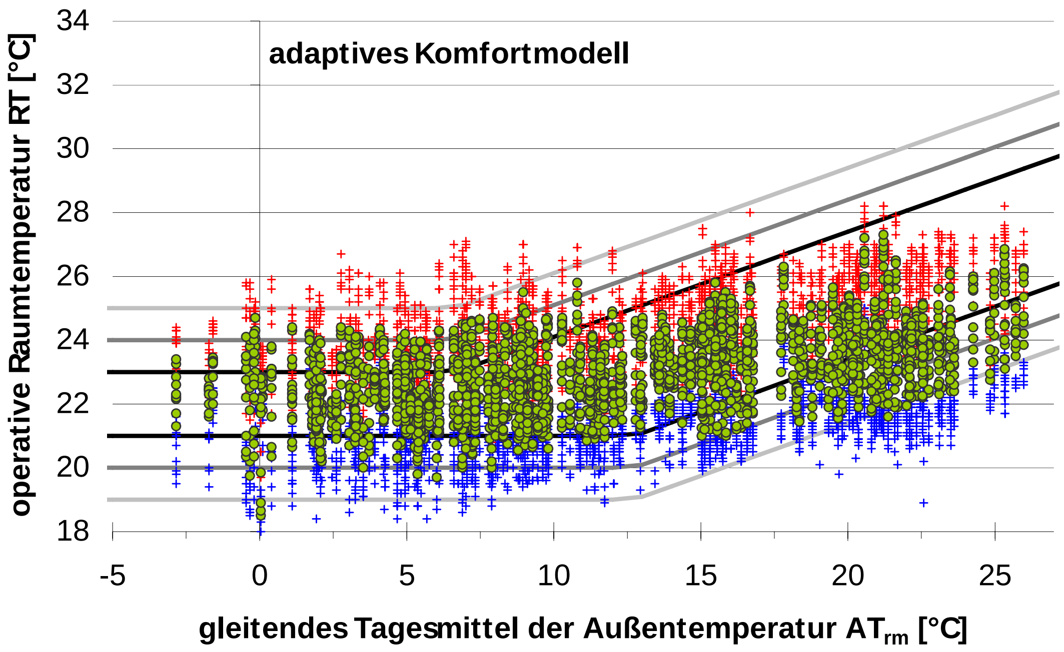
Intelligent Energy Europe

Results: Evaluation of interior thermal comfort

static approach: EN 15251:2007-08 (ISO 7730:2005)

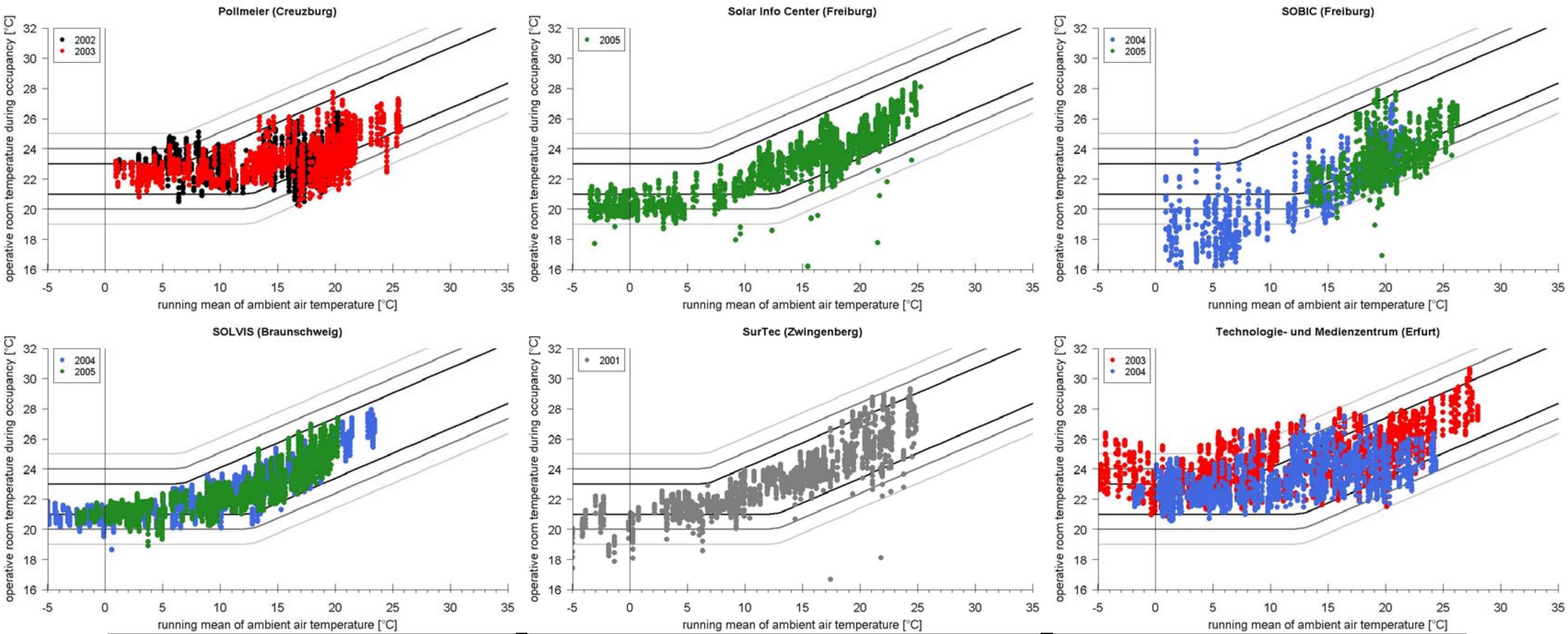


adaptive approach: EN 15251:2007-08



Results: Evaluation of interior thermal comfort

Allocation of the buildings in Germany to the comfort class A, B, C



Correlation of comfort, energy use and efficiency

Standardized data evaluation – Fraunhofer ISE

Successful cooling concept for a non-residential building:

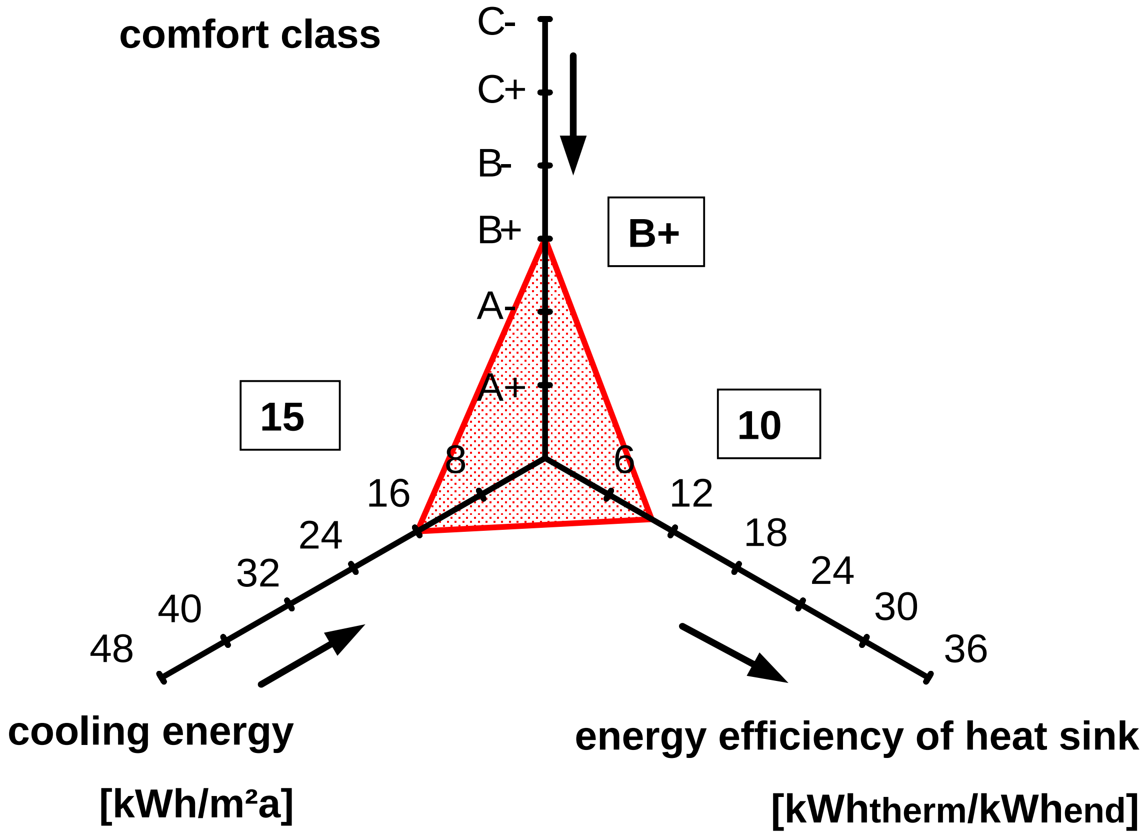
comfort class: B+ / II

useful cooling energy: 15 kWh/m²a

(optimized building envelope, passive cooling techniques)

efficiency: 10 kWhtherm/kWhend

(efficient plant with low auxiliary energy use)

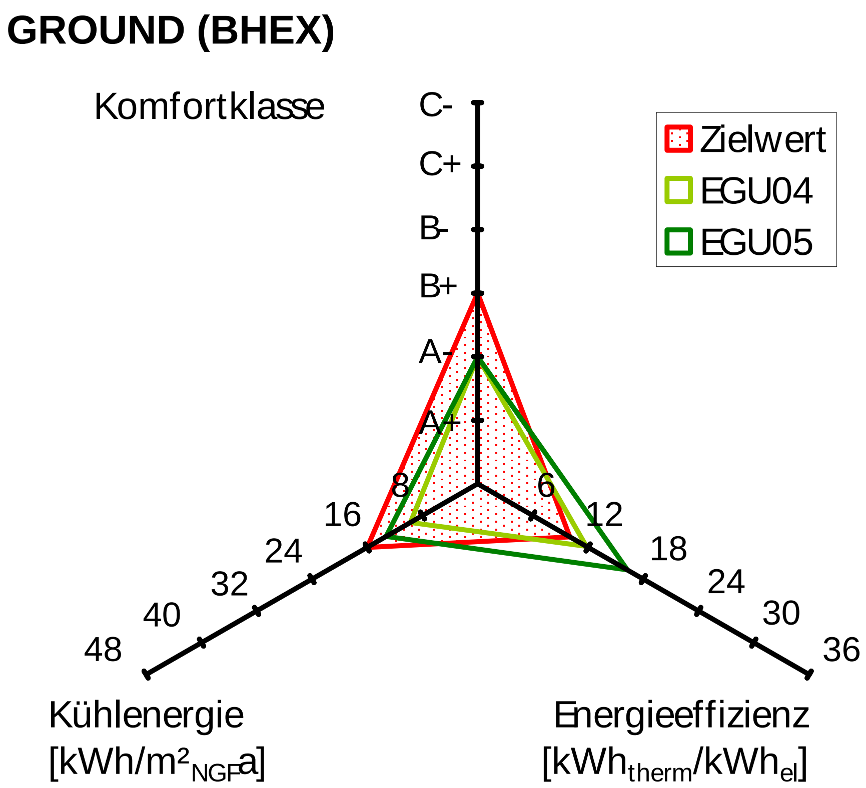


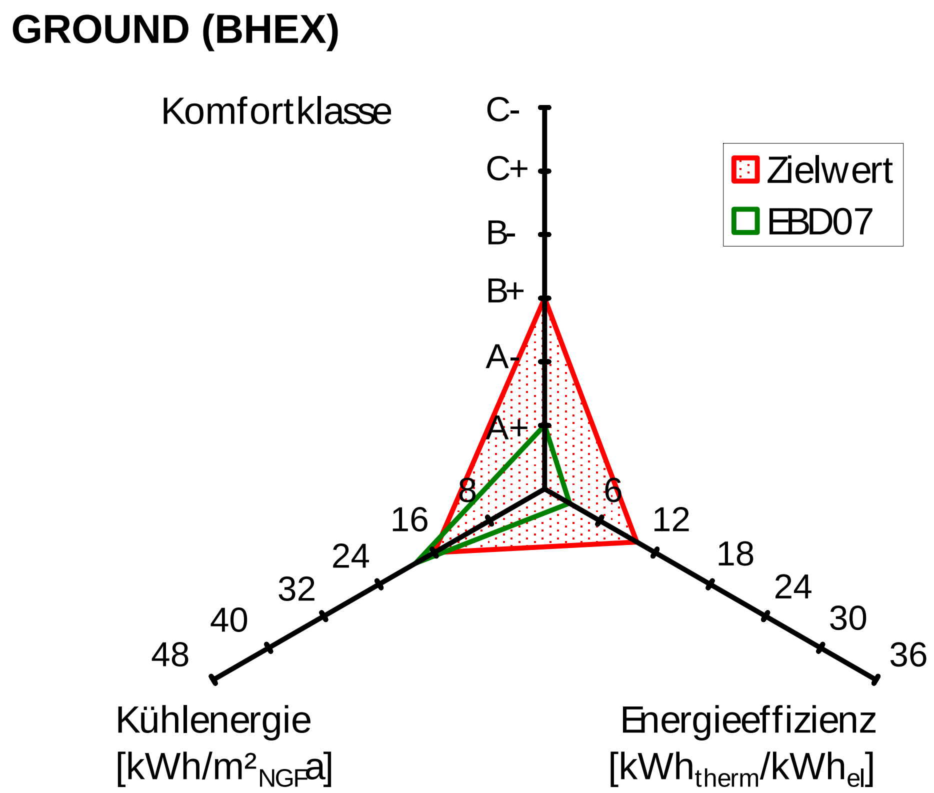
Fraunhofer Institut Solare Energiesysteme

Intelligent Energy Europe

Correlation of comfort, energy use and efficiency

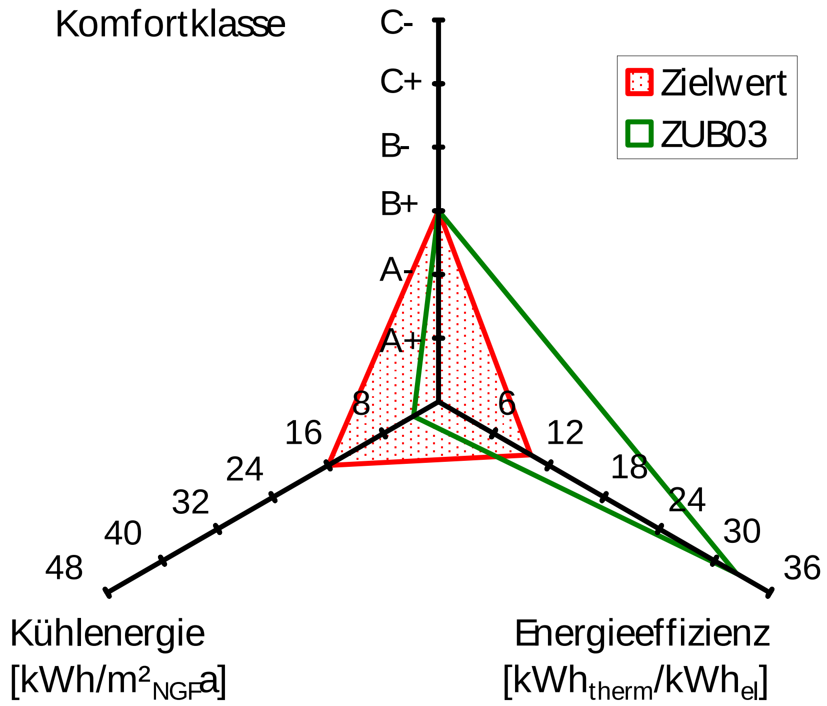
Standardized data evaluation



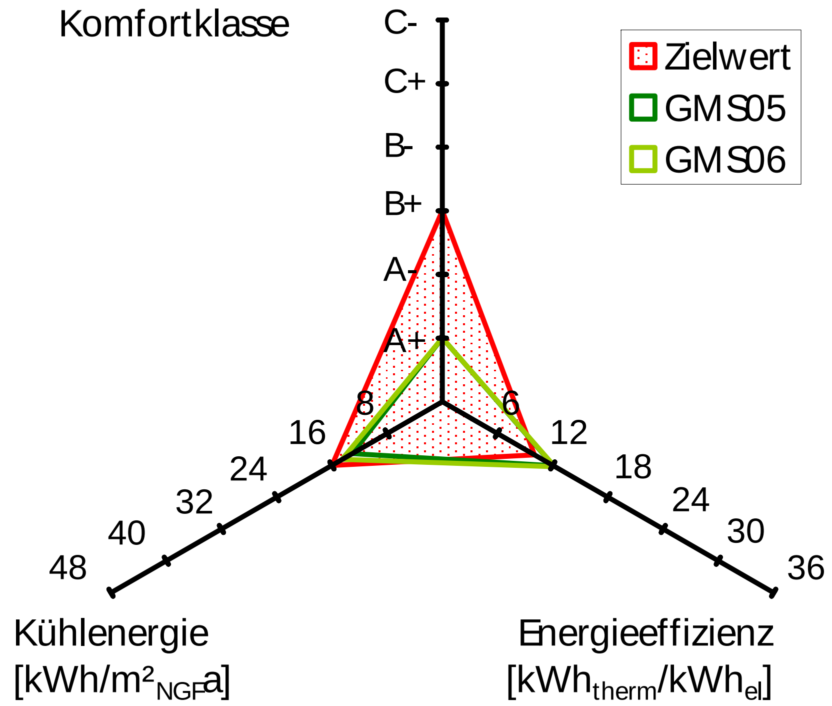


Correlation of comfort, energy use and efficiency
Standardized data evaluation

GROUND (BPEX)



GROUND WATER (well)



International workshop
Summer comfort and cooling

Barcelona 31 March 1st April 2009

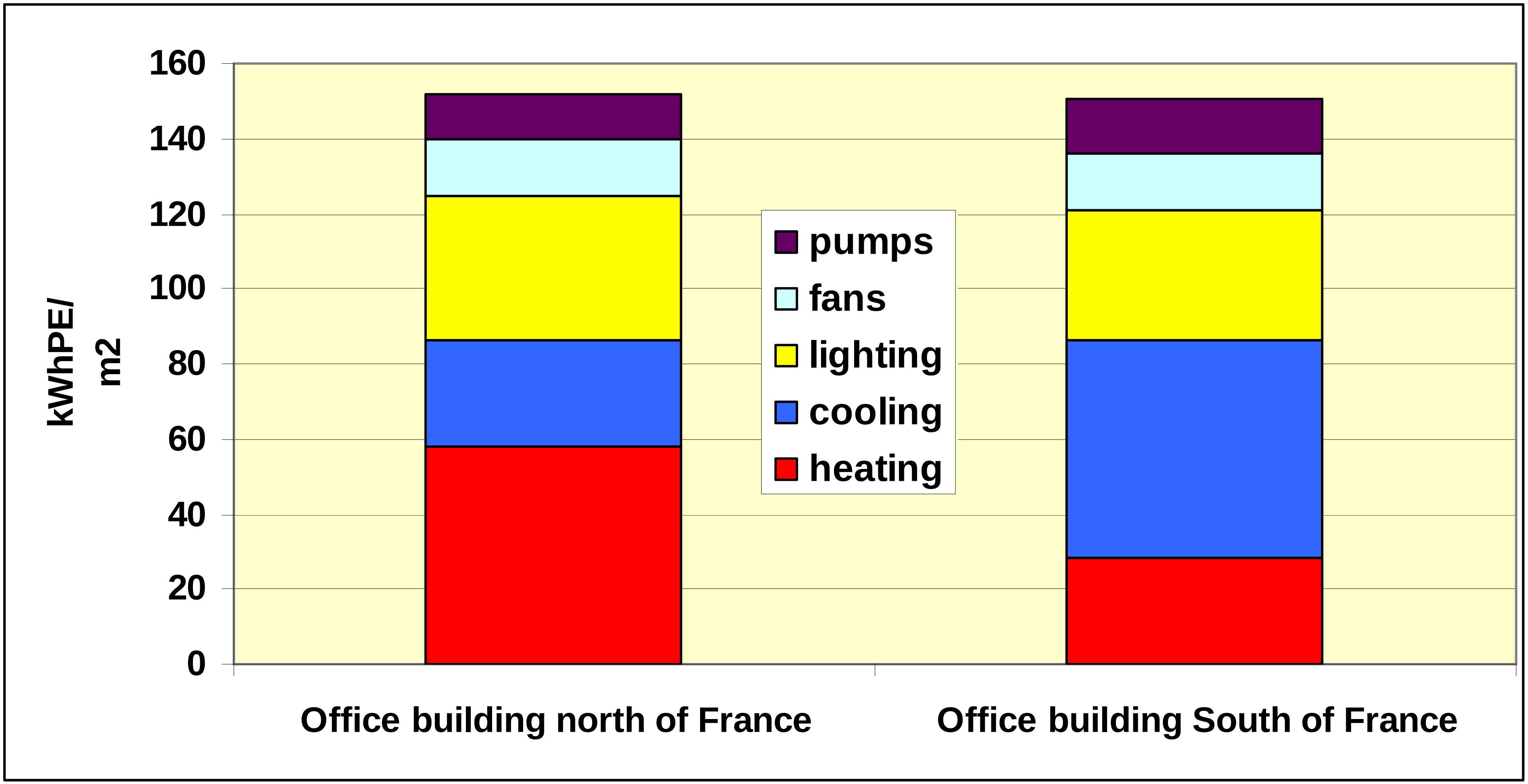
Current (and future) state in France

J.R. Millet CSTB

Summer comfort and cooling in the French regulation

- **Summer comfort is taken into account since 2000**
  - Indoor temperature is calculated for a reference warm period
  - Th-E method was improved for RT2005
- **Cooling has be introduced in 2005 (RT2005 regulation)**
  - Cooling is taken into account in the Primary energy coeff C (kWhPE/m2) including auxiliaries (Th-C method)
  - The C maximum values differs considering if the building can or not be comfortable without mechanical cooling
  - If it can be, the building energy for cooling must be balanced by gains on the other consumptions
- **Both are calculated with a dynamic hourly model according to CEN Standards**

Example of results for an air conditioned office building

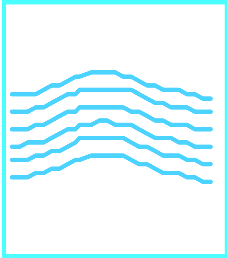


Summer comfort

- **The "TIC" result is the operative temperature for the warmest hour during occupancy**
- **Tic must be under <u>Ticref</u> which is calculated for the same building by applying :**
  - A reference inertia (medium)
  - Reference solar protection for windows and opaque component
- **Summer comfort criteria must be fulfilled if the building is considered as possibly comfortable in summer by passive means whether <u>it is or not air conditioned</u>**
  - Examples of exception : large stores, office building in noisy areas
- **Additional requirements has to be taken into account, as the area of openable windows**

The main parameters in Th-E method

- **Ventilation**



- **Thermal inertia**

- **Solar protection of windows and opaque components**

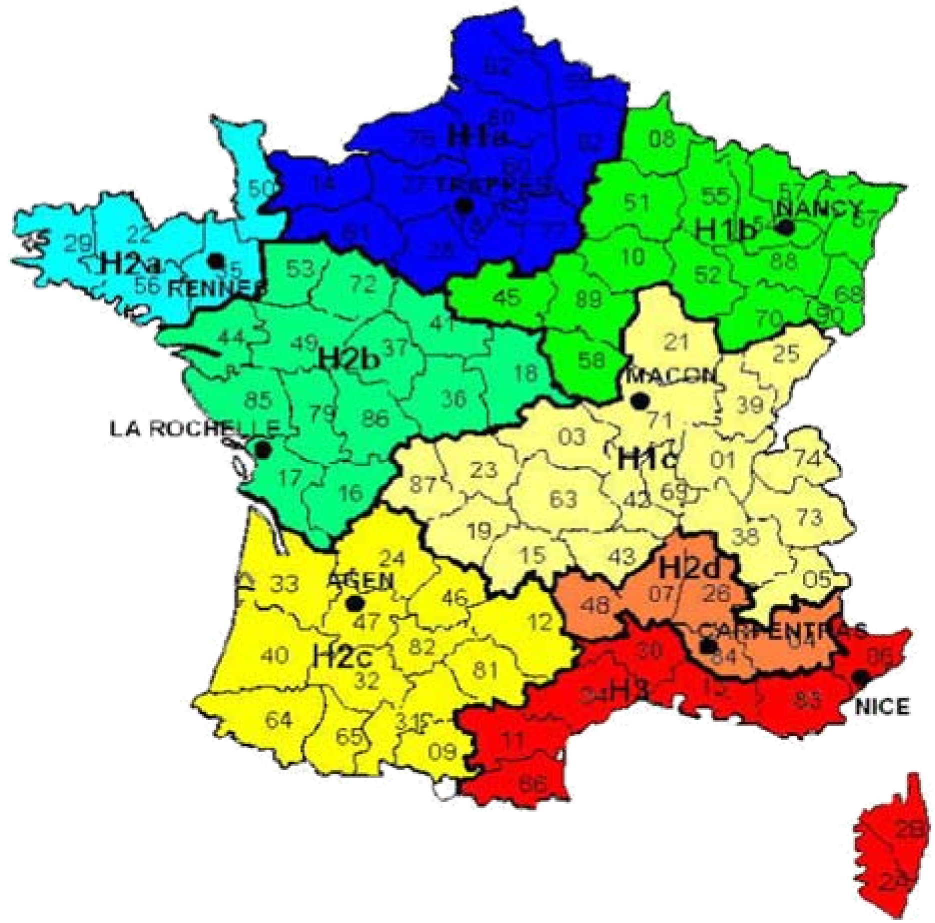
No surprise !

Climate zoning

- **8 zones**

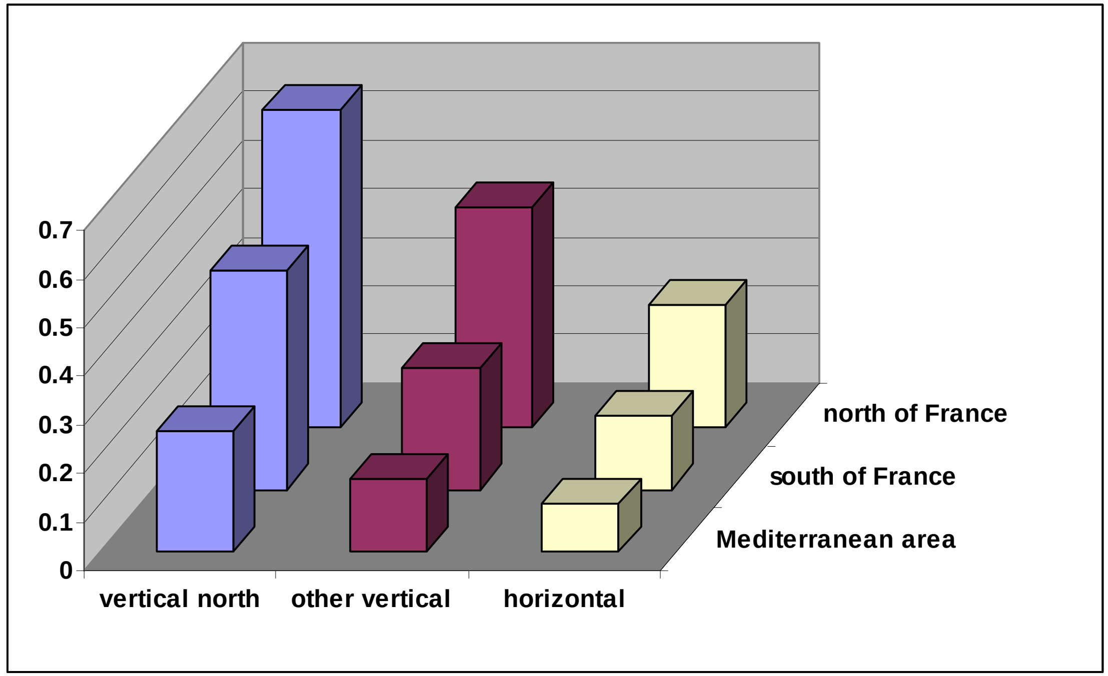
+ some corrections

- **Altitude**
- **Distance to the sea**



Reference solar protection

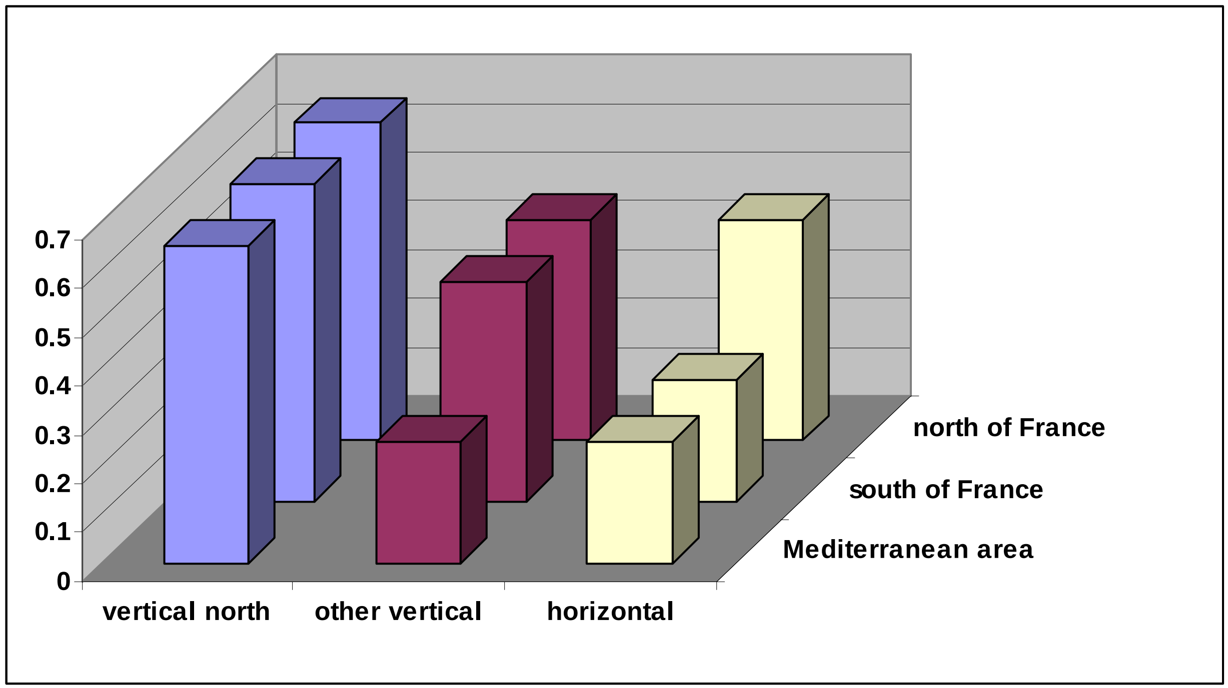
- **It depends on different parameters**
  - The climate, the orientation of the window, the room use and the noise exposure
- **Example of reference solar factor in calm area at sea level**



- **Reference solar factor is constant for opaque component = 0.02**

How to improve summer comfort through Th E

- **Improve thermal inertia**
  - As the reference Tic is calculated with medium inertia, it is difficult to fulfill the requirement with very low inertia
- **Example for high inertia :**
  equivalent solar factor



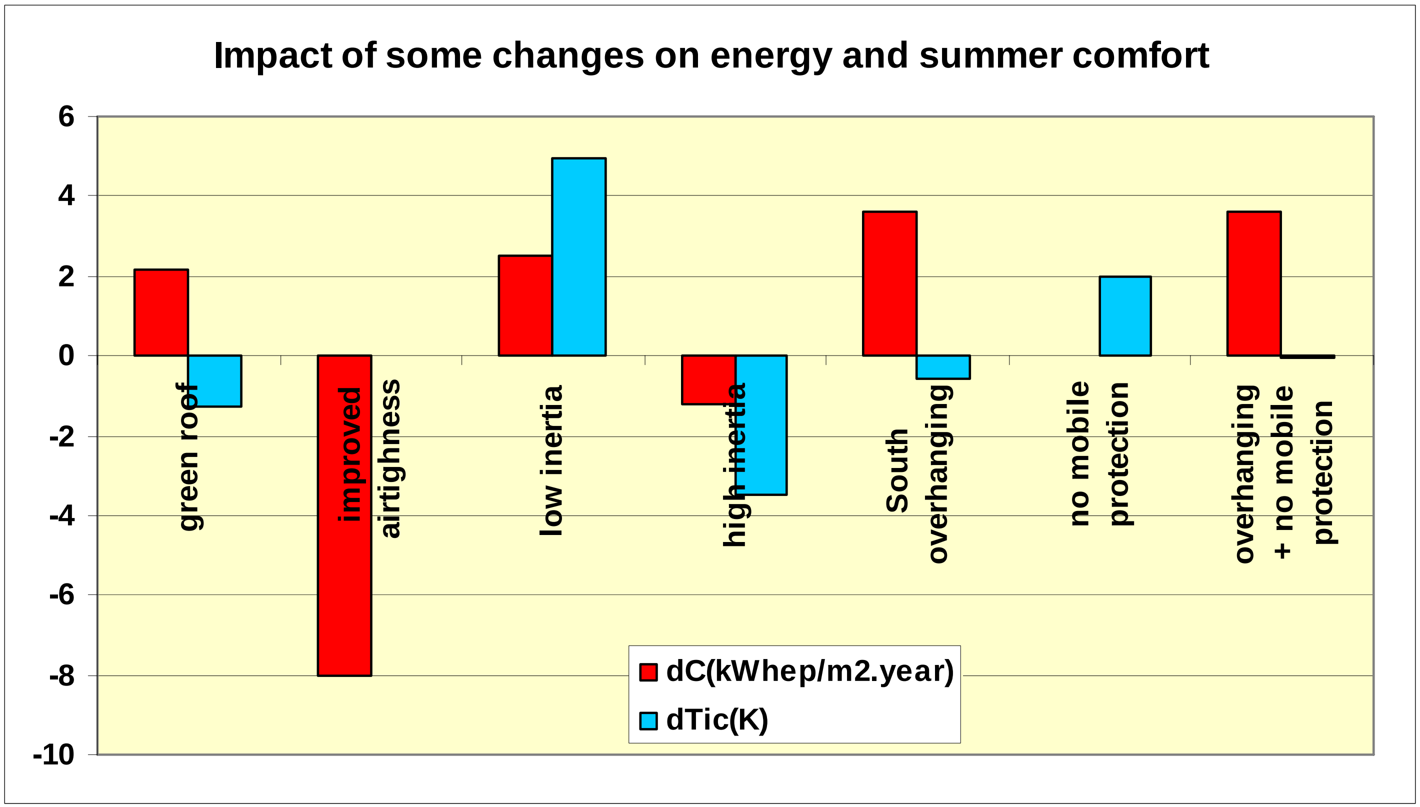
How to improve summer comfort through Th E

- **Improve solar protection**
  - Overhanging
  - Windows solar protection (outer mobile are the best)
  - Opaque components solar protection (color, insulation)
- **Improve ventilation**
  - Cross ventilation
  - Passive night ventilation
  - Mechanical night ventilation

example of sensitivity analysis

Detached house in Paris area

- C(kWhep/m2) = 110 Tic = 28,5 °C
- Medium inertia, mobile solar protection



CSTB
le futur en construction

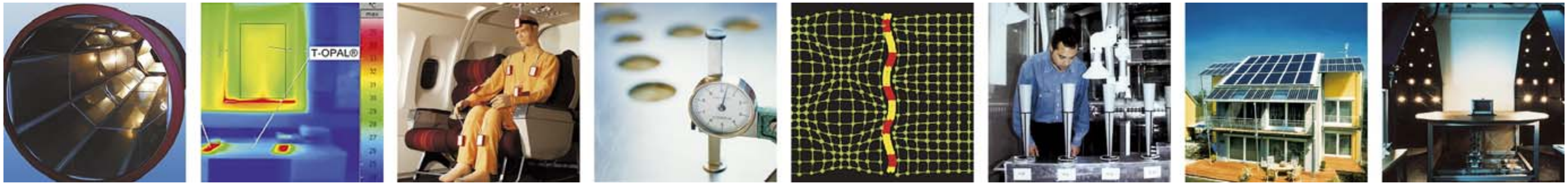
The future

New Regulation in preparation phase

- RT2012
  - First application on non residential buildings planned for beginning of 2011
- Basic objective : 50 kWhPE / m2
  - with correction factor for climate, building use, CO_2 impact ….

Major modifications

- No reference building
- 2 phases approach
  - Building check (envelope + inertia) : Bioclimatic needs > **new Bbio coefficient**
  - Energy consumption + Summer comfort check (as in 2005)
- Many improvements for the calculation method Th BCE
  - Systems efficiencies on hourly basis
  - Opening of windows for comfort in Th C



ASIEPI - Assessment and improvement of the EPBD Impact (for new buildings and building renovation)

Summer comfort and cooling – Current state in Germany

Hans Erhorn, Heike Erhorn-Kluttig
Fraunhofer Institute for Building Physics

ASIEPI
Intelligent Energy Europe

IBP
Fraunhofer Institut Bauphysik

Plan of the presentation

Status of German regulation related to summer comfort and cooling:

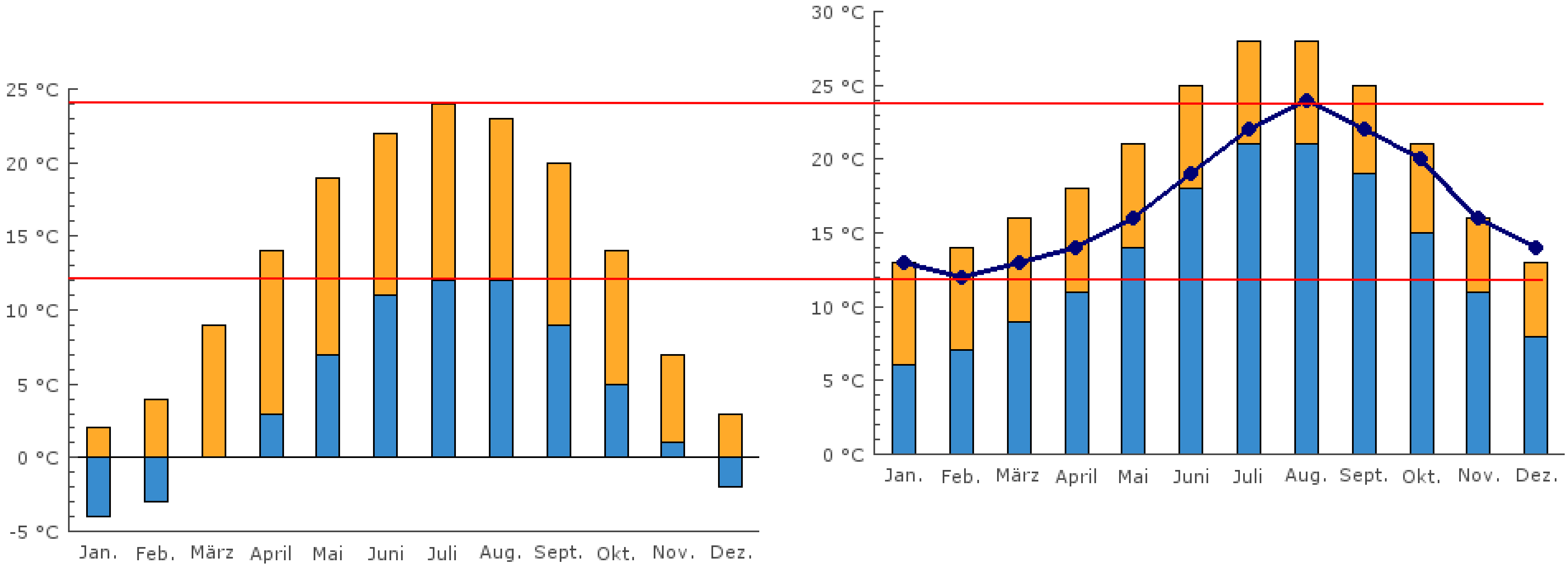
- good summer comfort
- building solar control
- improving energy efficiency during the summer period
- night time ventilation for passive cooling

Other points:

- framework for assessing innovative passive cooling and low energy cooling systems
- major trends in type of systems used

Climate in Germany

Würzburg **Barcelona**



Average monthly maximum temperature

Average monthly minimum temperature

Source: holidaycheck.de

ASIEPI Intelligent Energy Europe

Fraunhofer Institut Bauphysik IBP

Climate in Germany

-> cooling is only necessary in Germany ...

... in dwellings:

- if the house is not „correctly" designed or extraordinary heat sources are included
- if the tolerance of the building user towards warm temperatures is very low

... in non-residential buildings:

- with high ratio of glazed facades
- with high internal gains

Legal context

German energy decree

EnEV 2007-> DIN 4108-2

General requirement: Limitation of solar gains

(for buildings with and without cooling)

Residential buildings

How to assess buildings with cooling systems

-> Limitation of primary energy incl. cooling system

-> cooling as supplement to the standard primary energy demand

German energy decree

EnEV 2007

Non-residential buildings

How to assess buildings with cooling systems

-> Limitation of primary energy incl. cooling system

-> Cooling also added to the reference technologies of the reference building

German energy decree

EnEV 2007 -> DIN V 18599

General requirement: Limitation of solar gains DIN 4108-2

Background:

- Limit of the indoor temperature for 3 different climatic zones:
  - region A: summer cool (max. of monthly average outdoor temperature ≤ 16,5 °C): 25 °C
  - region B: moderate (16,5 °C < Θ < 18 °C): 26 °C
  - region C: summer hot (≥ 18 °C): 27 °C
- Temperatures mustn‘t be exceeded for more than 10 % of the occupation time (dwellings: 24 h/d, offices 10 h/d)

Simplified calculation method which has to be applied for critical rooms

Not to be used for buildings with:

- winter gardens
- glazed double skin facades
- transparent insulation

-> more detailed calculation with simulation tools (same boundary conditions)

General requirement: Limitation of solar gains

Solar gain factor:

$$S \leq S_{max}$$

$$\frac{\Sigma(A_{window} * g * F_C)}{A_{net\ floor}} \leq \Sigma\ S_X$$

With F_C: Reduction factor for shading devices

Influence Factors S_X:

- climate region (A-C)
- inertia
- use of night ventilation
- solar protection glazing
- inclination of window(s)
- orientation of window(s)

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How to assess dwellings with cooling systems EnEV 2007

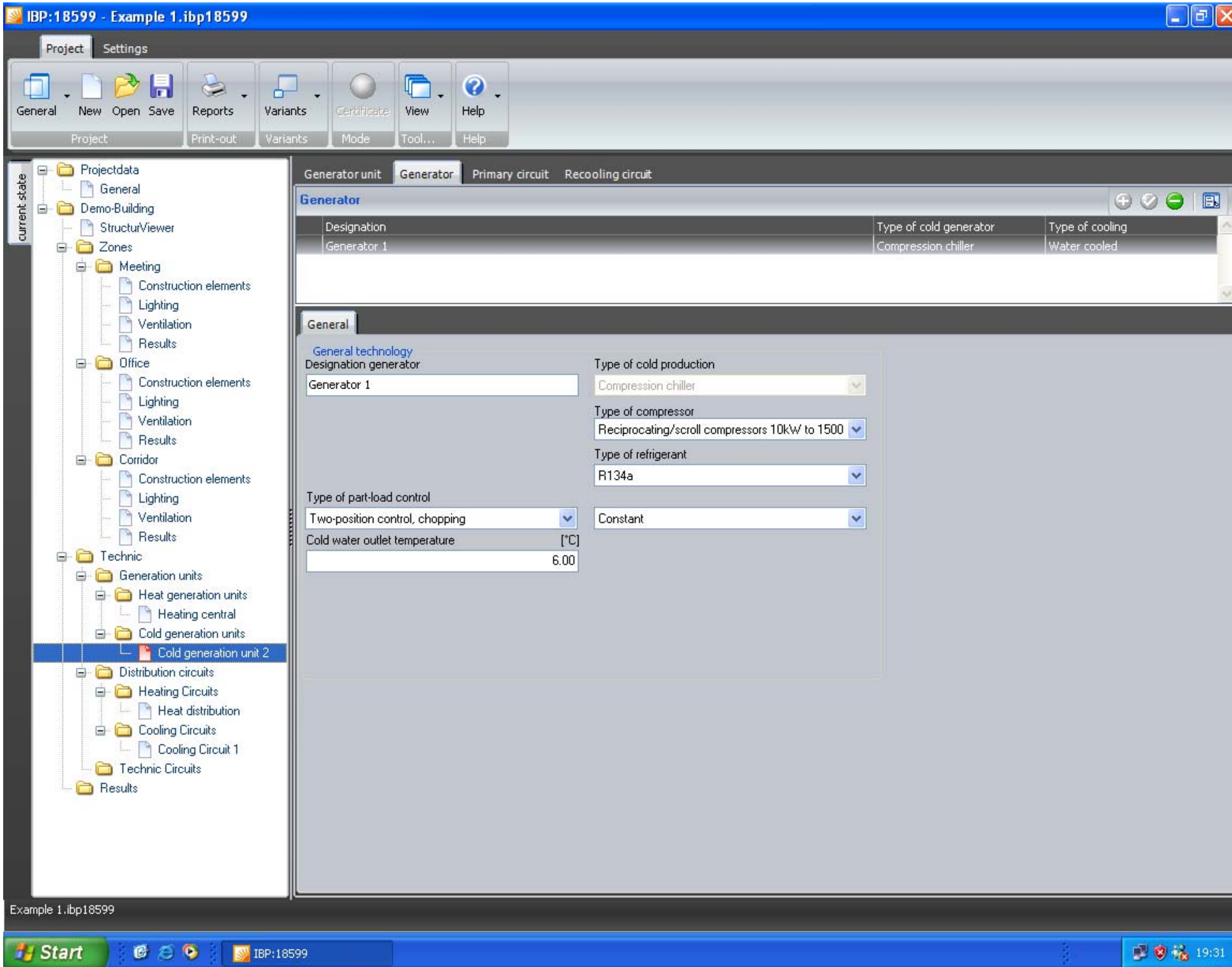
- Maximum allowed primary energy demand dependent on the building geometry and type of DHW generation (with or without electrical DHW generation)
- Supplement for cooling to the maximum allowed primary energy demand for heating, DHW and ventilation: 16,2 kWh/m²a * cooled floor area/total floor area
- Supplement per cooled area to the calculated primary energy demand for heating, DHW and ventilation of the real building depending on the used system:
  - Split, multi-split, compact units with energy efficiency class A-C and cooling with reversible heat pumps in residential ventilation systems: 16,2 kWh/m²a
  - Cooling surfaces in connection with electrical cooling generation: 10,8 kWh/m²a
  - Cooling based on renewable heat sinks (earth pipes, earth collectors, cisterns): 2,7 kWh/m²a
  - all other types: 18,9 kWh/m²a

How to assess non-residential buildings with cooling systems DIN V 18599

- Calculation of primary energy demand based on usage zones
- Maximum allowed primary energy demand based on reference building with reference technologies
- If a building contains cooling systems, the reference building mostly contains a cooling system as well (not for zones: offices, schools, patient rooms, traffic areas and storage areas, sportshalls and parking garages)
- The reference technology for cooling is: room: cold water fan coil (14/18 °C)

  generator: piston or scroll compressor (air-cooled)

How to assess non-residential buildings with cooling systems DIN V 18599



How to assess non-residential buildings with cooling systems DIN V 18599

Assessable cooling systems:

- Emission:
  - room conditioning: chilled water, fan coils, induction, cooled ceiling, thermo-active components, direct expansion
  - air-conditioning: variable air volume system, constant air volume system
- Distribution:
  - thermal losses due to temperature spread: 6/12, 14/18, 18/20
  - auxiliary energy depending on pressure loss of different components: plate evaporator, tube evaporator, condenser, cooling tower (closed or open circuit), heat exchanger water/water, hydraulic transfer, etc.
- Generation:
  - Compressor type refrigeration units:
    - water-cooled chillers, direct-evaporation units
    - air-cooled chillers, room air-conditioners
    - absorption chillers

Outlook (1)

Autumn 2009:

- Reduction of maximum primary energy demand by about 30 % (both dwellings and non-residentials
- Dwellings can be calculated with DIN V 18599
  - Maximum primary energy demand is then also defined by a reference building with reference technologies
  - No cooling in the reference building
- Non-residentials:
  - usage zones offices, schools, patient rooms, traffic areas and storage areas, sportshalls and parking garages:

    - so far without cooling reference technologies

    - now same reference technology as other zones, but only 50 % of the primary energy for cooling is added

Outlook (2)

In preparation:

- Assessment of solar cooling, passive systems, adiabate cooling, earth coupled cooling, renewable energies for cooling
- District cooling

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How to assess innovative systems

Innovative technology/ system	
	1. Generally known technology, but better efficiency than default value in the standard
	2. Technology/system that can‘t be calculated with the available standards for EP calculation

1. → Tested by certified institutions + certified by central German institution (DIBT)

2. → Other sources of proof to be accepted by the authorities

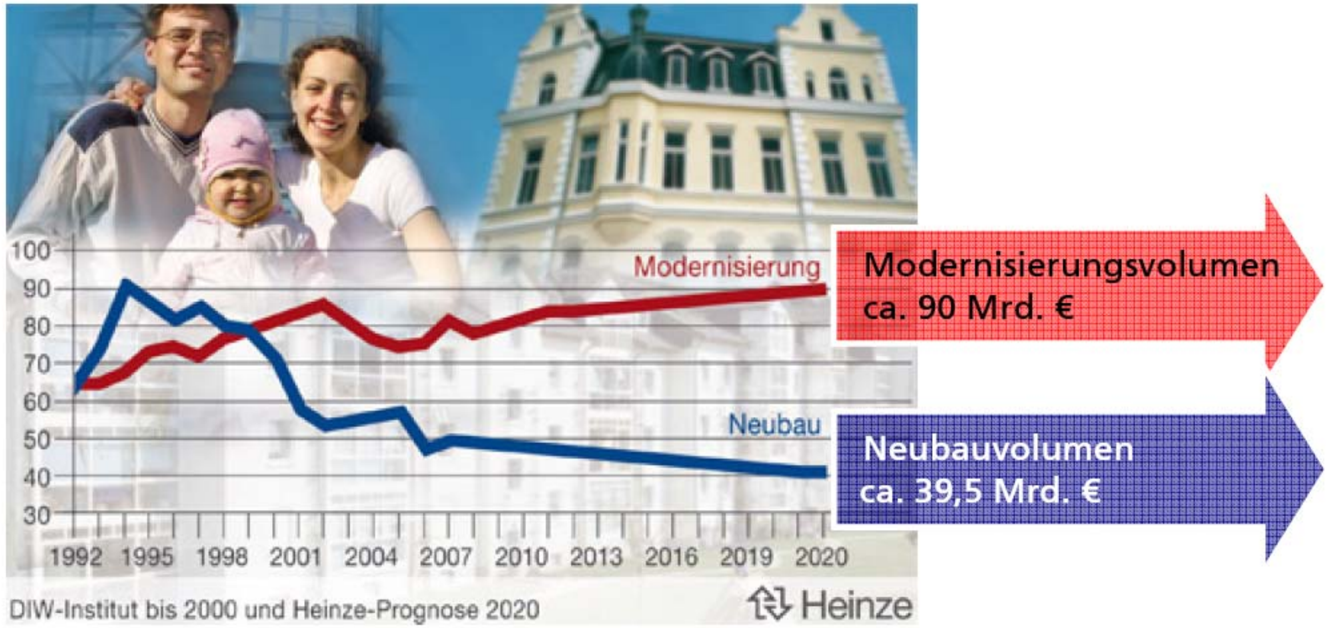
-> simulation tools

Trends

Current residential market:

Ca. 200.000 new dwellings per year; herein:

- ca. 7.000 passive houses (with HP mech. ventilation)
- ca. 20.000 HP low energy houses (with exhaust ventilation)



Tendency at the existing building stock:

Political goal: 3% renovation rate per year (ca. 1,2 Mio dwellings per year)

- currently below 2%
- very few realized mechanical ventilation systems (mostly exhaust ventilation)
- split units bought by residents

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Trends

Non-residential market:

ca. 50.000 central air handling units per year (+ 20% p.a.)

approx. 1 billion US$ per year contract volume (but mostly cooling equipment)

trend is going towards decentralized solutions

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Specific study in relat
Requirements in the E
summer comfort and
cooling (EPBD Article

Supported by:
EPBD Building Platform represented by

Executed by:
Fraunhofer-Institut für Bauphysik, Stutt
Hans Erhorn
Heike Erhorn-Kluttig

In cooperation with:
Instituto Nacional de Engenharia, Tecn
Hélder Gonçalves
Susana Camelo

Stuttgart, 15. August 2008

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[Minimum Energy Performance Requirements]

EPBD BUILDINGS PLATFORM

P135

10-12-2008

Requirements in EU Member States related to Summer Comfort and Energy Consumption for Cooling

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Instituto Nacional de Engenharia, Tecnologia e Inovação, I.P. - INETI
Portugal

www.buildingsplatform.eu

The EPBD Buildings Platform has initiated an investigation on the status of setting requirements regarding summer comfort and energy consumption for cooling in the EU Member States, as well as their plans for the future. This paper gives an overview of the content and the results of the study.

1 > Related EPBD articles

The Directive on the Energy Performance of Buildings (Directive 2002/91/EC) [1] decrees in Article 4 that the Member States are responsible for setting minimum energy performance requirements and defines the energy performance of buildings in Article 2 as follows:

> ***Article 4 - Setting of energy performance requirements***
>
> *Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings are set, based on the methodology referred to in Article 3. When setting requirements, Member States may differentiate between new and existing buildings and different categories of buildings. These requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and the age of the building. [...]*
>
> ***Article 2 - Definitions***
>
> *Energy Performance of a building: the amount of energy actually consumed or estimated to meet the different needs associated with the standardised use of the building, which may include, inter alia, heating, hot water heating, cooling, ventilation and lighting.*

2 > The questionnaire on which the study was based

A questionnaire was distributed to representatives of the 27 Member States of the European Community, as well as Croatia and Norway, in spring 2008. Of these, 22 answers were returned from: Austria, Belgium (Flanders), Bulgaria, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Sweden and the United Kingdom (England & Wales). The questionnaire was structured into the following main headers:

EUROPEAN COMMISSION
Directorate-General for Energy and Transport

Fraunhofer Institut Bauphysik
IBP

Table 1: Answers to questions concerning the type of present summer comfort and cooling energy requirements in the national building regulations.

Building types	1 Austria	2 Belgium-Flanders	3 Bulgaria	4 Cyprus	5 Czech Republic	6 Denmark	7 Finland	8 France	9 Germany	10 Hungary	11 Ireland	12 Italy	13 Latvia	14 Lithuania	15 Luxembourg	16 Norway	17 Poland	18 Portugal	19 Slovak Republic	20 Slovenia	21 Sweden	22 UK: England and Wales	Total
2.1 Limitation of glazed areas or window openings																							
New Res.													No summer requirements				No summer requirements						3
Non-res.																							4
Exist. Res.																							1
Non-res.																							1
Spec. buildings																							-
2.2 Shading requirements																							
New Res.													No summer requirements				No summer requirements						5
Non-res.																							4
Exist. Res.																							2
Non-res.																							-
Spec. buildings																							-
2.3 Maximum U-value requirements (not only for winter)																							
New Res.													No summer requirements				No summer requirements						7
Non-res.																							5
Exist. Res.																							4
Non-res.																							3
Spec. buildings																							-
2.4 Minimum building mass requirements (inertia)																							
New Res.													No summer requirements				No summer requirements						4
Non-res.																							4
Exist. Res.																							2
Non-res.																							1
Spec. buildings																							1
2.5 Minimum summer ventilation rate. If night ventilation is required please state under comments.																							
New Res.													No summer requirements				No summer requirements						2
Non-res.																							2
Exist. Res.																							1
Non-res.																							1
Spec. buildings																							-
2.6 Limitation of solar gains																							
New Res.													No summer requirements				No summer requirements						4
Non-res.																							5
Exist. Res.																							1
Non-res.																							1
Spec. buildings																							-
2.7 Limitation of overheating time. In case of no air-conditioning or in case of defect air-conditioning (worst case scenario).																							
New Res.													No summer requirements				No summer requirements						5
Non-res.																							5
Exist. Res.																							3
Non-res.																							3
Spec. buildings																							-
2.8 Limitation of cooling energy needs. In case of air-conditioning or in case of no air-conditioning (theoretical cooling needs).																							
New Res.													No summer requirements				No summer requirements						4
Non-res.																							5
Exist. Res.																							2
Non-res.																							3
Spec. buildings																							1
2.9 Overall requirement. CO_2-emission or primary energy incl. cooling energy.																							
New Res.													No summer requirements				No summer requirements						8
Non-res.																							8
Exist. Res.																							3
Non-res.																							2
Spec. buildings																							-

Res.: residential buildings Non-res.: non-residential buildings Spec. buildings: specific buildings

Based on a questionnaire answered by experts from 22 EU Member States.

Questions:

1. General information regarding present summer comfort and cooling energy requirements in the national building regulations

2. Type of present summer comfort and cooling requirements

3. Details on calculation procedures

4. Planned requirements

5. Advantages and drawback of summer requirements

6. Impacts of the summer requirements

Fraunhofer Institut Bauphysik

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Summer Comfort and Cooling

Introduction

- Buildings use 40% of primary energy and 50% of CO_2
- Rapid growth in cooling demand
- Rapid growth in air conditioning
- Buildings not adapted to local climate

Consequences:

- Increase CO_2 emission and energy demand
- Pressure on peak energy load
- Power cuts
-IAQ and comfort problems
- Cost

Summer Comfort and Cooling

Country Contributions

Portugal

-First EU country to address cooling in Regulations
- Started with outdoor shading, high mass construction, night cooling
- Dropped reference building approach for CO_2 targets
- Regulations et a limit irrespective of natural or mechanical approach

Design and implementation:

Simulation → 3 year monitoring → Correct

Summer Comfort and Cooling

Country Contributions

Finland

-Strong relationship between indoor climate and productivity
- For small cost large improvements can be achieved
- Comfort cooling used to ensure good indoor climate
- All new buildings must have heat recovery

Summer Comfort and Cooling

Country Contributions

Czech Republic

- 26 – 28C for A/C spaces
- Maximum of 31.5C for non AC buildings

Problems:

- Modern ‘low energy’ buildings suffer from summer overheating
- Night passive cooling difficult to implement due to security issues

Summer Comfort and Cooling

Country Contributions

Israel

- Small country but many climatic zones
- Almost all energy imported
- Philosophy pre 1990 was p[assive cooling but now …
- 60 - 70 % of households have air conditioning – an explosion
- Shopping malls have added to demand
- Huge rise in electricity demand and carbon emission
- Steps to reduce CO_2 are needed

Initiatives:

- Green Building Standard has developed to encourage energy and environmental performance.
- Energy Efficiency Labelling
- Case Studies
- Ice Storage to reduce peak load

Summer Comfort and Cooling

Country Contributions

Netherlands

Early Buildings:
-Overheating due to large areas of glazing
- High heat loss due to poor ventilation

Now:
- High Insulation:
- Mechanical Extract with Natural Inlets or Heat Recovery.
-Try to improve energy performance each year once it becomes affordable and achievable
- Minimum requirements are the same for cooled or non-cooled buildings.
- Mechanical cooling discouraged
- No thermal comfort requirements - overheating can still occur. (This is now being addressed)
- There is more focus on mechanical systems although passive cooling solutions are now being considered.

Summer Comfort and Cooling

UK

-Reference building concept. Must achieve savings over previous Regulations
- Limitations on occupied hours over 28C
- Most EU countries in growth state fo A/C
- Could building design reduce saturation level?
- UK has good climate for passive cooling.
- Monitoring shows that passive measures generally work

Problems:

- Top floor overheating
- Night cooling conflict with 24 hour occupation

Summer Comfort and Cooling

Country Contributions

Belgium

- Initially energy efficiency installation was poor
- Now good control of installation is required - EPB Declaration
- Automatic fines and penalties imposed for failure
- Night cooling security measures important
- Controls for variability in night cooling rates needed
- If non A/C buildings overheat then A/C will be installed – assess probability

Summer Comfort and Cooling

Daikin

Pragmatic Solutions:

- Design for cooling from the start otherwise inefficient systems might be installed later
- Need to solve problems with energy efficient practical solutions
- Holistic problem solving

Summer Comfort and Cooling

Country Contributions

Greece

- Statistical increase in temperature over last 30 years
- Increase in hot spells
- impact of heat islands
- Therefore increase in demand for cooling and peak electricity demand
- Low income houses are poorly insulated – high cost for cooling
- Additional power plants needed for peak demand

Actions:

- U value requirements and maximum annual energy consumption
- Existing buildings public buildings: A/C random inspections, cool coatings mandetory, fans, shading of a/c free cooling, condenser and exhaust air heat recovery, controls.
- Assistance for low income buildings
- Design buildings for cooling

Summer Comfort and Cooling

Country Contributions

Spain

-Massive penetration of air conditioning units
- Increasing interest in low energy solutions

Solutions:

-Natural ventilation with solar chimneys
- Thermal inertia with night ventilation
-Night radiative cooling
-Buried pipes
-Evaporative cooling
- PV ventilation
- Phase change materials
- Improved Building Codes

Summer Comfort and Cooling

Country Contributions

Italy

-Problems with urban heat islands and temperature increase
- Electricity peak in summer (as for other hot countries
- Growth in A/C units
- Continued growth in peak demand predicted
- Problems with installed capacity

Solutions

- Past emphasise has been on heating season
- 2009 -Efficiency and building performance regulations for cooling
- Maximum energy for cooling
- Calculation procedure for cooling
- Glazing system requirements
- Thermal mass and thermal transmittance requirements
- Vegetation considerations
- Cool paints
- Natural ventilation preferred
- Solar shading compulsory
- Restrictions on total primary energy for cooling
-Informal dress code

Summer Comfort and Cooling

Country Contributions

France

- Cooling introduced in 2005 Regulations
- Cooling energy must be compensated elsewhere – cannot use more energy
- Heating and cooling accounts for 50% of energy (north and south of France)
- Must provide a building to be comfortable in passive mode even if A/C is installed
- Noise issues with open windows
- Low inertia buildings not possible for summer comfort
- Solar protection
-Green roofs
-Ventilation for cooling
-Winter/Summer energy balances

Future – New Regulations
-No Reference building
-50 kWh primary energy/m2

Summer Comfort and Cooling

Country Contributions

Germany

Regulations for:
-Good summer comfort
- Solar control
-Improved energy efficiency
- Passive cooling and night ventilation

A/C necessary when:
-Building design is poor
- Occupants are intolerant to high temperature
- Too much glazing
- High internal heat gains

Summer Comfort and Cooling

Projects and Institutions

Aimed at promoting sustainability in buildings

ASEIPI - Assessment of EPBD
ADVENT - Advanced Ventilation Technologies
EURIMA - Insulation
EUROACE - Association of Manufacturers of Sustainable Building Components
IEE Cool Roofs - Roof Design, Reflective Materials
HARMONAC - Field analysis
IBPSA - Simulation (sceptical about modelling within EPBD)
ES-SO - Solar Shading
THERMCO - Thermal Comfort and Cooling

Summer Comfort and Cooling

Conclusions

- Large growth in EU air conditioning – market is nowhere near saturation
- Huge demand for peak energy load – not possible to satisfy
- Many similarities between countries but …

Summer Comfort and Cooling

Conclusions

Strong climate differences cold – mild – hot:

- Cold climate – comfort cooling by AC is a small load that improves indoor climate
- Mild climate – passive cooling more feasible
- Hot climate – many solutions needed to limit high A/C load
- Cannot always transplant a technology from one climate to another
- Design buildings for climate

Summer Comfort and Cooling

Conclusions

Many Similarities:
- Issues about internal heat gains
- Dealing with solar gains - shading is critical
-Thermal mass
- Innovative/ role of insulation
- Identifying and planning for actual cooling load at the design stage

Summer Comfort and Cooling

Conclusions

Potential Differences:

- Definitions of overheating – fixed vs adaptive
- Role of passive cooling vs air conditioning
- Mechanical vs natural ventilation
- Innovative/ role of insulation
- Identifying and planning for actual cooling load at the design stage
- Role of heat recovery – mandatory in some countries
- Occupant behaviour

Summer Comfort and Cooling

Conclusions

And Finally ...

- Many different ideas discussed that are applicable to all countries
- This workshop has provided a useful opportunity to share and adapt ideas
- All country contributions will be published as AIVC Information Papers
- We have the knowledge here that the politicians and policy makers need