Energy Efficient and Good Indoor Climate in Buildings

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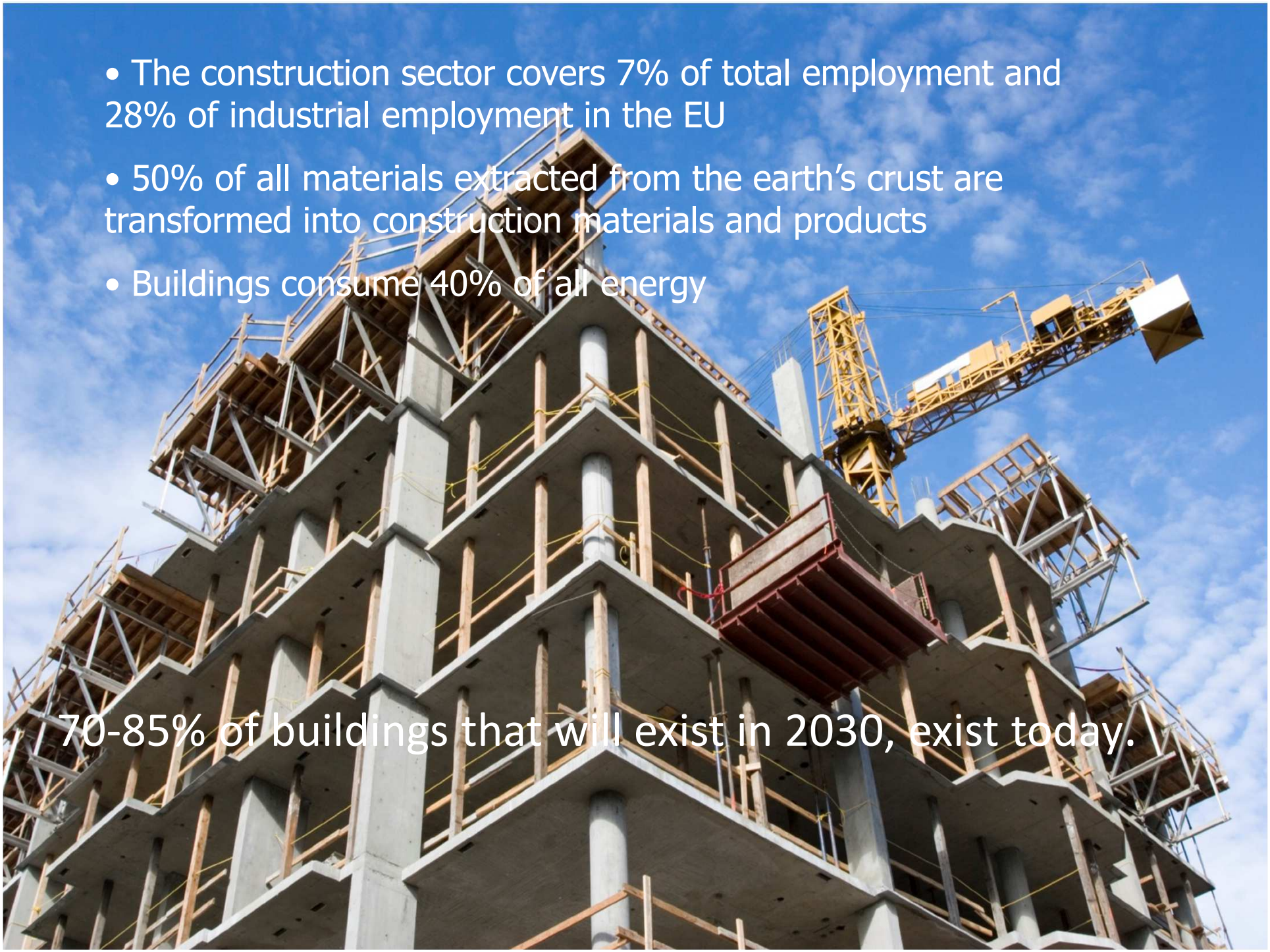
• The construction sector covers 7% of total employment and 28% of industrial employment in the EU
• 50% of all materials extracted from the earth's crust are transformed into construction materials and products
• Buildings consume 40% of all energy
70-85% of buildings that will exist in 2030, exist today.

Requirements towards more energy efficient buildings

EBPD demands Member States to fix and implement:

- **A methodology to calculate and rate the energy performance**
- **Minimum energy performance requirements (nZEB) for new and for major renovation**
- **Energy performance certificates**
- **Regular inspections of heating and air-conditioning systems**

Ecodesign Directive main legal instrument to improve the environmental performance of **energy-related products**


Wellbeing and health of people
Environment friendly
Life time cost effective
Sustainable Indoor Environment

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Healthy and Satisfied Persons

- Clean air to breath.
- Thermal balance is a result of a various environmental conditions.
- Comfort sensation depends on the individual: the metabolism, the activity level of body and the clothing resistance.
- Light is the most important factor influencing our daily rhythm.
- Disturbing sound environments cause irritation
- Discomfort increases stress hormone level, breaks and sick leaves and reducing productivity.

In comfortable environment human brains work more effectively.

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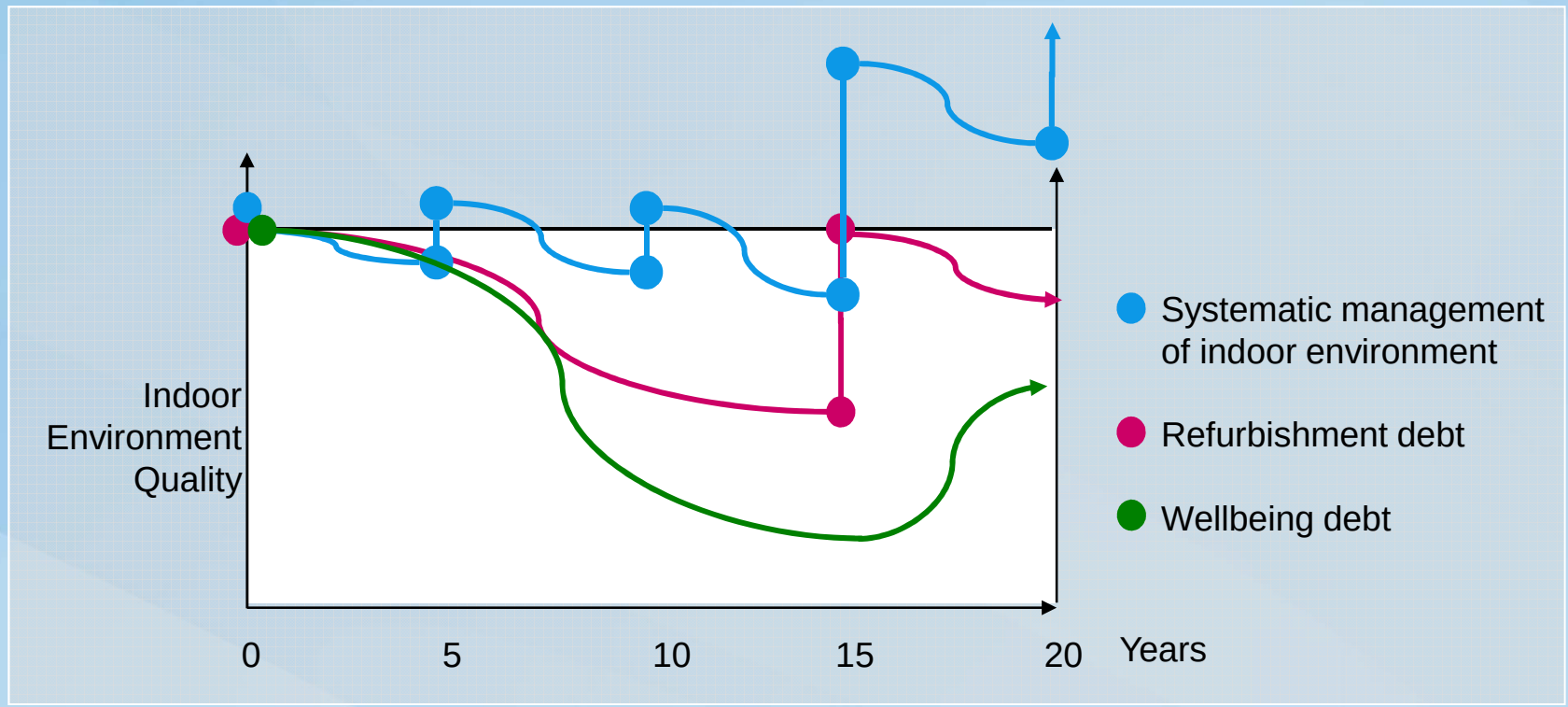
Indoor Environment and Wellbeing Debt



- Wellbeing debt grows slowly
- After refurbishment it disappears slowly

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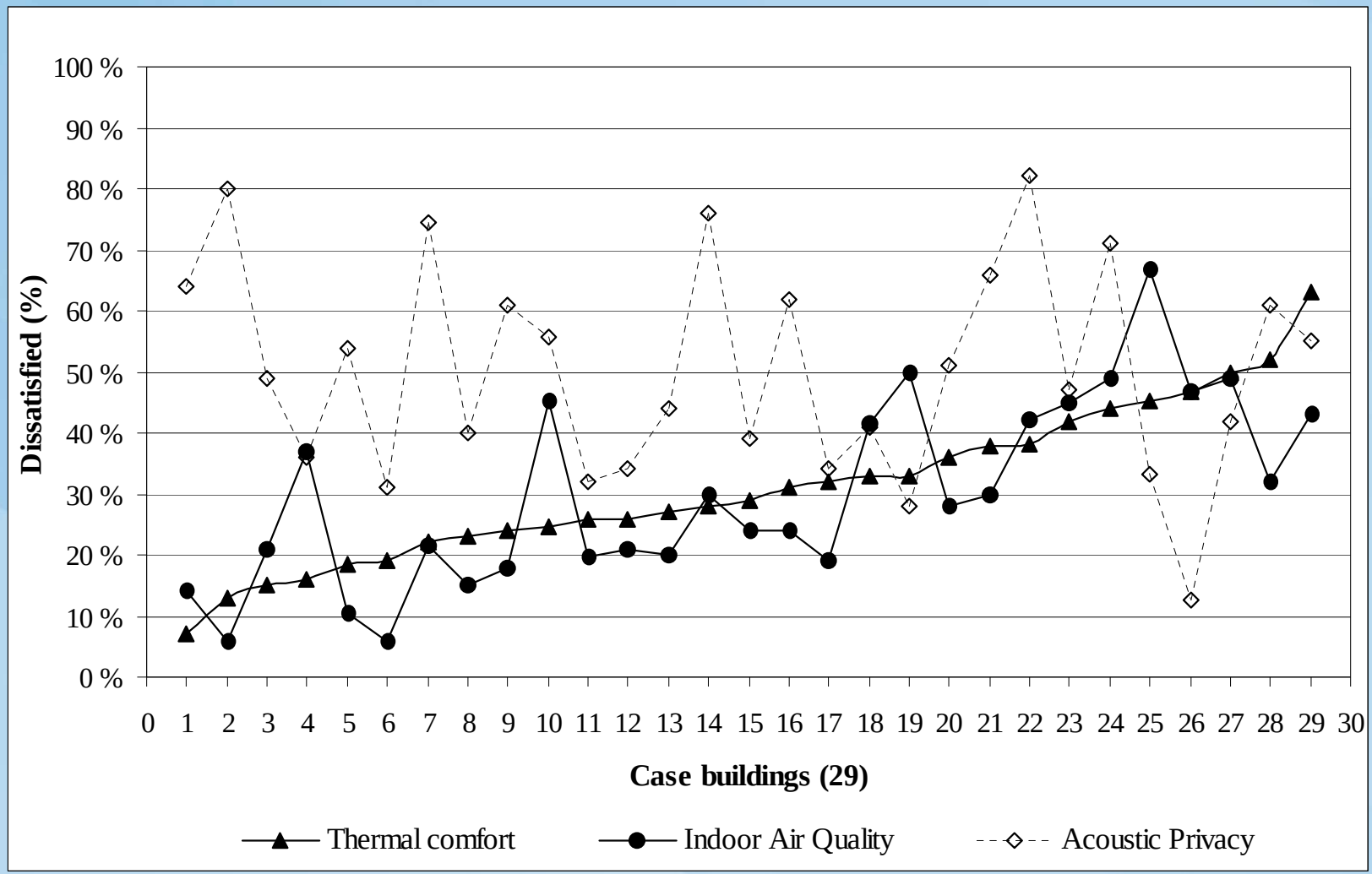
The percentage of the dissatisfied on thermal comfort, air quality and acoustic privacy



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Dissatisfaction in Office Environment

(thermal comfort of the whole body)

< 6% (A-class, pr EN15251)

> 30 % (real projects)

Is project designed poorly ?

Is building built wrongly ?

Is maintenance poor ?

Are spaces used wrongly ?

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Comprehensive Indoor Environment Management

- **UNDERSTAND PROBLEM**
- **PROVIDE SOLUTION**
- **SECURE OPERATION**

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Diagnose findings

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Chamber pressure out of the operation range

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Natural convections

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Indoor conditions should be adjusted

What should we do as an industry?

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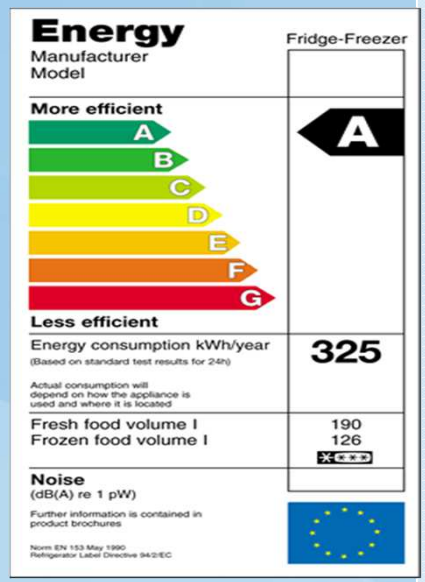
Sustainable Living Environment



ENVIRONMENT

Use of energy and other resources

VS

WELLBEING:

Healthy, productive, comfortable indoor environment

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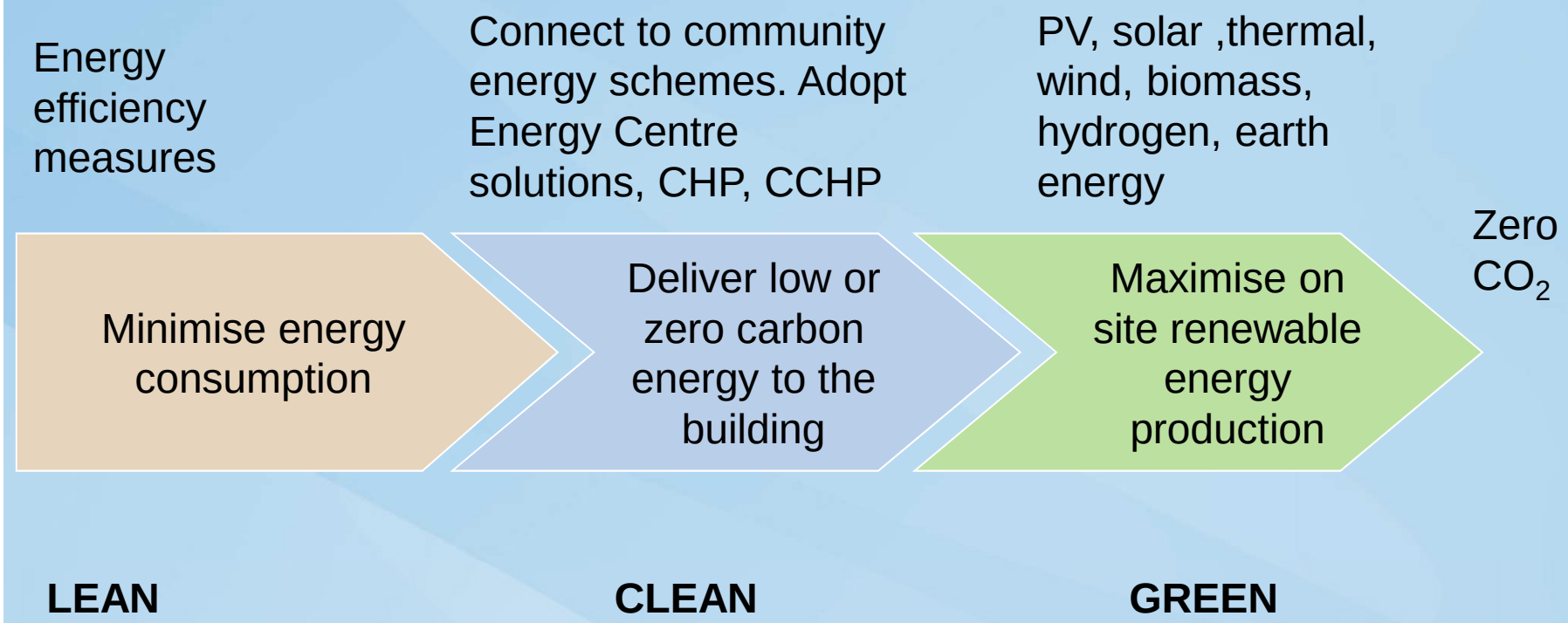
A roadmap to zero carbon buildings



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Minimising energy consumption in HVAC systems

- Increased reliance on passive measures – thermal mass, high performance envelope
- Mixed mode operation using hybrid systems
- Free cooling
- Demand based ventilation
  - Areas to be shut off when not in use
  - Air quality monitoring with automatic system response
- Increased individual user comfort control
- More intelligent building control
- Utilization of renewable energy sources

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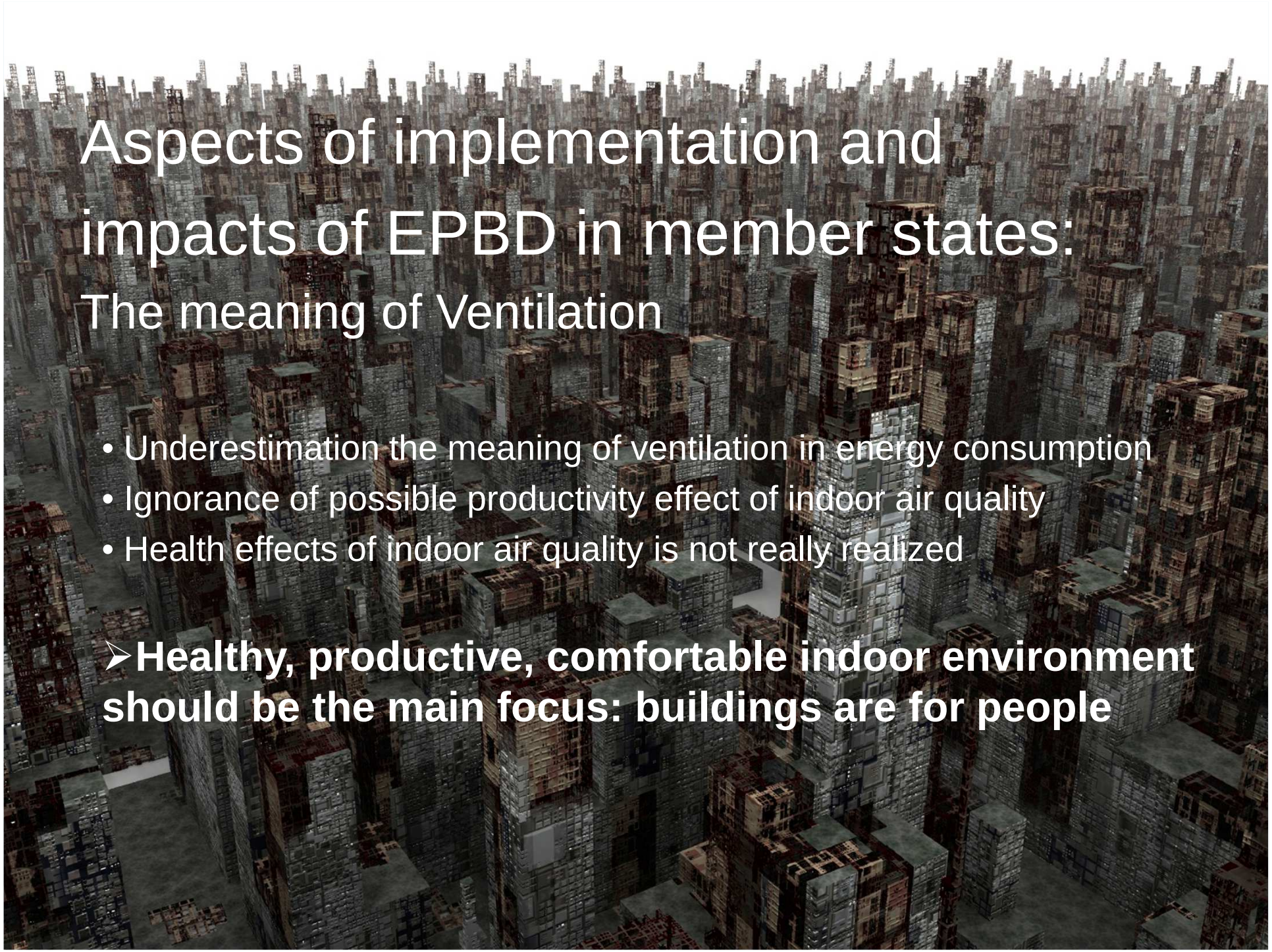


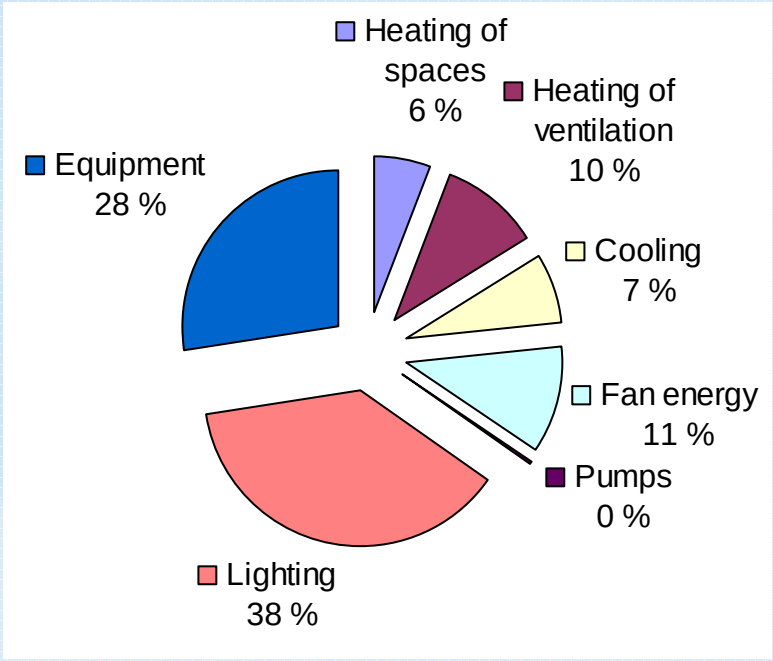
Aspects of implementation and impacts of EPBD in member states:

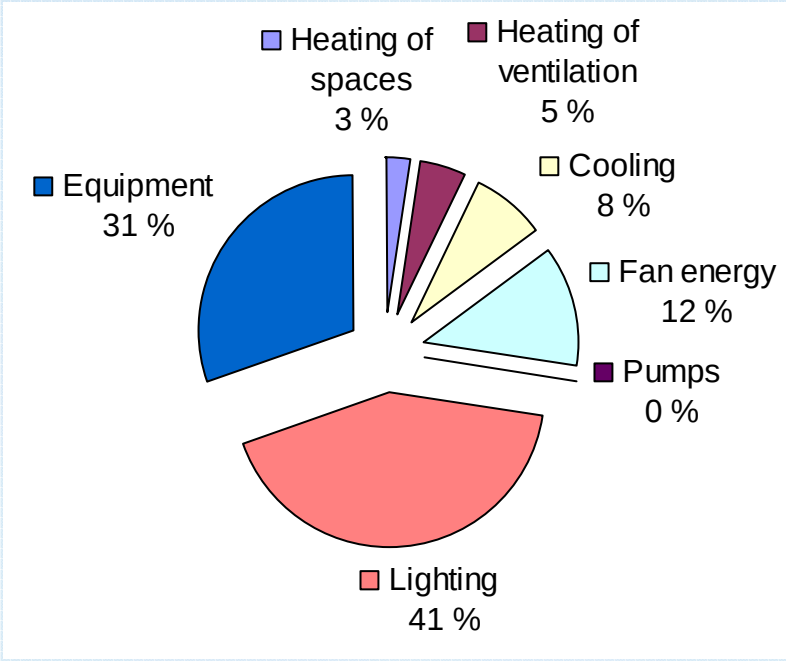
The meaning of Ventilation

- Underestimation the meaning of ventilation in energy consumption
- Ignorance of possible productivity effect of indoor air quality
- Health effects of indoor air quality is not really realized

➢ **Healthy, productive, comfortable indoor environment should be the main focus: buildings are for people**

Delivered and Primary Energy Consumption





Delivered energy 77.7 kWh/m^2,a

HVAC + lights: 48.9 kWh/m^2,a

Primary energy 175.4 kWh/m^2,a
(Primary energy factors: Gas 1 , Electricity 2.5)

HVAC + lights: 125.9 kWh/m^2,a

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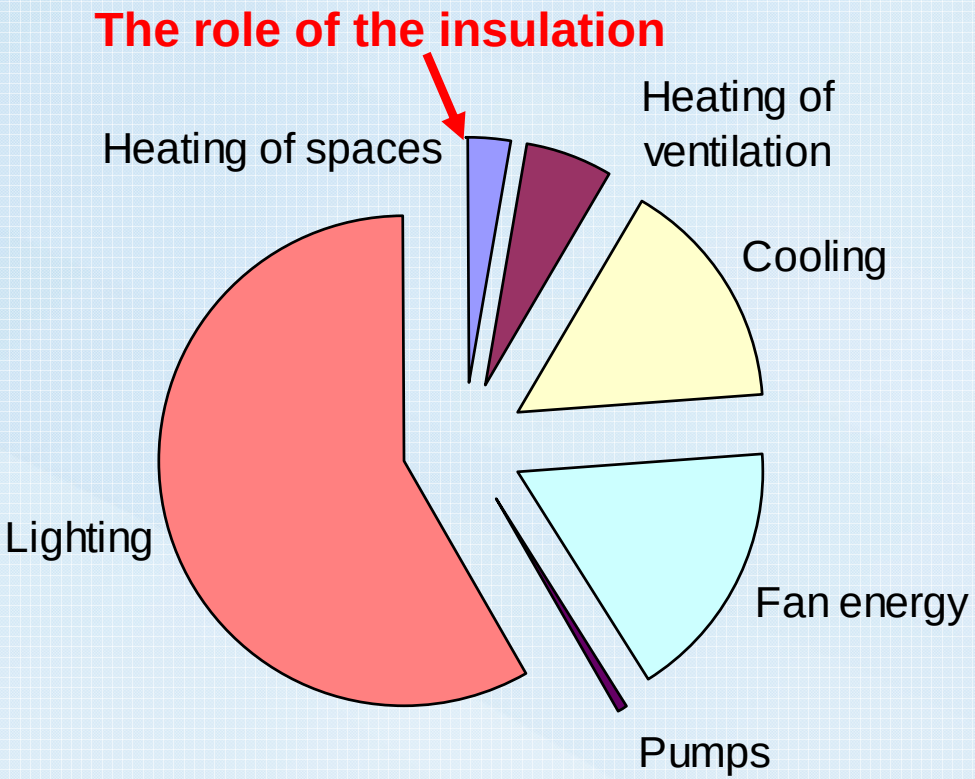
Improvement in Primary Energy Efficiency: Focus should be on Building Services



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”Use technologies that enable the use of sustainable low energy cooling:
- displacement ventilation
- chilled ceilings
- chilled beams”

Source: Sustainable low energy cooling: an overview
CIBSE Knowledge Series, 2005

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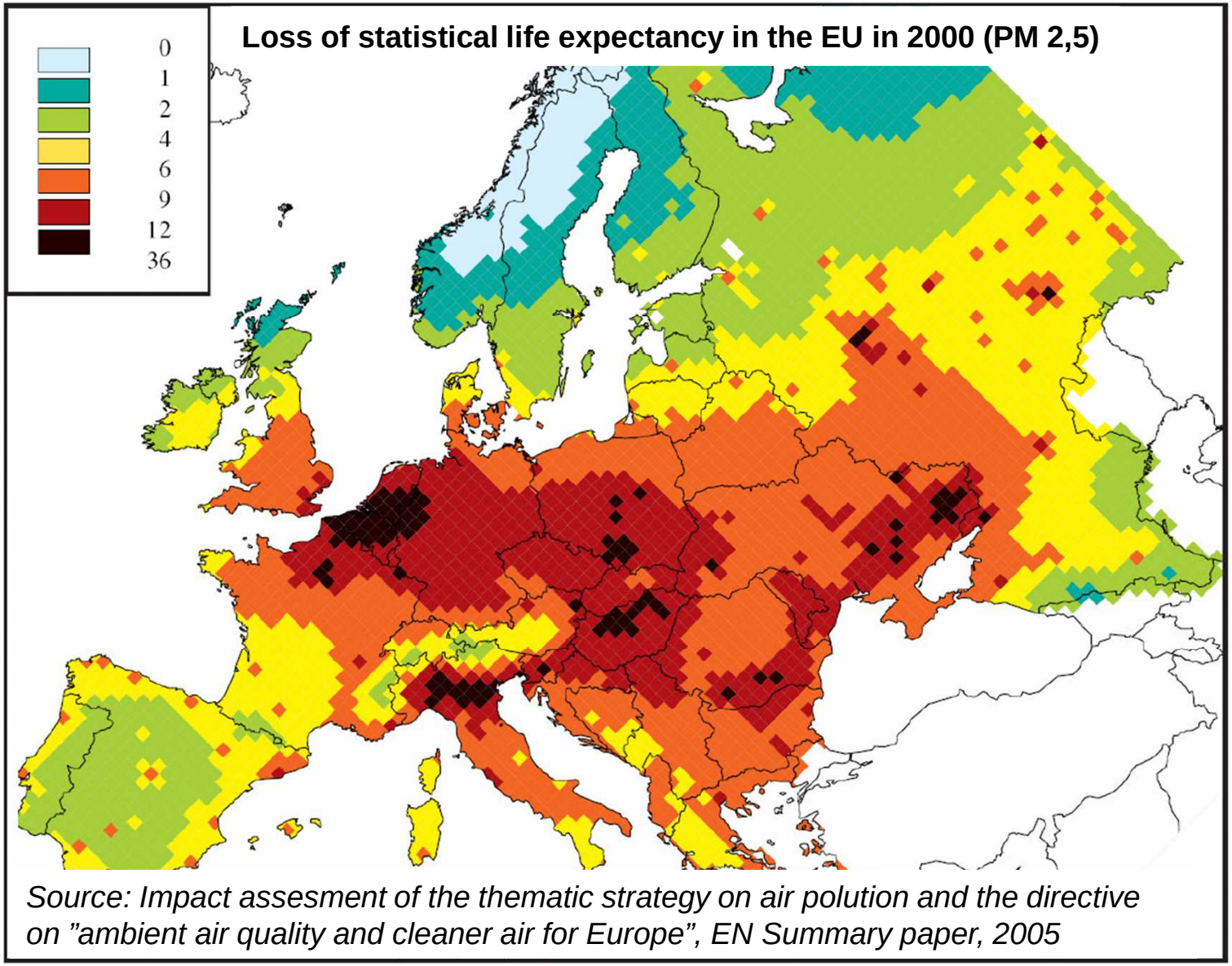
Loss of statistical life expectancy in the EU in 2000 (PM 2,5)



Source: Impact assesment of the thematic strategy on air polution and the directive on ”ambient air quality and cleaner air for Europe”, EN Summary paper, 2005

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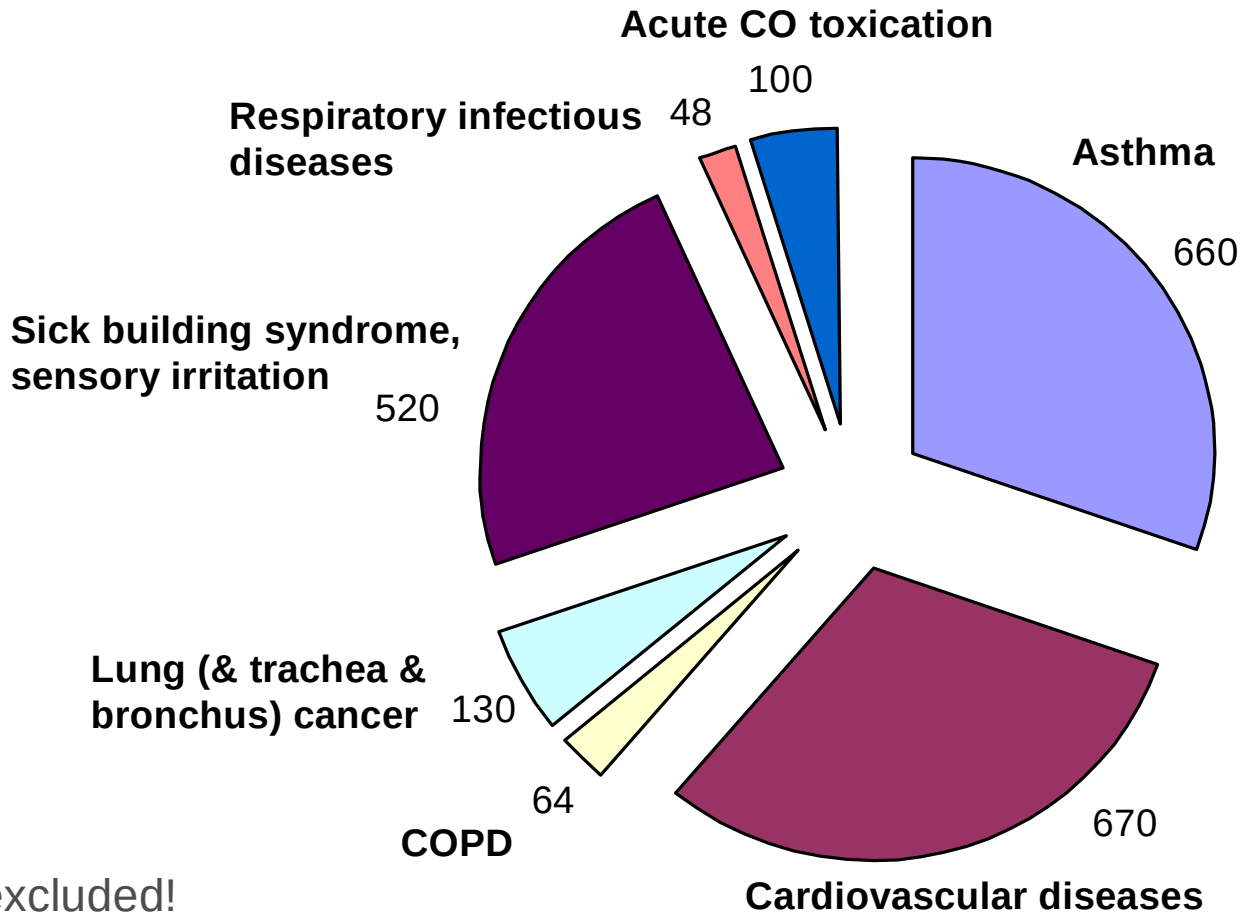
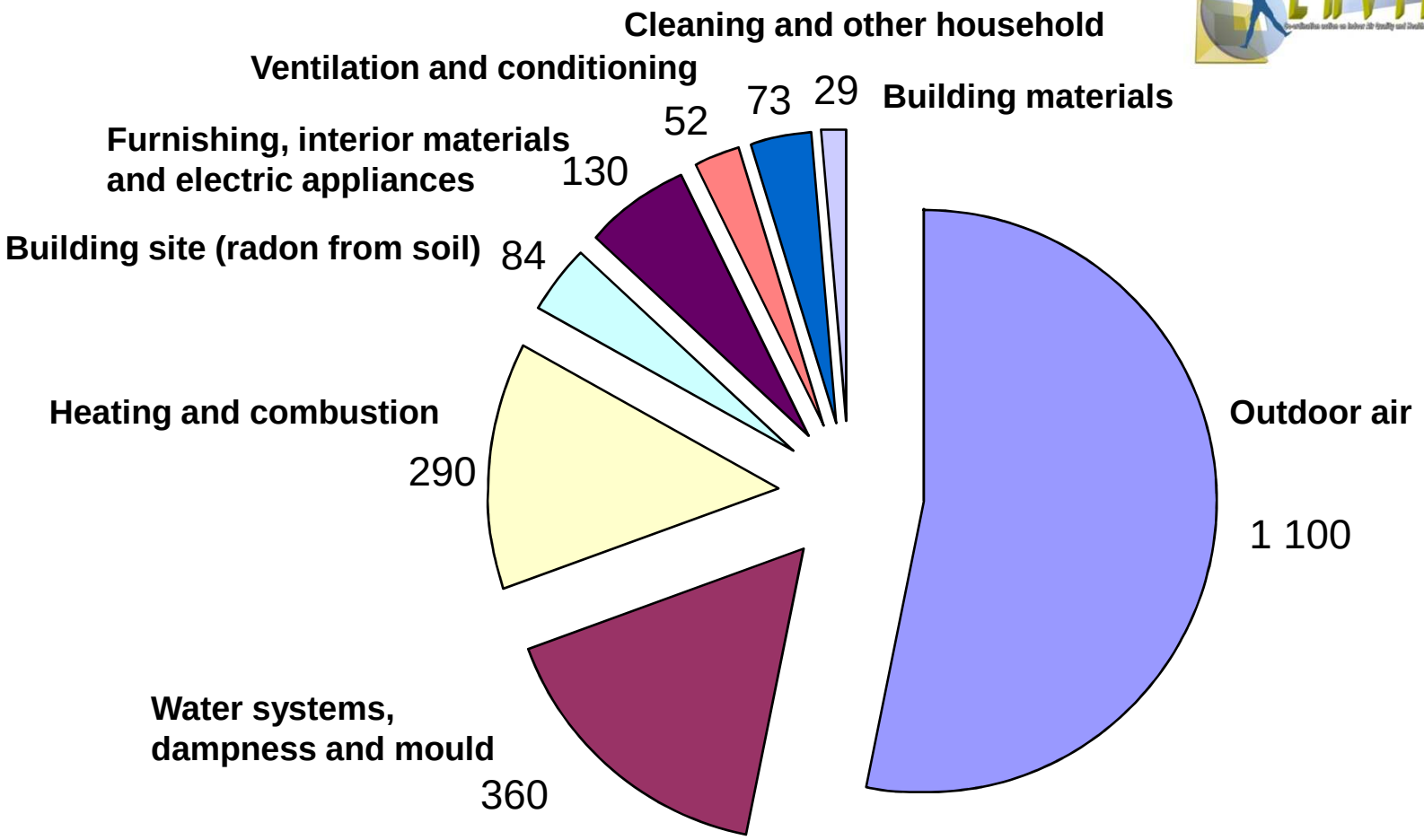
Disease caused by indoor air contaminants in EU-27



ETS excluded!

Source of indoor air contaminants in EU-27



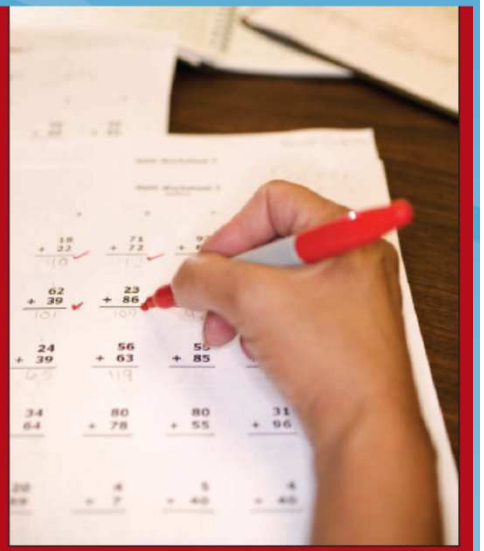
ETS excluded!

Indoor Climate and Productivity

- ”A minor 1 % (5 min/day) increase in office work can off-set the annual cost of ventilating the building.”
- ”Doubling the outdoor air supply rate can reduce sick leave prevalence by 10 %, and increase office work by 1,5%.”

Source: Wargocki, Seppänen: Indoor Climate and productivity in Offices, Rehva guidebook n:o 6, 2006.

'...air quality and temperatures in classrooms are important factors in the learning process and improving them should be given as much priority as improving teaching materials and methods.'



Research Report on

Effects of HVAC On Student Performance

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Sustainable Indoor Environment

- Well insulated and tight buildings with good solar shading.
- Mechanical air intake with good outdoor air filtering.
- Demand based ventilation.
- Right temperature, high air quality, low velocities and noise in the space.
- Low energy cooling and heating technologies and renewable energy.
- Individual control of indoor environment.

VALUE OF BUILDING

Cost item	Value (€/m^2)	Potential change	Change (€/m^2)
Value of building	3500	+ 1…15 %	35…525
Annual energy cost	20	- 5…30 %	1…6
Annual rent income	300	+ 1…3 %	3…9

CHURN COSTS

	Cost
Design work	15 - 20 €/m^2
Changes in automation systems	5 - 10 €/m^2
Changes in mechanical systems	20 - 50 €/m^2
Changes in electrical systems	15 - 20 €/m^2
TOTAL	55 - 100 €/m^2

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Better buildings create value

	Research name	Year	Impact
Rental Value	Miller & all.	2008	0…3%
	Eichholtz, Kok & Quigley	2008…2009	3…6%
	Fuerst & McAllister	2008…2009	4…6%
	Pivo & Fisher	2009	5%
	Leopoldsberger & al.	2010	0…6%
	Wiley & al.	2010	7…17%
Asset valuation	Salvi & al.	2008	3…7%
	Miller & al.	2008	6…10%
	Eichholtz, Kok & Quigley	2009	16%
	Fuerst & McAllister	2009	31…35%
	Pivo & Fisher	2009	13%
Occupancy rate	Fuerst & McAllister	2010	3…8%
	Wiley & al.	2010	10…18%

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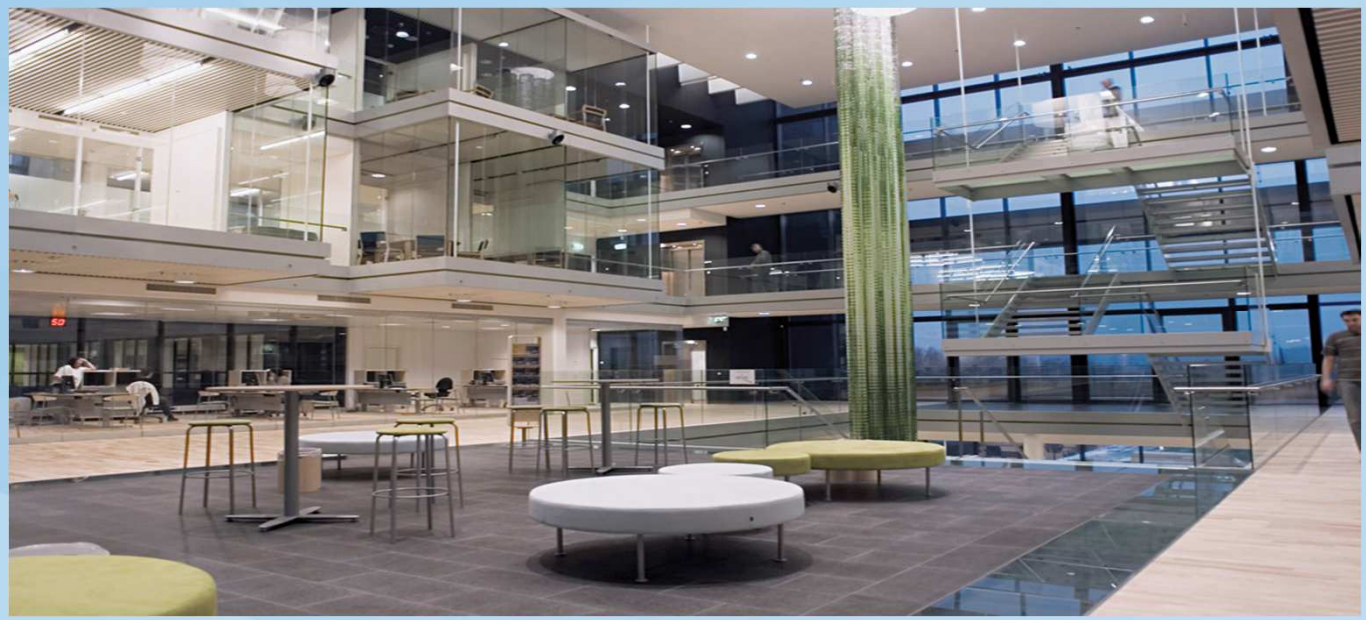
SURVEY RESULTS:
30-40% SEAT OCCUPANCY



A lot of effort is put into estimating proprieties of the building elements and adjusting the systems to the building related prerequisites and constraints, less effort is spent on considerations regarding the users and their activities.

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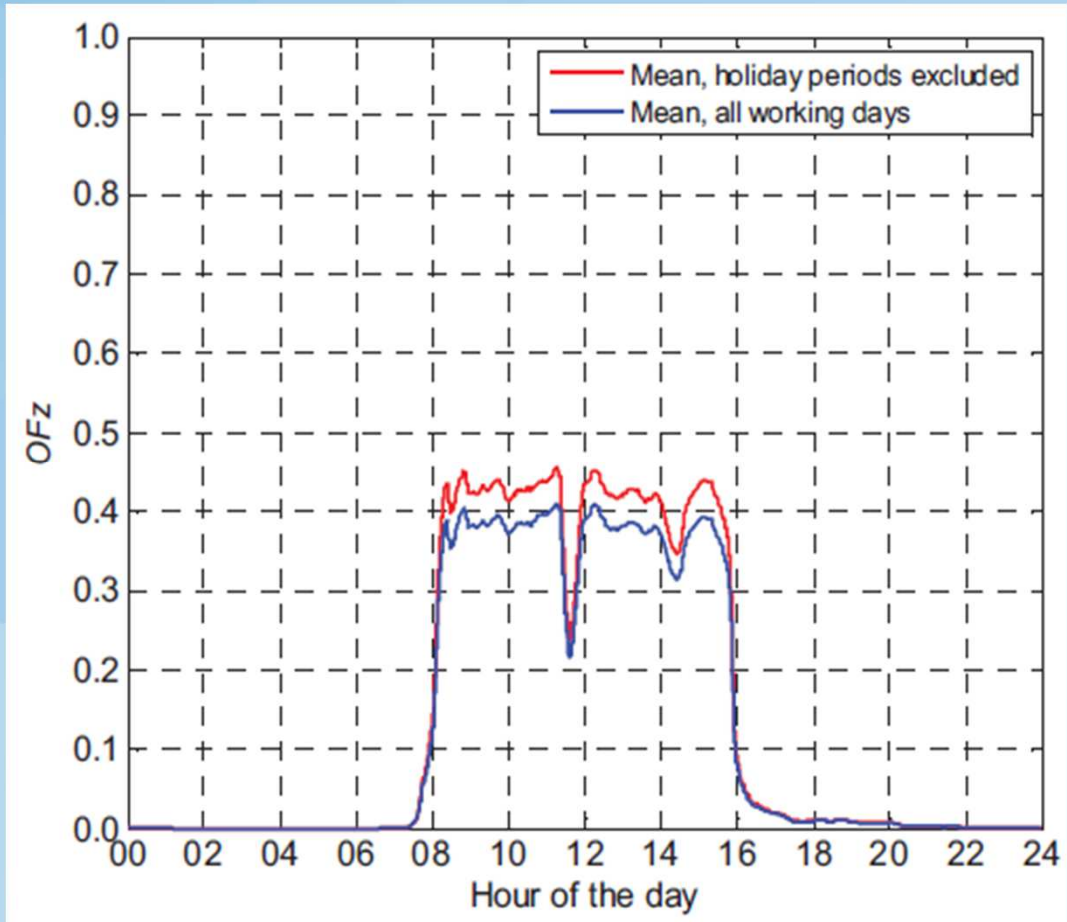
Typical Occupancy Factor



The zone based occupancy factor (OFz) expresses the ratio between the numbers of occupied sub-zone/rooms and the total number of sub-zones/rooms.

Typically the occupancy factor in offices is only 35-40 %

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System comparison

System	
Traditional beam	Tradional chilled beams in every room Meeting rooms with constant HAQ (additional air flow, open within fan schedule)
Adaptable beam	Adaptable beams in meeting rooms, traditional beams in other rooms. HAQ-control principle in meeting rooms: CO2-concentration
VAV beam	Variable air flow (VAV) beams in meeting rooms and in other rooms. Operation of beam system in unoccupied room closed HAQ-control principle in meeting rooms: CO2-concentration

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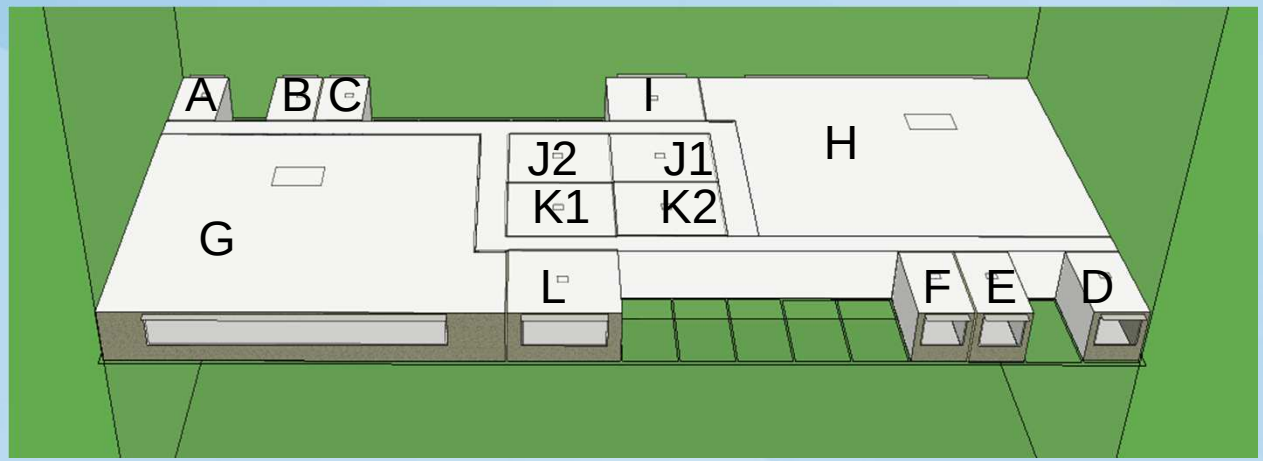
Project building data

- 10 similar floors, 1100 m² each
  - Landscape office 57 %
  - Office rooms 20 %
  - Meeting rooms 15 %
  - Other 8 %
- Simulation for one middle floor

	Quantity	Area [m2]
A. Office N	1	13
B. Office N	3	13
C. Office N	5	13
Corridor	1	113
D. Office S	1	13
E. Office S	3	13
F. Office S	5	13
G. Open office S	1	290
H. Open office N	1	292
I. Meeting room N	1	27
J1. Meeting room	1	27
J2. Meeting room	1	27
K1. Meeting room	1	27
K2. Meeting room	1	27
L. Meeting room S	1	27



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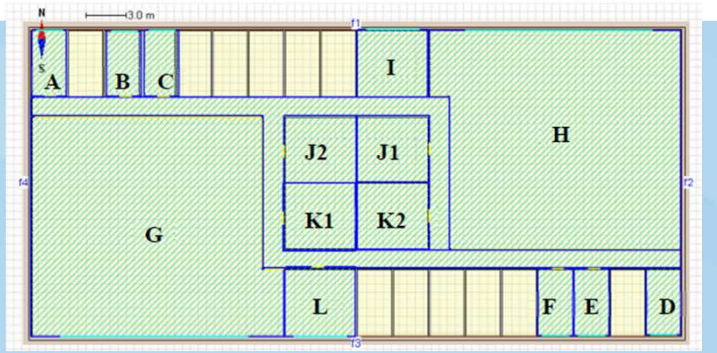
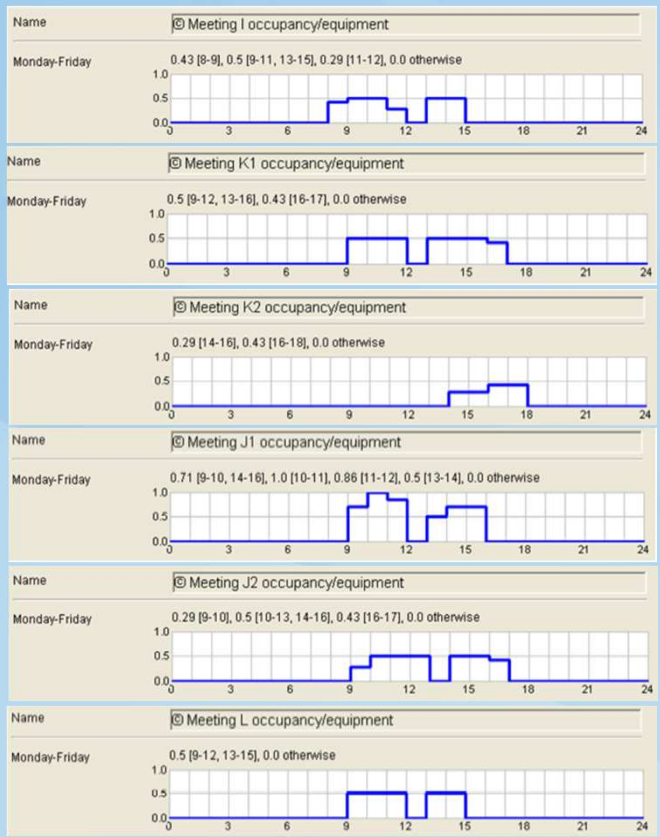
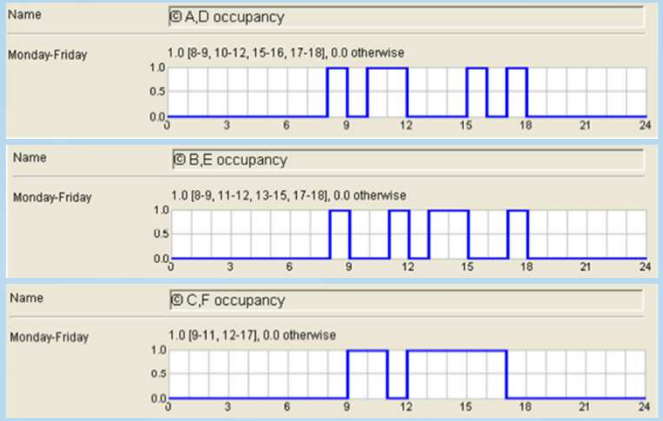
Occupancy profiles in energy simulation



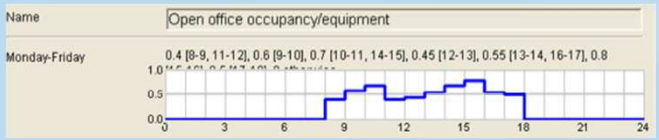
Building occupied every week Mo-Fri from 8-18
Meeting rooms:
Average occupancy 30%



Office rooms:
Average occupancy 57%



Open offices:
Average occupancy 57%



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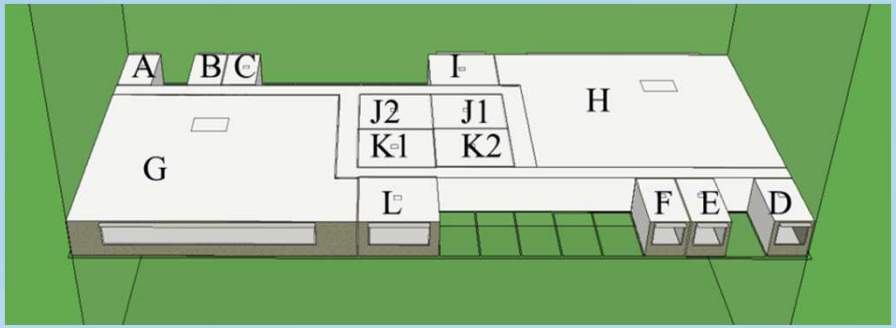
RESULTS – Design cooling and heating power

- Cooling and heating demand W/m² in design conditions
- Results correlate with locations
- Meeting rooms J and K independent of location



	PARIS		STOCKHOLM		SINGAPORE		RIYADH		HOUSTON	
	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
I. Meeting room N	59	**43**	58	**49**	**80**		**72**	**28**	62	**37**
A. Office N	37	51	35	**66**	58		55	**38**	**44**	**51**
D. Office S	**55**	**54**	**62**	63	38		48	37	42	45
G. Open office S	28	21	31	29	31		35	13	32	19
H. Open office N	30	22	29	29	28		35	13	32	20
B. Office N	33	36	32	41	51		45	23	37	32
C. Office N	33	35	32	40	51		45	23	37	32
E. Office S	51	34	61	40	31		38	23	36	31
F. Office S	51	34	61	39	31		38	23	36	30
L. Meeting room S	**80**	40	**89**	48	**59**		**67**	27	**65**	35
J1. Meeting room	52	9	52	10	52		54	9	52	9
K2. Meeting room	52	9	52	10	52		54	9	52	9
J2. Meeting room	52	9	52	10	52		54	9	52	9
K1. Meeting room	52	9	52	10	52		54	9	52	9

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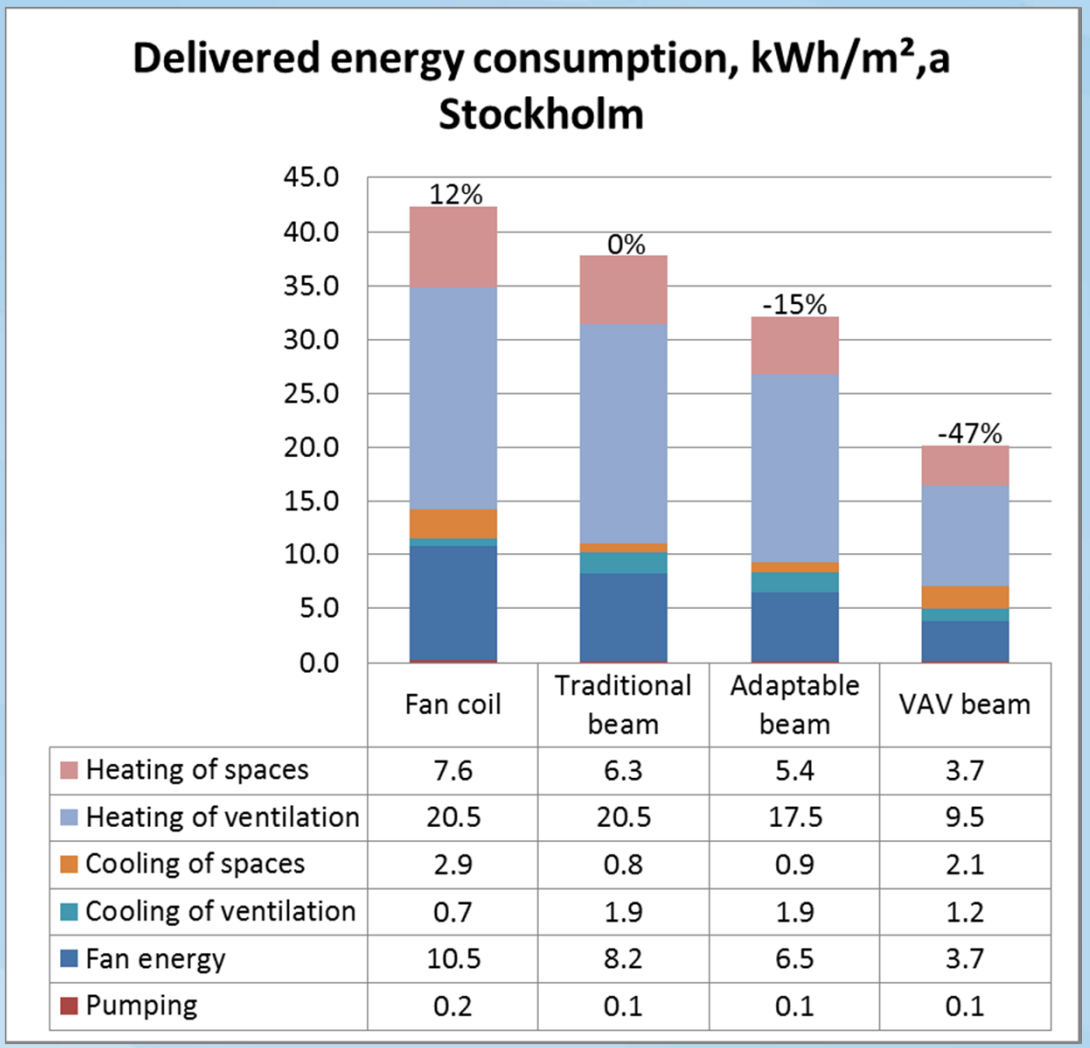
RESULTS - Stockholm

- Night heating (setpoint 18 ºC)
- Freecooling reduces the energy for cooling of spaces



	Fan coil	Traditional beam	Adaptable beam	VAV beam
Heating of spaces	7.6	6.3	5.4	3.7
Heating of ventilation	20.5	20.5	17.5	9.5
Cooling of spaces	2.9	0.8	0.9	2.1
Cooling of ventilation	0.7	1.9	1.9	1.2
Fan energy	10.5	8.2	6.5	3.7
Pumping	0.2	0.1	0.1	0.1

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Buildings are built for people to live and work comfortably, effectively and safely - not only to save energy and environment!

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