Recent trend of radiant cooling and heating panel in Europe and US

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Heating and Cooling of Buildings

- Heating, cooling and ventilation systems play a significant role in the energy use (42%) and for the indoor environment quality in a building
- The main purpose of these systems is to provide a comfortable, healthy and productive indoor environment for the occupants
- These goals should however be achieved with the lowest possible energy consumption.

COMFORT-PRODUCTIVITY
Building costs

People	100
Maintenance	10
Financing	10
Energy	**1**

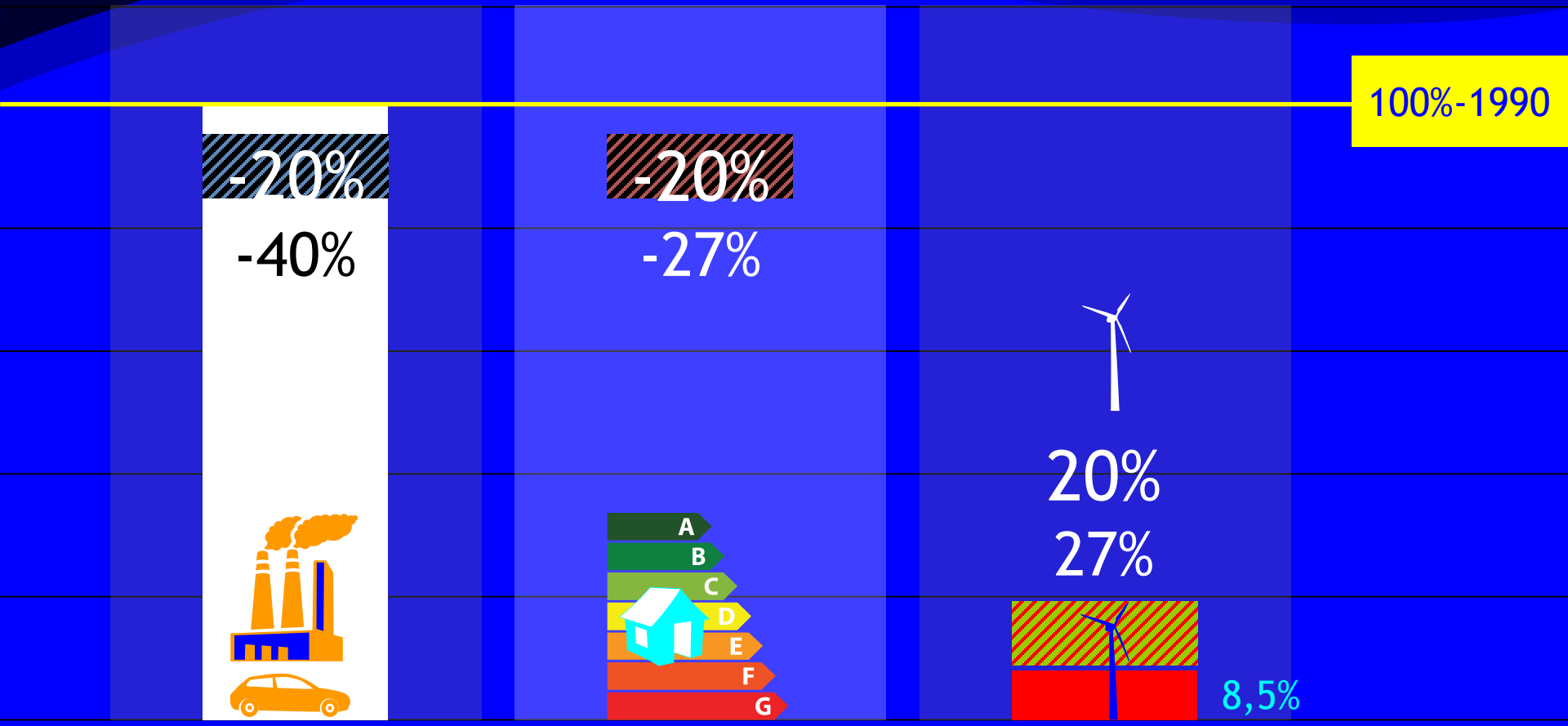
Energy Demand-Energy Efficiency-Energy Sources

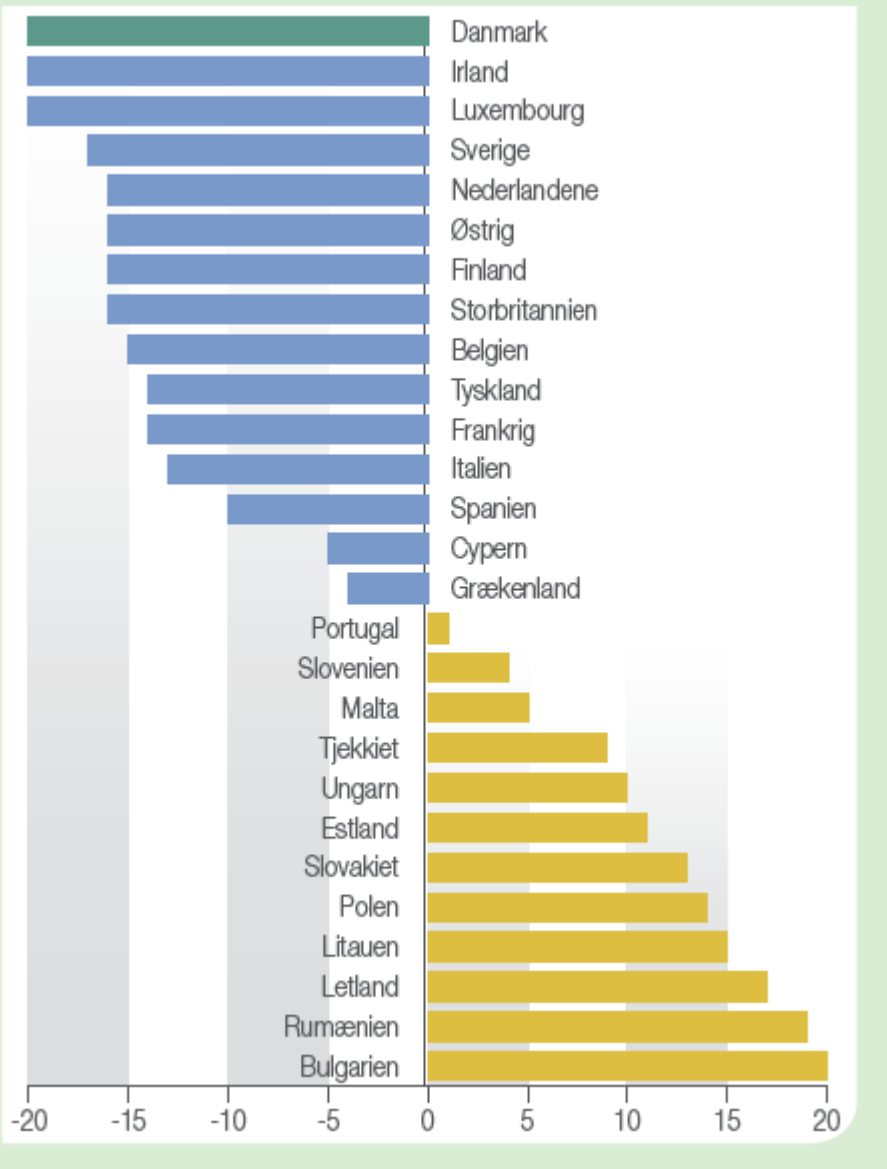
- As the resources of fossil fuels are limited and the use of nuclear power is associated with several safety issues there is a worldwide need for reducing the energy demand of buildings.
- Reducing the energy demand is much more efficient and sustainable than increasing energy sources
- When constructing new buildings and renovation old buildings the first priority is to decrease the energy demand

POSSIBLE ACTIONS

- **Decrease energy demands (building design)**
- **Increase energy efficiency (HVAC systems)**
- **Increase use of renewable energy sources (wind, solar, geothermal, biomass)**
- New energy sources (fuel cell)

The 20-20-20 EU policy by 2020
New policy for 2030 proposed





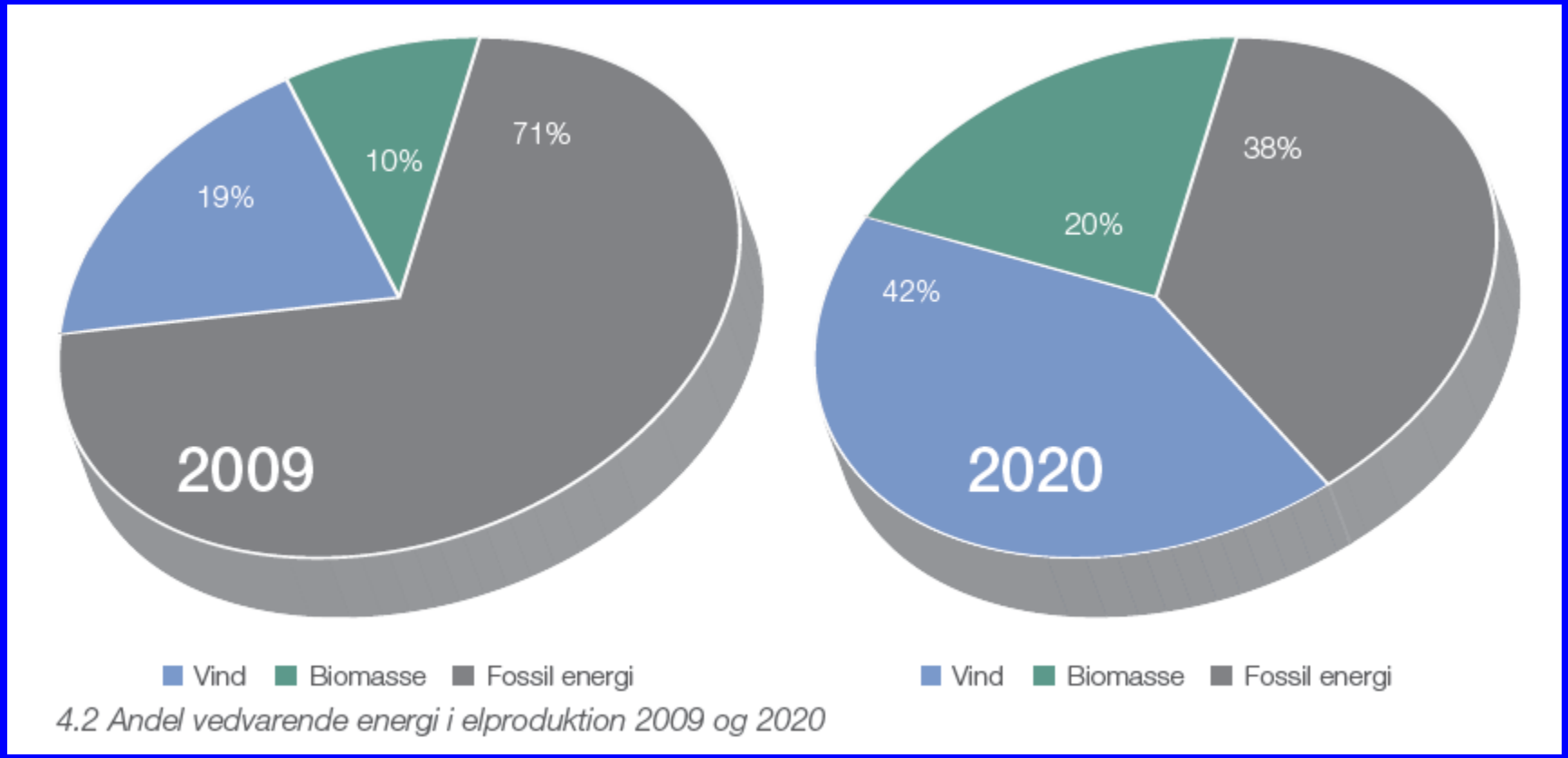
Required reductions in energy use in European countries
2020 in relation to 2005

National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2020

	2005	2020
Belgium	2,2	13 %
Bulgaria	9,4	16 %
Czech Republic	6,1	13 %
Denmark	**17,0**	**30 %**
Germany	**5,8**	**18 %**
Estonia	**18,0**	**25 %**
Ireland	3,1	16 %
Greece	6,9	18 %
Spain	8,7	20 %
France	10,3	23 %
Italy	5,2	17 %
Cyprus	2,9	13 %
Latvia	**32,6**	**40 %**
Lithuania	15,0	23 %
Luxembourg	0,9	11 %

	2005	2020
• Hungary	4,3 %	13 %
• Malta	0,0 %	10 %
• Netherlands	2,4 %	14 %
• **Austria**	**23,3 %**	**34 %**
• Poland	7,2 %	15 %
• Portugal	20,5 %	31 %
• Romania	17,8 %	24 %
• Slovenia	16,0 %	25 %
• Slovak Republic	6,7 %	14 %
• **Finland**	**28,5 %**	**38 %**
• **Sweden**	**39,8 %**	**49 %**
• United Kingdom	1,3 %	15 %

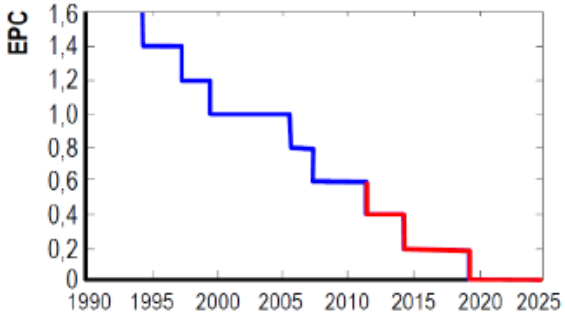
Part of renewable energy sources (wind and bio-fuel) in Denmark (no nuclear)



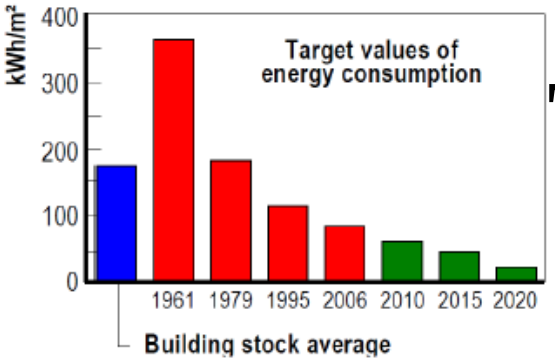
4.2 Andel vedvarende energi i elproduktion 2009 og 2020

The effect of building regulations

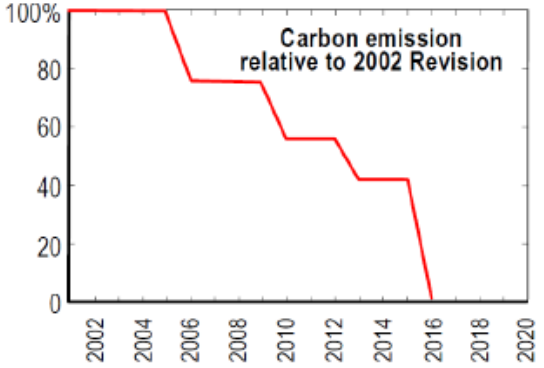
The Netherlands



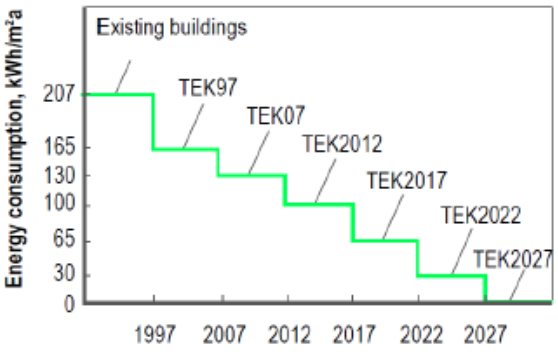
Denmark



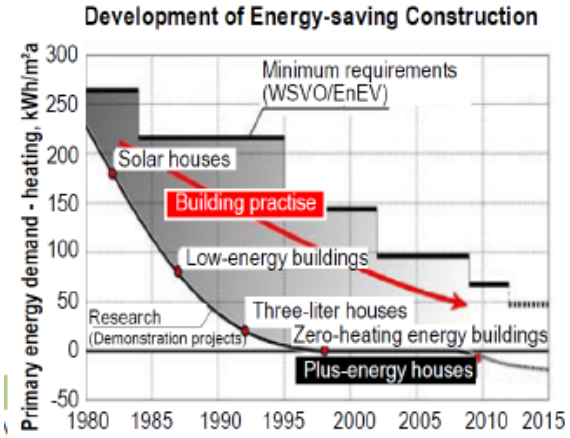
United Kingdom



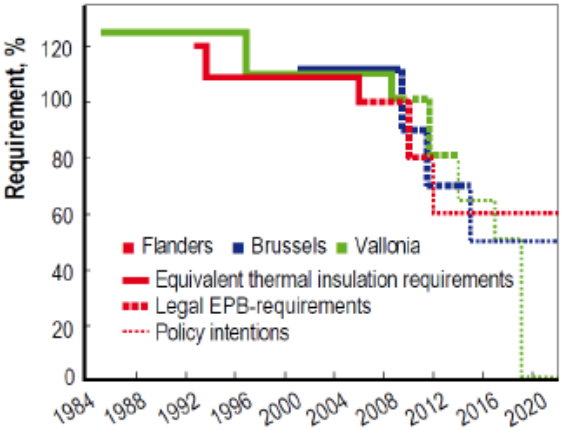
Norway



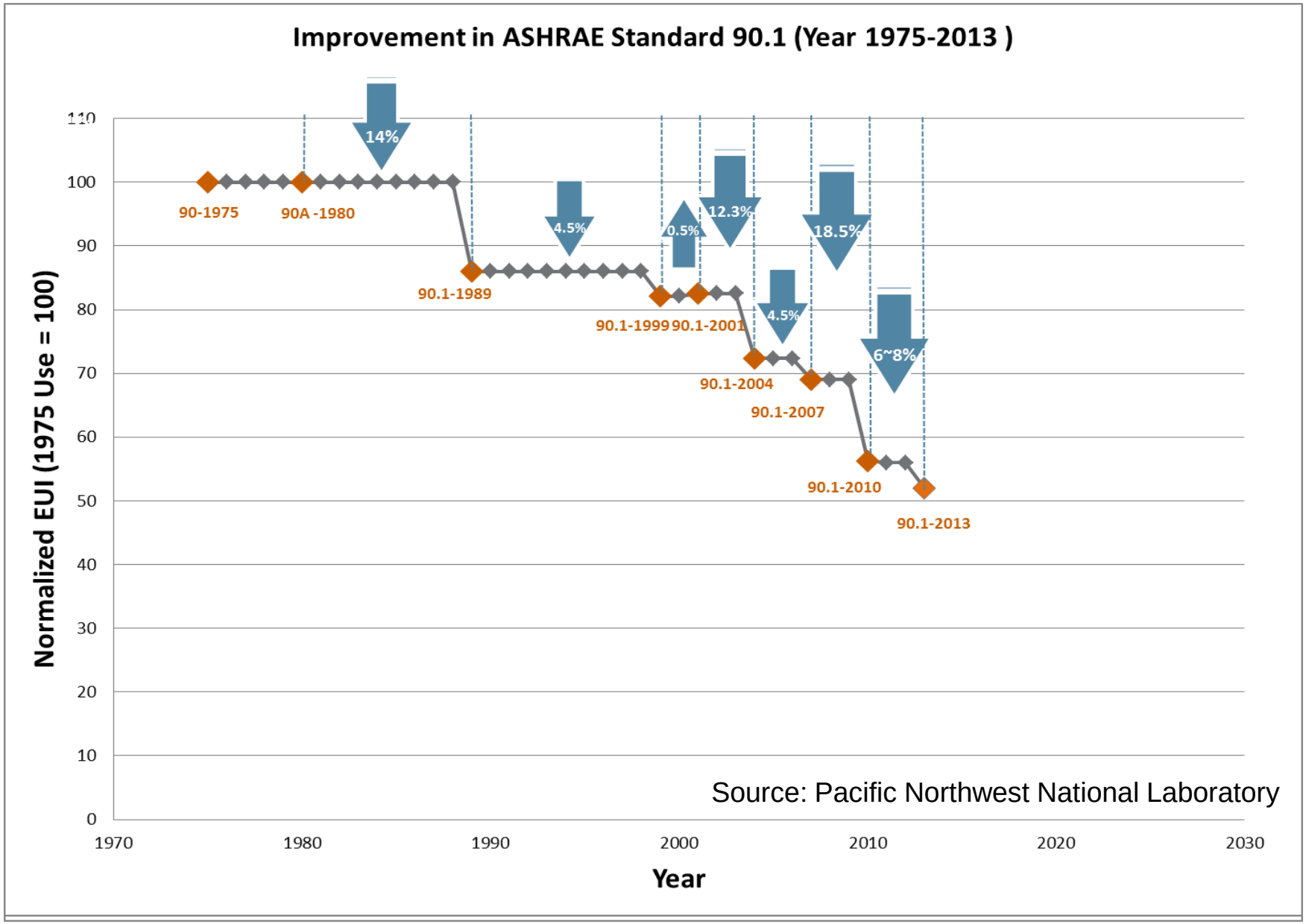
Germany



Belgium



ANSI/ASHRAE/IES Standard 90.1-2013 -- Energy Standard for Buildings Except Residential Buildings



Advanced Energy Design Guides: 522,000 in circulation

Four 50% AEDGs

Being Implemented

- 50% Grocery Stores
  - Quick Serve Restaurants
  - Places of Assembly

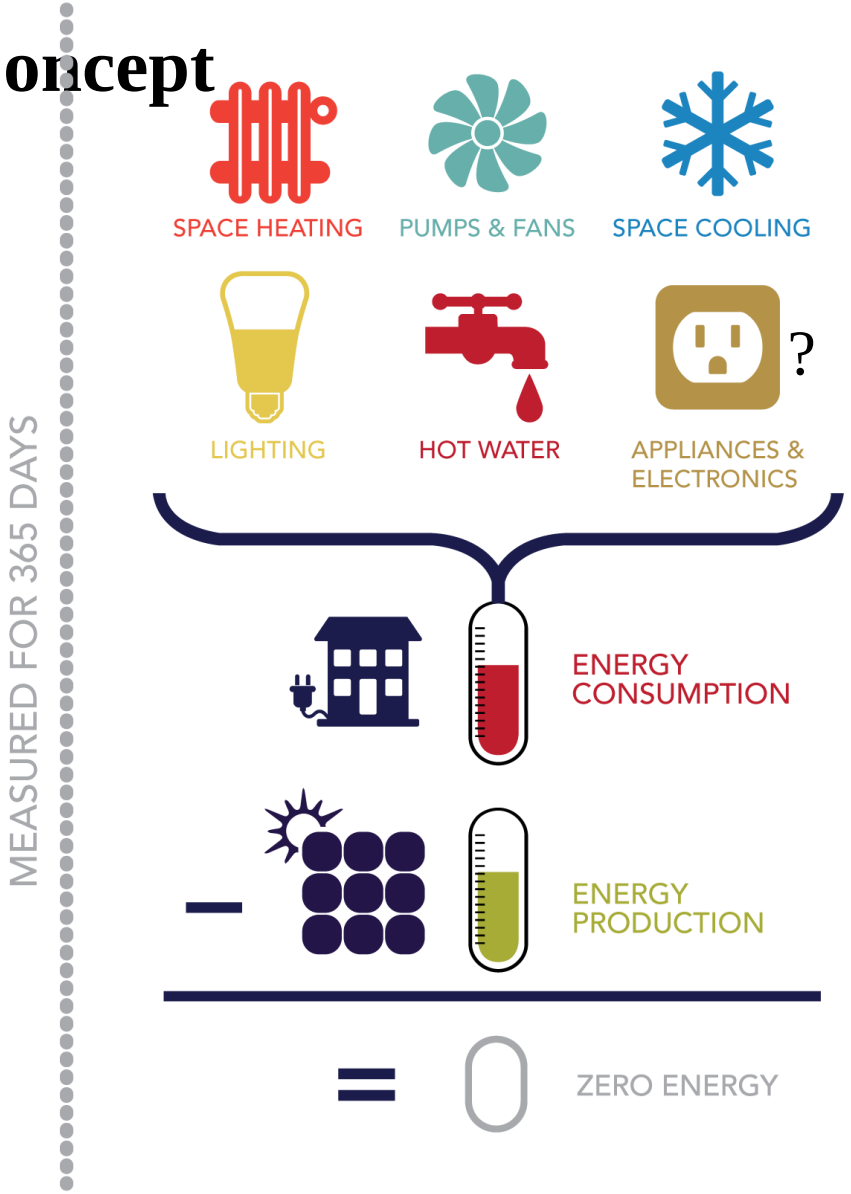
Under Discussion

- Net Zero
  - K-12 Schools (2)
  - Quick Serve Restaurants
  - Places of Assembly
  - “Net Zero Ready” Guidance

www.ashrae.org/freeaedg

ZEB Concept

Over the course of a year, if the (on-site or source) renewable energy produced ≥ the energy used within the boundary, it is considered a ZEB



Energy Efficient Technologies

- Indoor air quality
  - Reduce loads (pollution sources)
  - Heat recovery
  - Increase system efficiency
  - Natural ventilation-Hybrid ventilation
  - Air distribution (contaminant removal) effectiveness
    - Personal ventilation
  - Air cleaning

- Thermal comfort
  - Reduce loads (building shell, solar screen, internal loads)
  - Increase system efficiency
  - Low Temperatur Heating- and High Temperature Cooling Systems
  - Use of building mass to reduce peaks (Thermo-Active-Building-Systems (TABS))
  - Drifting indoor temperatures

Low Temperature Heating – High Temperature Cooling

- Higher efficiency of boilers, heat pumps chillers
- Lower distribution looses
- Better use of renewable energy sources
  - Ground heat exchangers
  - Waste heat from processes
  - Dry coolers
  - Heat pumps
- Low energy use for distribution
- Low exergy

CONCEPTS OF RADIANT HEATING AND COOLING SYSTEMS

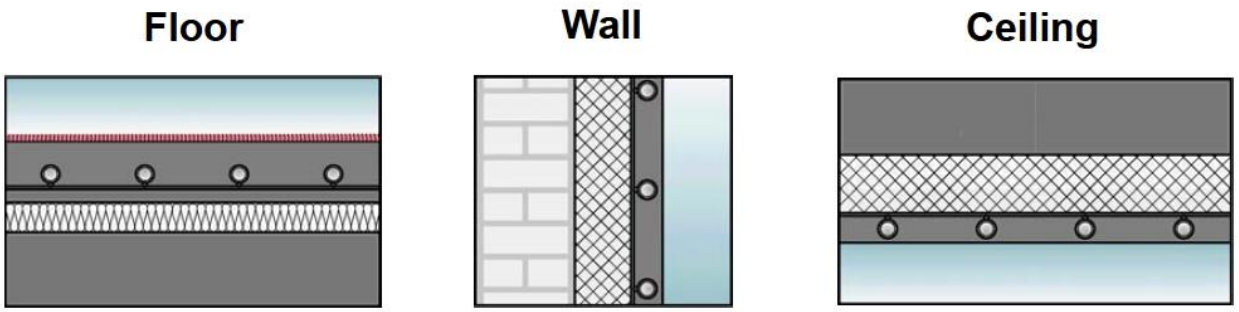
- Minimum 50% heat exchange by radiation

- Heating - cooling panels
- Surface systems
- Embedded systems

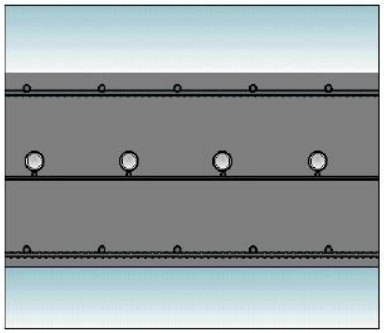
- Most recent development is the increasing application world wide.

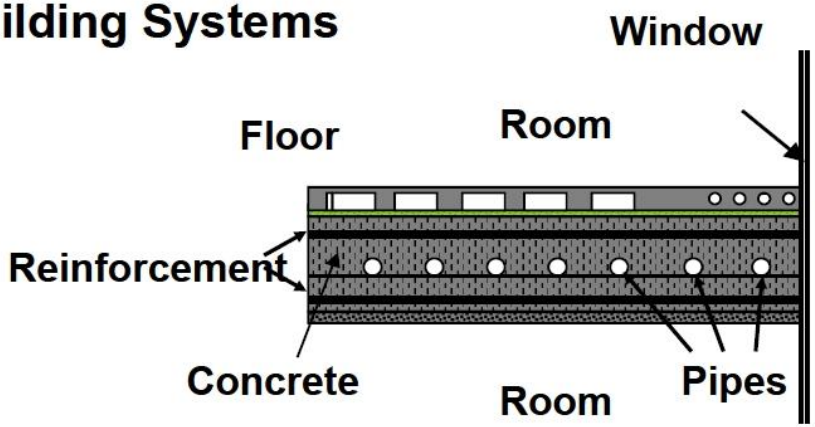
System types

- Different installation concepts
  (thermally coupled or insulated form the building structure)

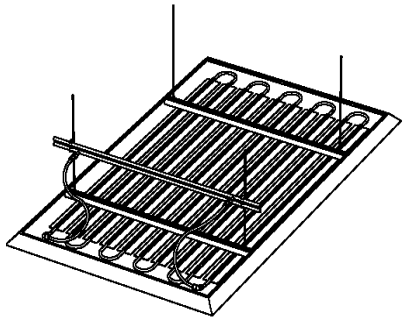


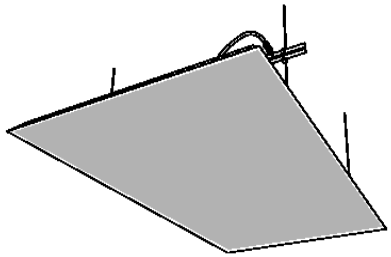
Thermo Active Building Systems

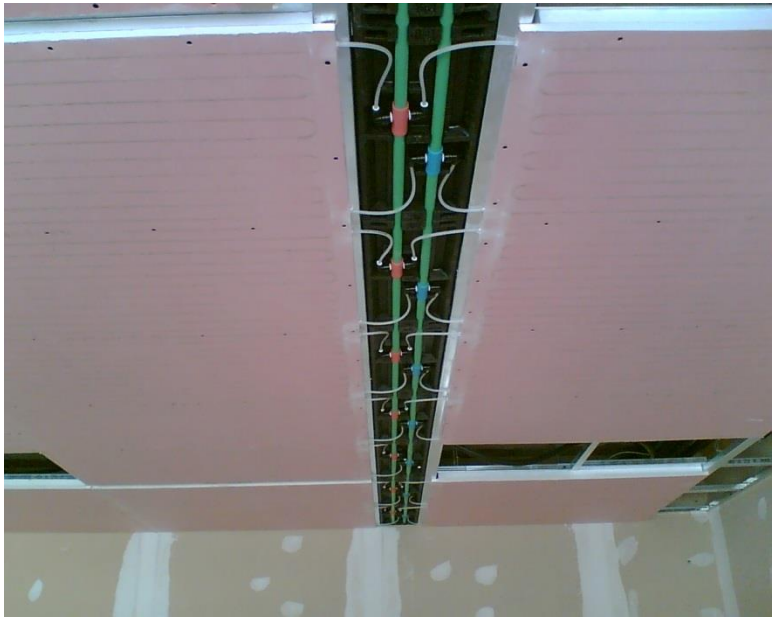




Cooling panels



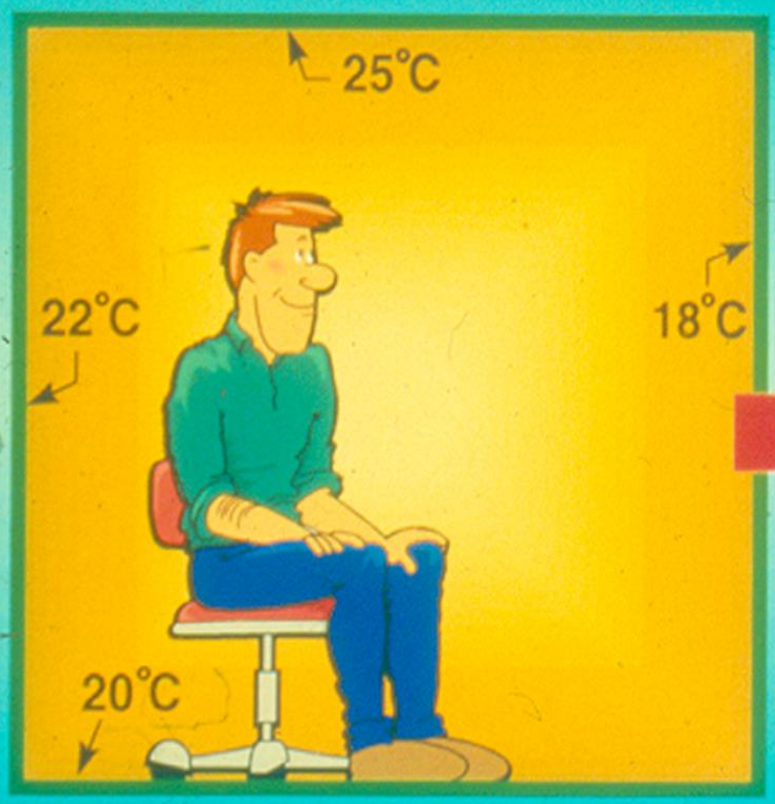




COMFORT

- GENERAL THERMAL COMFORT
  - PMV / PPD, OPERATIVE TEMPERATURE
- LOCAL THERMAL DISCOMFORT
  - Radiant temperature asymmetry
  - Draught
  - Vertical air temperature difference
  - Floor surface temperature

Mean radiant temperature



892696e

Mean radiant temp. = 21°C
Air temperature = 25°C

Operative temperature

23°C

Operative temperature ~ $\frac{1}{2}$(mean radiant temp. + air temp.)

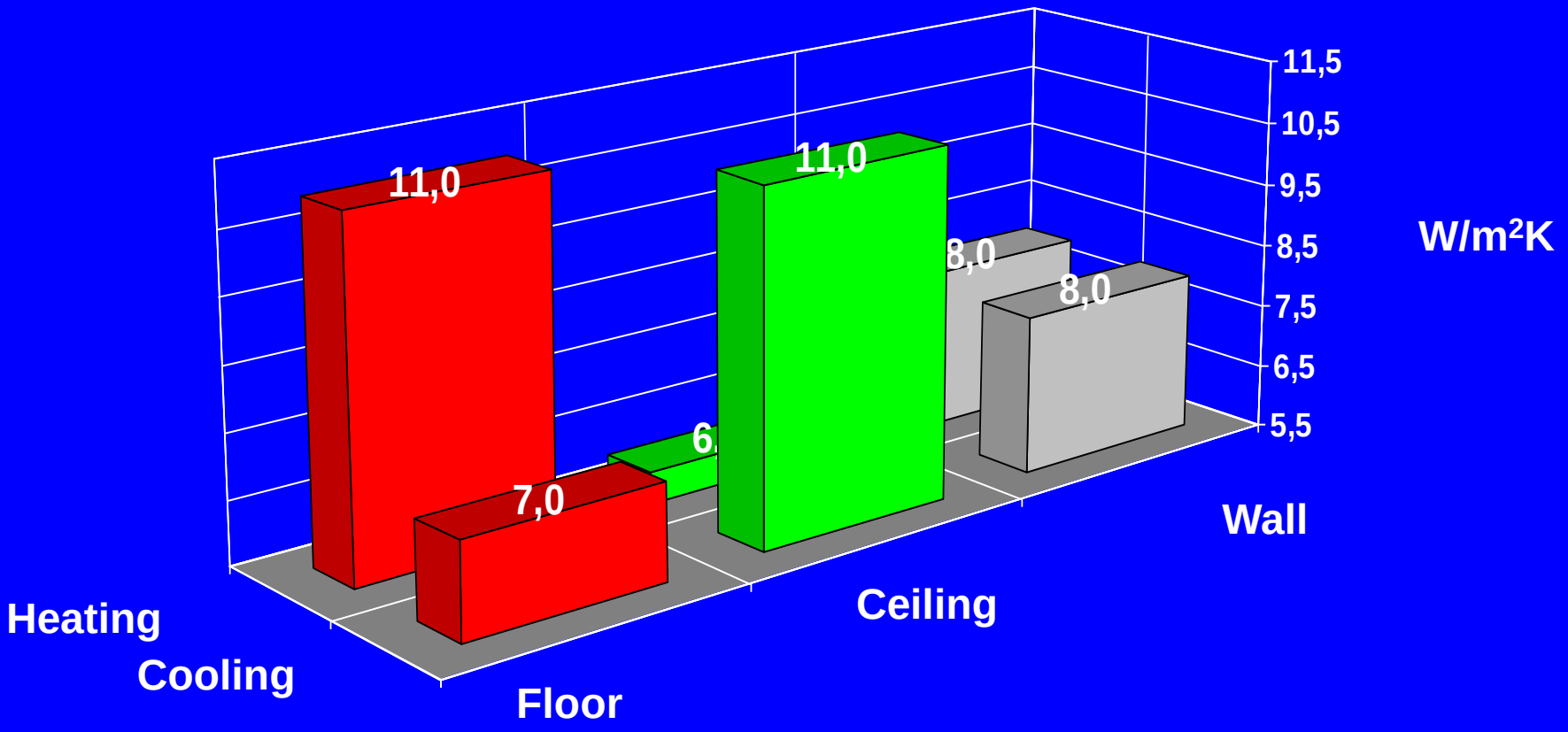
892697e

GENERAL THERMAL COMFORT

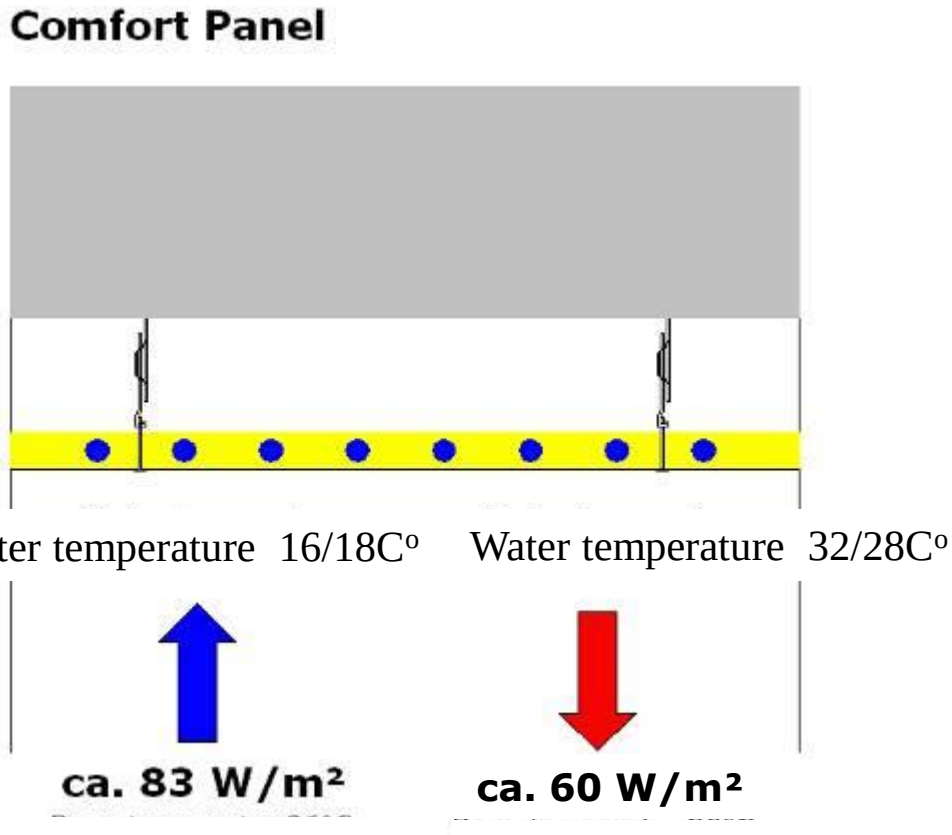
- OPERATIVE TEMPERATURE
  - $t_o = (h_c t_a + h_r t_r)/(h_c + h_r)$
  - $t_o = 0.5t_a + 0.5t_r$ (low air velocity)
    - t_a = Air temperature
    - t_r = Mean radiant temperature
    - h_c = Convective heat exchange coefficient
    - h_r = Radiative heat exchange coefficient

SURFACE HEATING AND COOLING

Heat transfer coefficient



Radiant Heating-Cooling Panels



ISO 18555 Building Environment Design — Design, test method, control and operation of radiant heating and cooling panel systems

- **Part 1: Definition, symbols, technical specifications and requirements**
- **Part 2: Determination of heating and cooling capacity of ceiling mounted radiant panels**
- **Part 3: Design of ceiling mounted radiant panels**
- **Part 4: Control and operation of ceiling mounted radiant heating and cooling panels**

Control of radiant heating and cooling systems

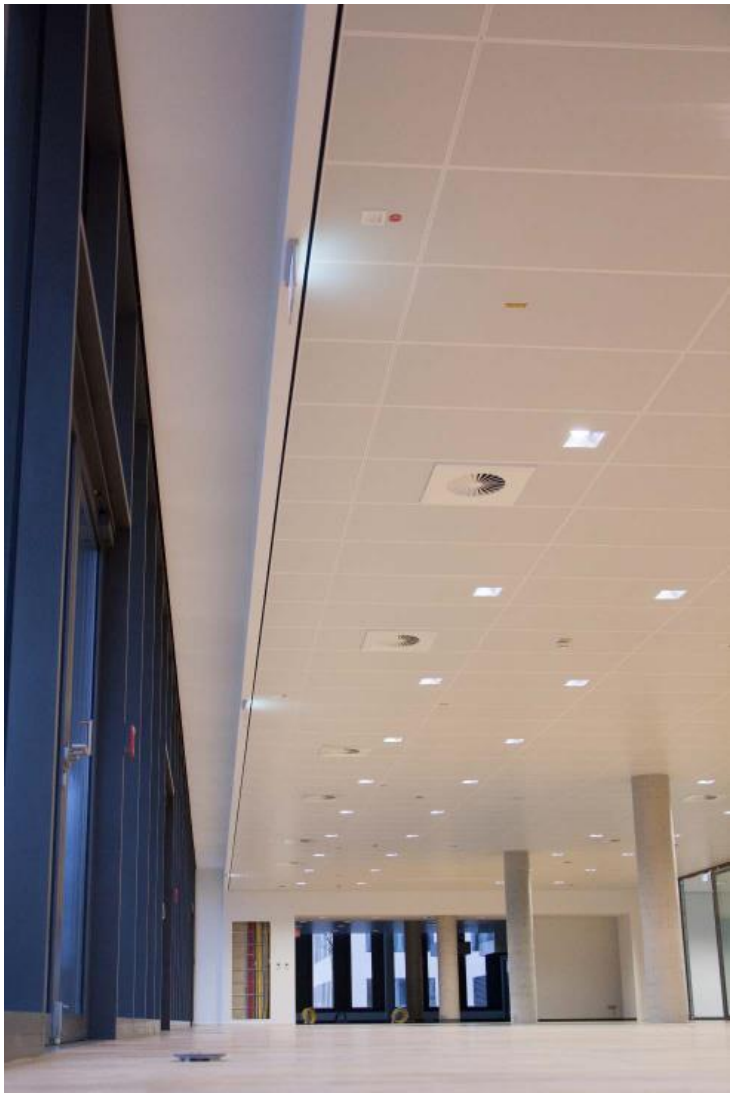
- **Radiant surface cooling systems shall include controls to avoid condensation.**
- **This can be done by a central control of the supply water temperature limiting the minimum water temperature based on the zone with the highest dew point temperature.**
- **If the supply water temperature is limited, the temperature of the rest of system will be higher than the dew point, and there is no risk of condensation on the pipes, and on the surface of the radiant system.**
- **Limiting the supply water temperature will lower the cooling power of radiant system at high indoor humidity levels.**
- **Dehumidifying the ventilation air will result in lower dew point temperature and will allow higher cooling capacity of radiant system.**

Residential Buildings

- Middle and Nothern Europe
  - More than 50% floor heating
  - Mechanical Ventilation with heat recovery
  - Risk of over heating
- Southern Europe
  - Increasing use of split-unit
  - Some Air Conditioning

Airport Administration Düsseldorf

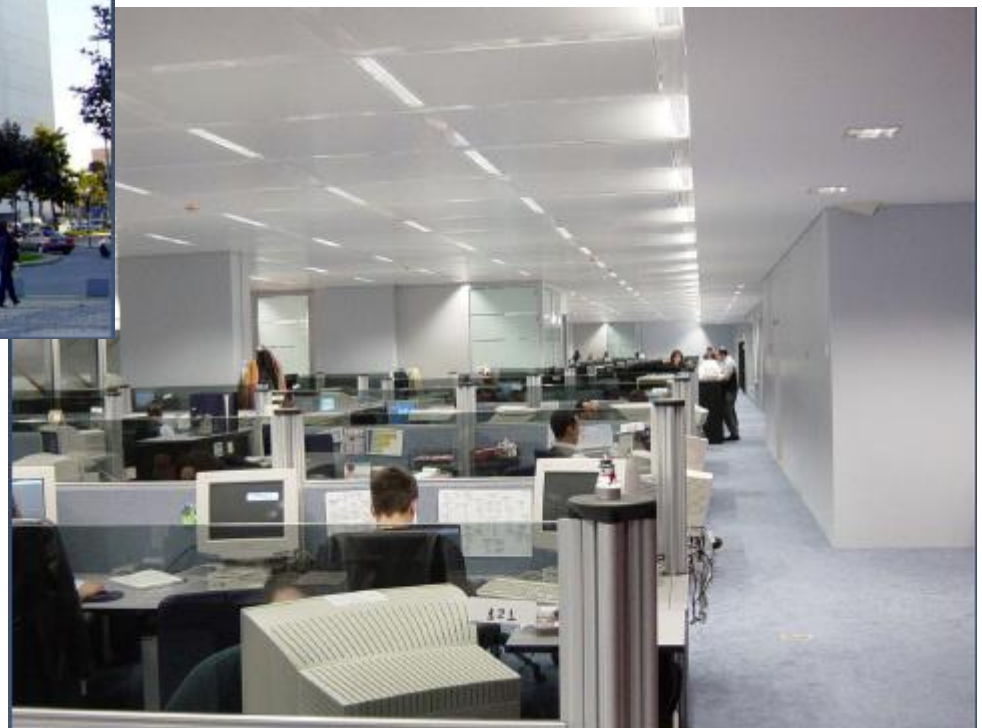
5.000 m^2 cooling panels



Campus in Cologne

7.000 m^2 gibson board cooling panels

Telecel Headquarters, Lisbon



Renovation Deutsche Bank Frankfurt

Built 1984
Renovated 2006 for 200 mill. €
Radiant ceiling panels
100kWh/m^2 year
LEED-Platin and DNGB-Gold
Energy savings:

- 67 % Heating,
- 55 % Electricity
- 74 % Water

Dutch Bank Buildings

IDEAS FOR THE BUILT ENVIRONMENT

Radiant cooling panels Saudi Arabien

DOE-USA

Table 4-1: Energy Savings Potential Summary for 15 Options

Technology Option	Technology Status	Technical Energy Savings Potential (quads)
Adaptive/Fuzzy Logic Controls	New	0.23
Dedicated Outdoor Air Systems	Current	0.45
Displacement Ventilation	Current	0.20
Electronically Commutated Permanent Magnet Motors	Current	0.15
Enthalpy/Energy Recovery Heat Exchangers for Ventilation	Current	0.55
Heat Pumps for Cold Climates (Zero-Degree Heat Pump)	Advanced	0.1
Improved Duct Sealing	Current/New	0.23
Liquid Desiccant Air Conditioners	Advanced	0.2 / 0.06[12]
Microenvironments / Occupancy-Based Control	Current	0.07
Microchannel Heat Exchanger	New	0.11
Novel Cool Storage	Current	0.2 / 0.03[13]
Radiant Ceiling Cooling / Chilled Beam	Current	0.6
Smaller Centrifugal Compressors	Advanced	0.15
System/Component Diagnostics	New	0.45
Variable Refrigerant Volume/Flow	Current	0.3

DOE-USA

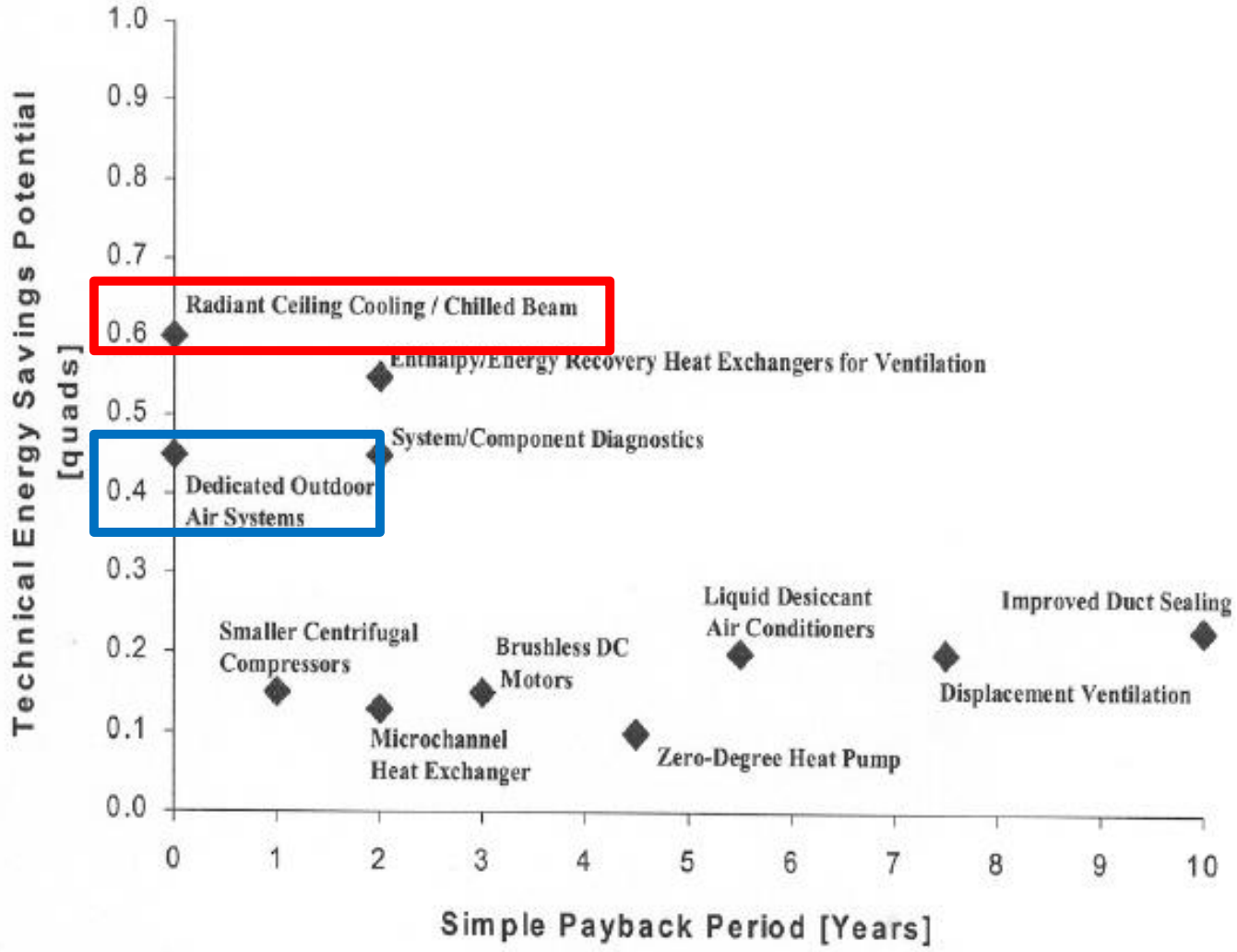


Figure 5-2: Estimated Technical Energy Savings Potential and Simple Payback Periods for the 15 Options

COOPER UNION NEW YORK

First costs

Overhead VAV lab +Fan Coils	4,107,200
Radiant ceil[illegible]n VAV lab +Fan Coil	3,676,279

10.5%

$220,000/year utility savings

Cooper Union, New York, New York
库珀广场，纽约市

- LEED Platinum

  LEED白金认证

- The total energy cost savings were 34% below the budget case

  建筑能耗成本低于标准值34%

- Energy consumption was 46% below the budget case.

  建筑能耗低于标准值46%

IBE CONSULTING ENGINEERS

Possible LEED Points

- Energy – DOAS and radiant panel reduces energy 25-35%, chiller without HCFC's
- Materials – radiant panels 100% recyclable and easily can contain recycles
- IEQ – increased ventilation effectiveness, thermal comfort, controllability of system
- Innovation credit – decoupling sensible and latent loads
- Fast response time allows use of operable windows

Low Energy/Exergy Hydronic Radiant Heating and Cooling
Why?

- Water based systems
- Low Temperature Heating - High Temperature Cooling
- More economical to move heat by water:
  - Greater heat capacity than air
  - Much smaller diameter pipes than air-ducts
  - Electrical consumption for circulation pump is lower than for fans
- Lower noise level
- Less risk for draught
- Lower building height
- Higher efficiency of energy plant
- Increased use of renewable energy sources