Smart and nZEB buildings

Zoltan MAGYAR, PhD

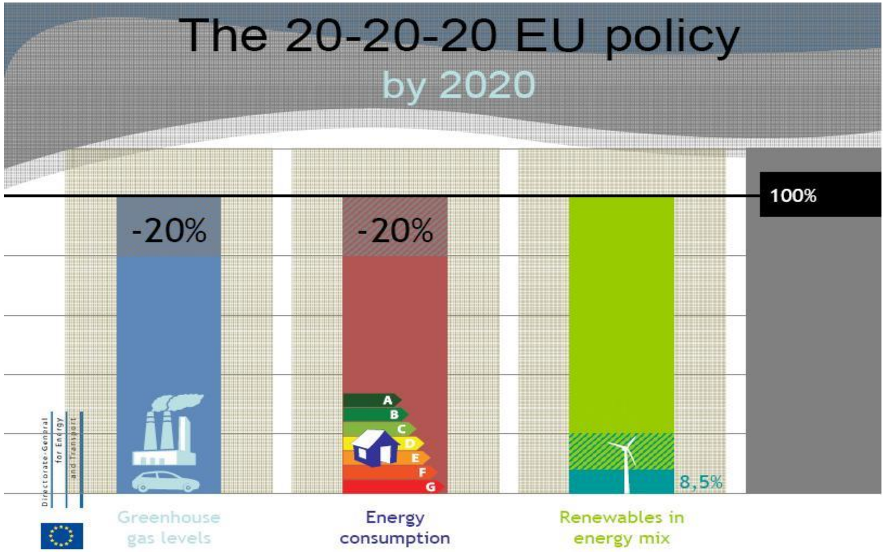
BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
DEPARTMENT OF BUILDING ENERGETICS AND HVAC

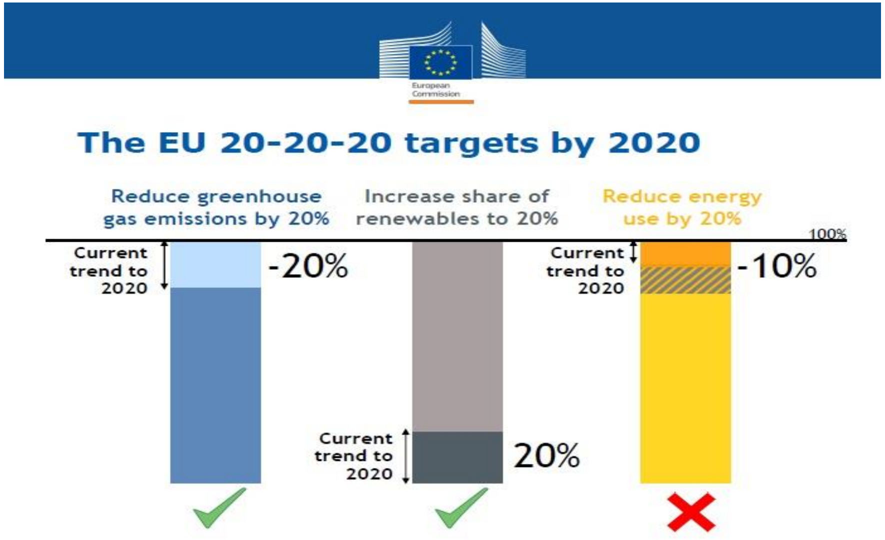
CONTENT

- Background
- 2010/31/EU EPBD recast, Nearly zero energy building (nZEB)
- Directive (EU) 218/844: Revised EPBD (19. June 2018)
- Smart buildings, Smart Readiness Indicator, SRI

Background

Buildings account for approximately 40% of energy consumption and 36% of all greenhouse gas emissions in the European Union.





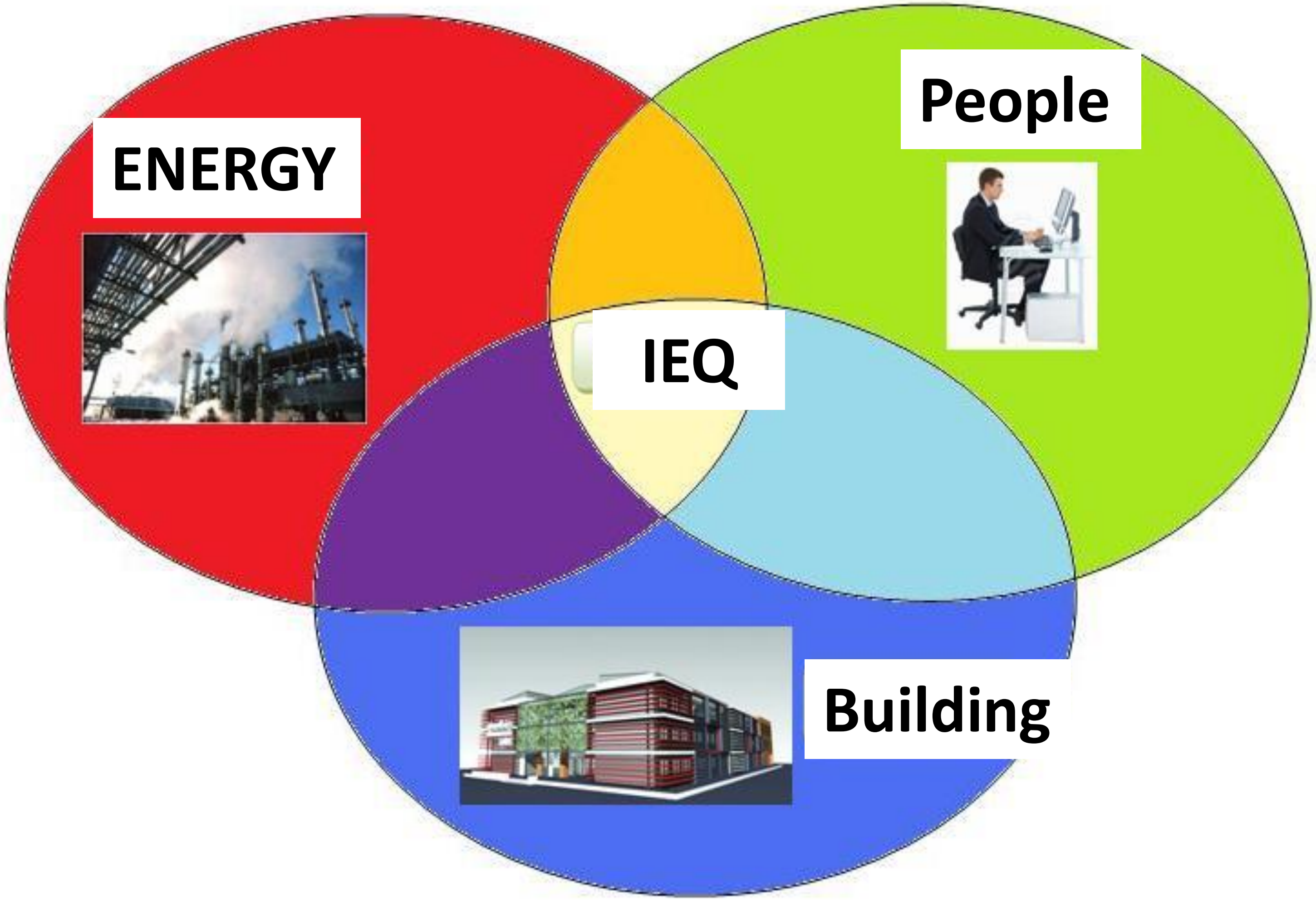
The EU's target (EPBD recast) is to build all the **new public building from 2019**, and all the **new buildings from 2021 on nearly zero energy level.**

News
European Parliament

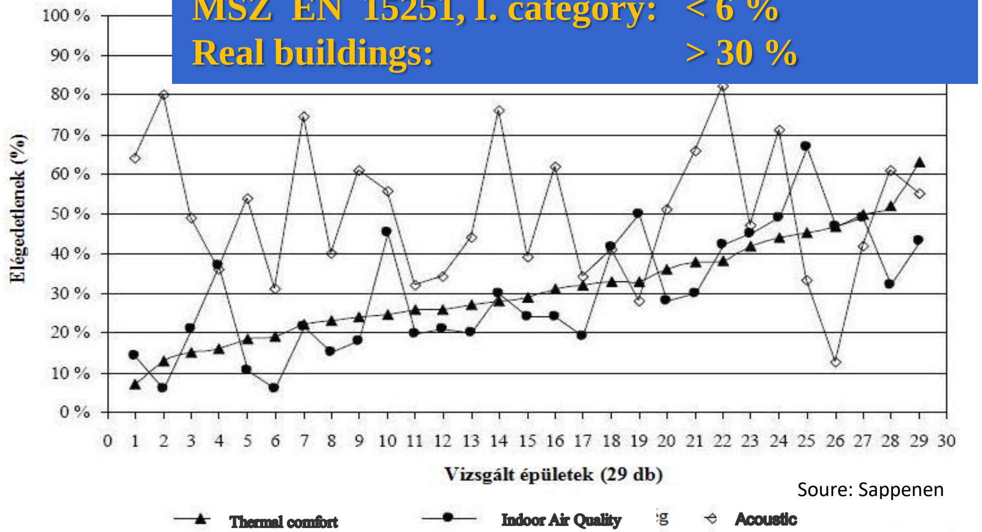
Cleaner energy: new binding targets for energy efficiency and use of renewables

Press Releases 28-11-2017 - 13:24

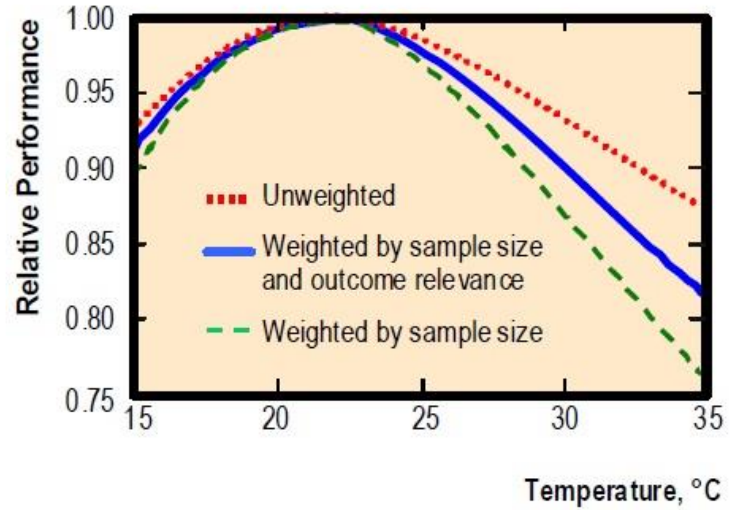
- EU energy consumption to be reduced by 40% by 2030
- At least 35% of all EU energy has to come from renewables by 2030
- Support for consumers who use self-produced energy


ENERGY
People
IEQ
Building

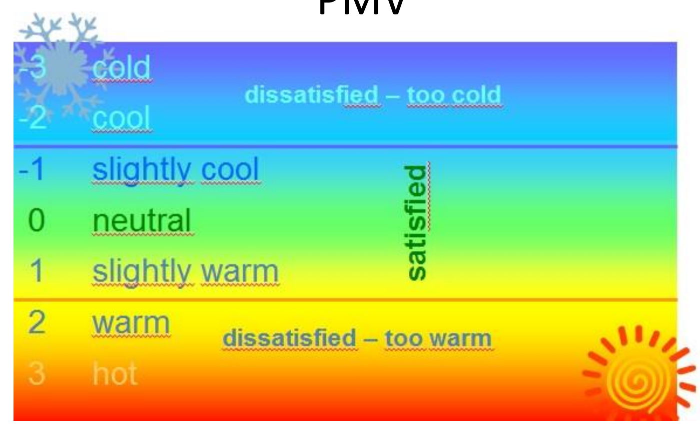
MSZ EN 15251, I. category: < 6 %
Real buildings: > 30 %



Soure: Sappenen



PMV



Better indoor climate – less energy

nZEB definition in the EPBD recast, 2010/31/EU

Article 2 of the EPBD recast:

Nearly zero energy building *means a building that has a very high energy performance, and the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.*

The EPBD recast does not provide exact definitions for the details, such as:

- The numerical requirement of the primary energy consumption
- The mandatory share of RES
- What exactly means nearby

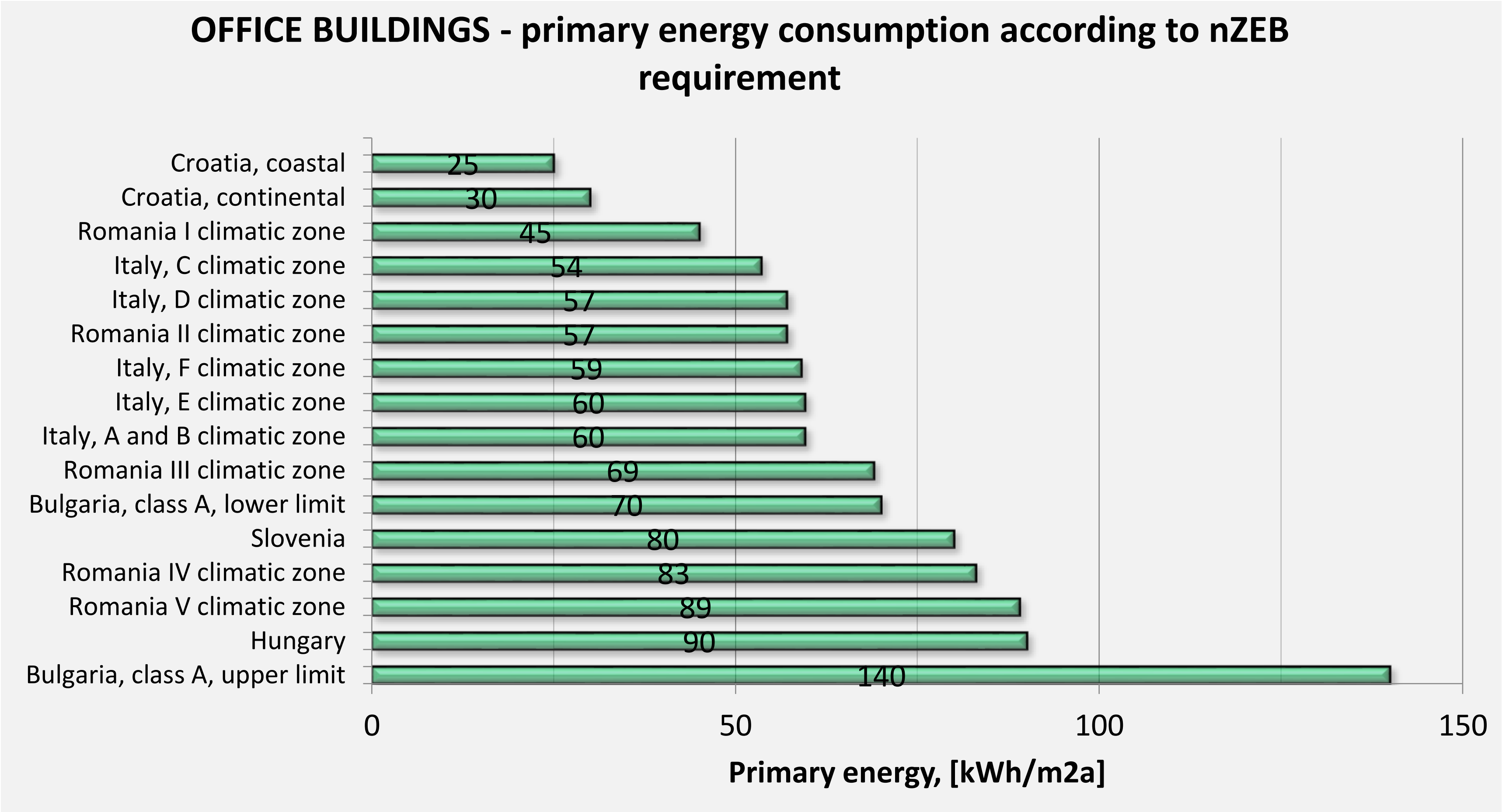
What is the proper „mix" of all these ideas, criteria we will be speaking about in the near future?

nZEB ≠ NZEB

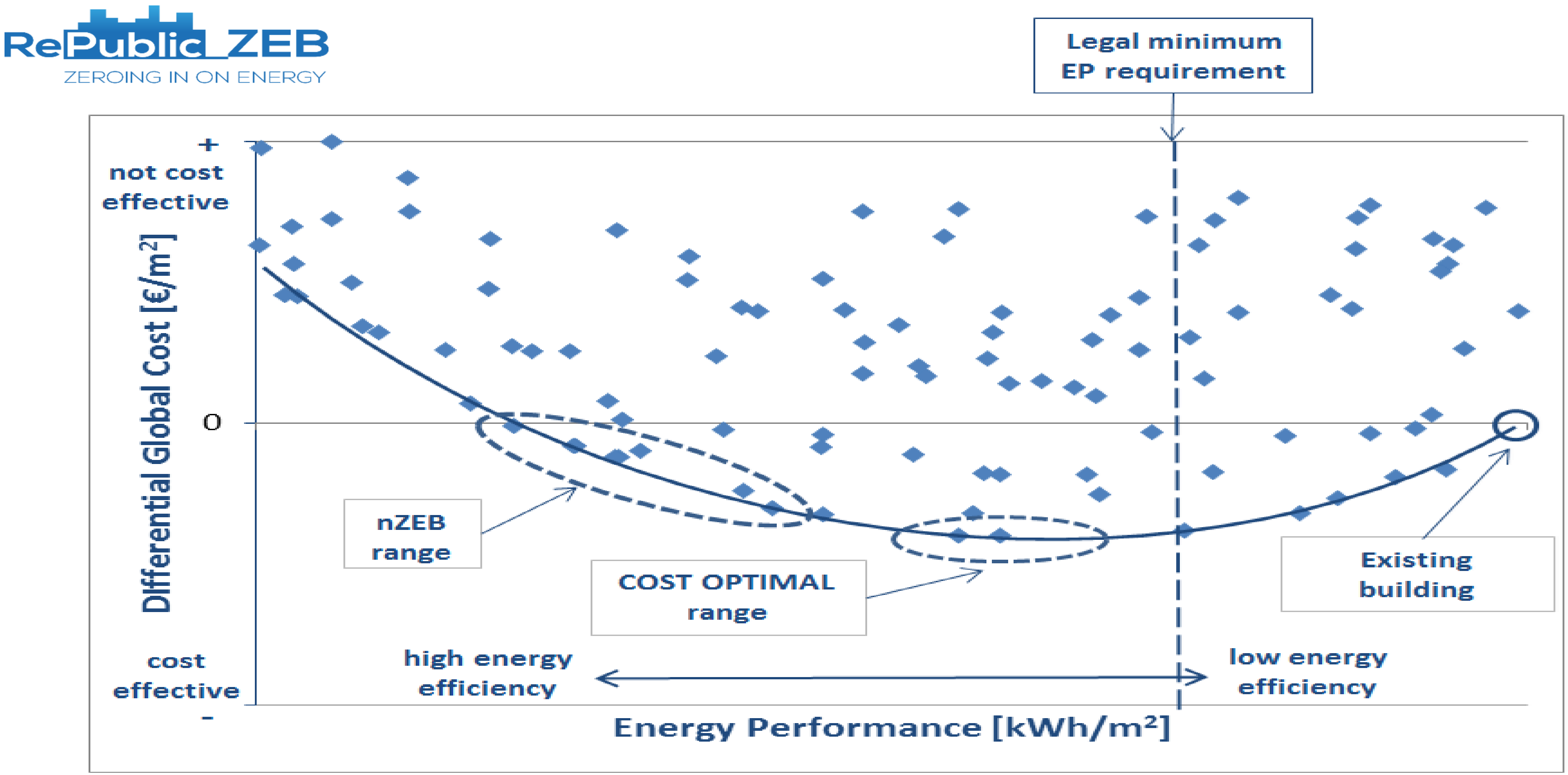
nearly Zero Energy Building	Net Zero Energy Building
Energy use > 0 $kWh/(m^2a)$	**Energy use = 0 $kWh/(m^2a)$**

- Proper building envelop
- Energy efficient HVAC systems
- Use of Renewable energies
- **Proper execution, installation**
- **Precise commissioning and operation**
- **Monitoring, inspection,…**

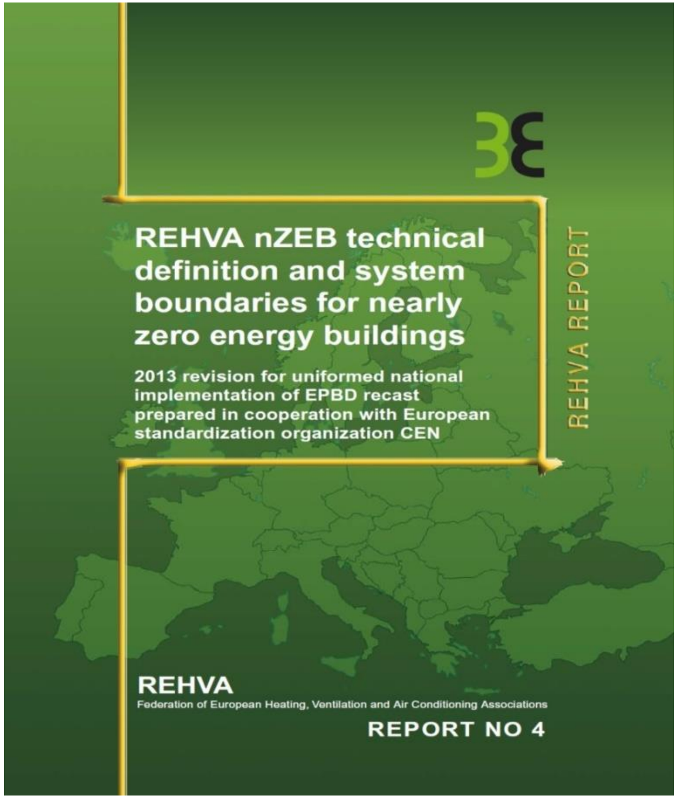
RePublic_ZEB
ZEROING IN ON ENERGY



RePublic definition for nZEB

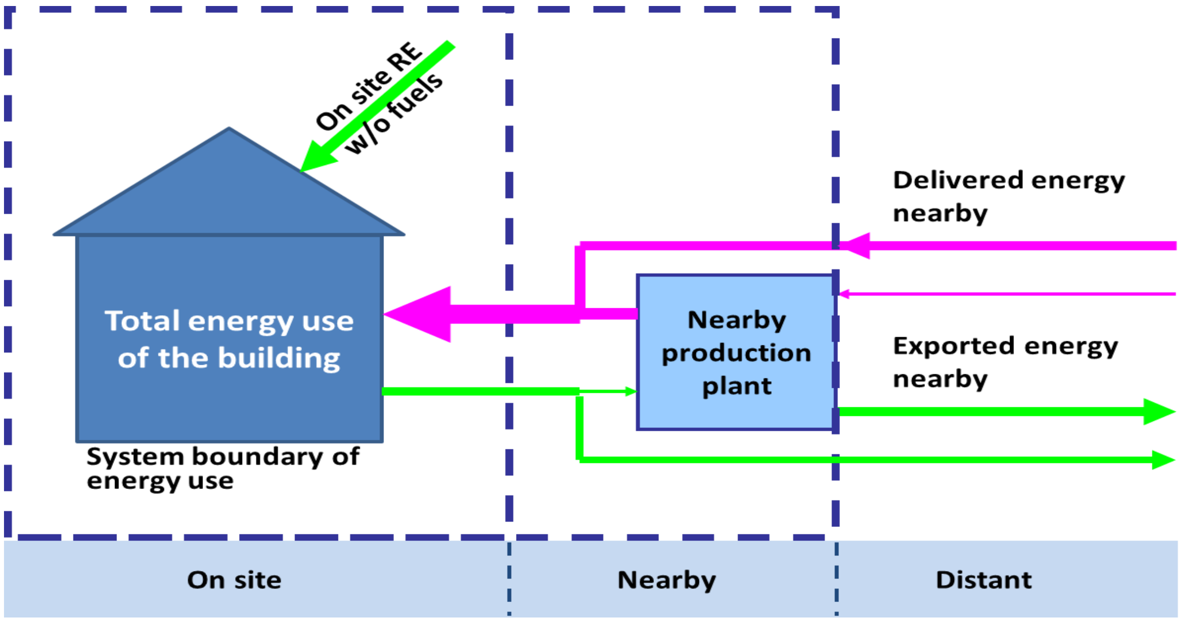


Criteria for definition of nZEB for public buildings

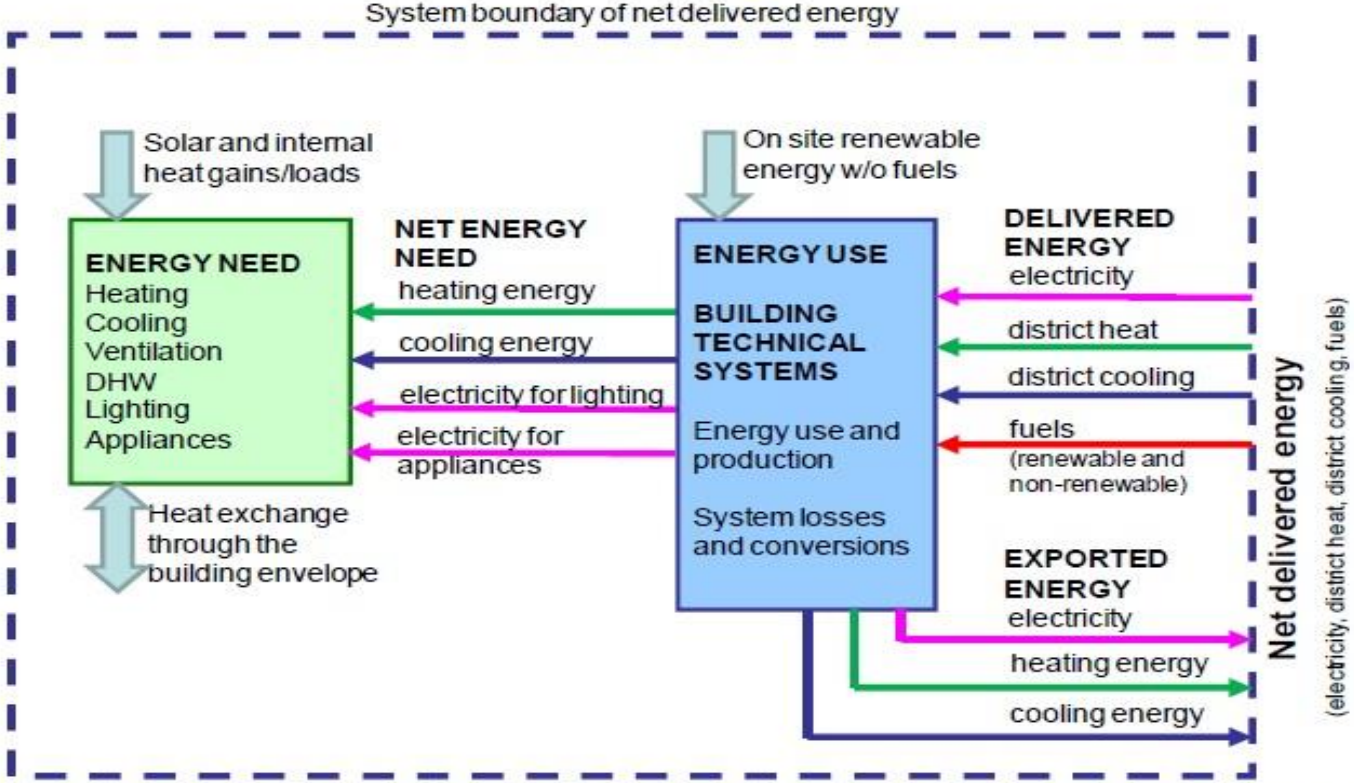


- ZEB, net ZEB, PEB and nZEB definitions
- A set of system boundaries to calculate:
  - Energy need
  - Energy use
  - Delivered and exported energy
  - Primary energy
  - Renewable energy ratio
  - Nearby energy production
  - Sites with multiple buildings

Nearly zero-energy buildings



nZEB – detailed system boundary

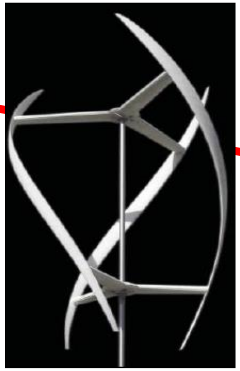


Energy boundary of net delivered energy. The box of "Energy need" refers to rooms in a building and both system boundary lines may be interpreted as the building site boundary.

What do we need to do?

Reduce energy needs to a minimum (like passive houses etc.).

Use clean, renewable energy to cover the remaining need for thermal energy (for heating and cooling).



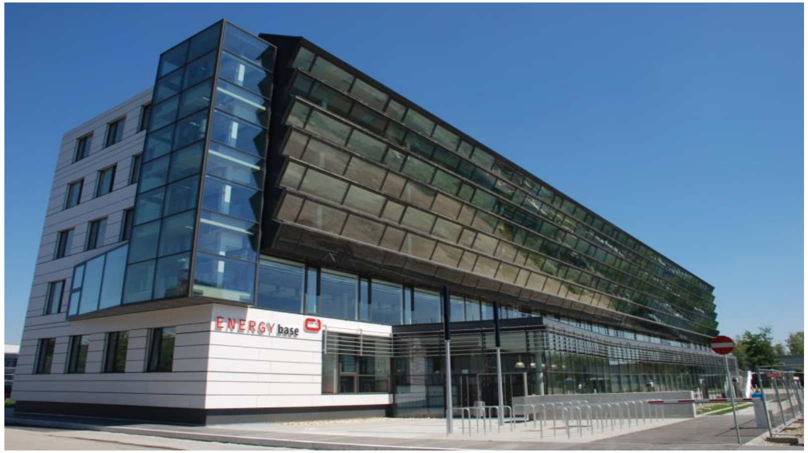
Use renewable energy to cover the need for electricity.

Consider embodied energy as well.

Source: Tor Helge Dokka, NTNU

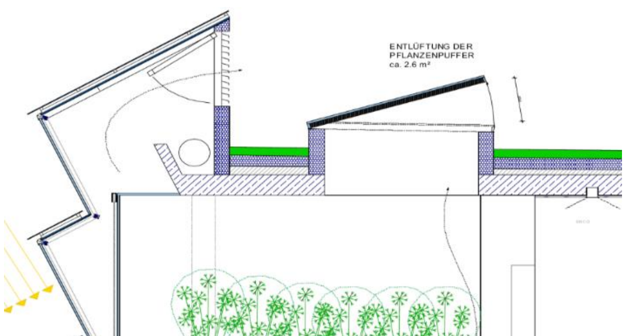
What do we get ?

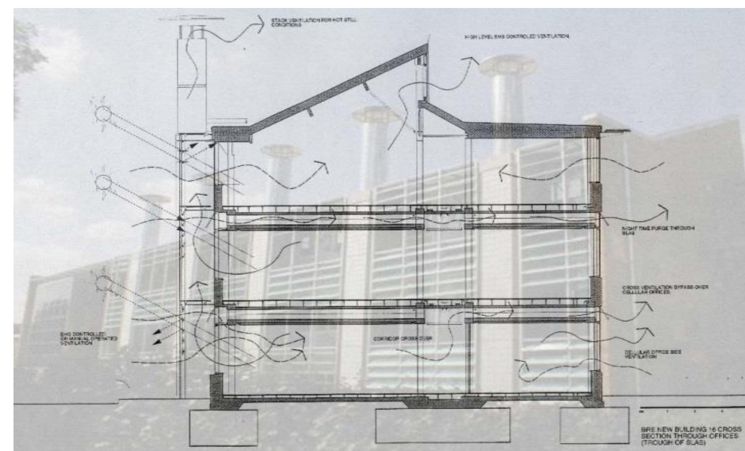
1. Buildings with (very) low energy use
2. Buildings, which consumes energy and generates (maybe) energy from renewable sources (”prosuming” buildings)
3. Buildings, in which the annual balance between consumption and generation is close to zero (near zero, net zero or plus)
4. Buildings, which is connected to energy infrastructure and interact with it



EnergyBase, Vienna

BRE, UK





12 MW photovoltaic system SEAT car manufactory, Martorell, Spain

Deep renovation of residential building into nZEB
More than 60% heating energy saving
More than 30,000 kWh/a electricity production
Primary energy (Ep): 199,6 → 75,7 kWh/m²a

Revised EPBD - 19. June 2018

- Directive (EU) 218/844 amending Directive 2010/31/EU (EPBD)
- Main objectives of the revised EPBD are:

1. Creates a clear path towards a decarbonised building stock in the EU by 2050.
2. Integrate and strengthens long term building renovation strategies.
3. Encourages the use of information and communication technology (ICT) and smart technologies to ensure buildings operate efficiently (eg. introducing automation and control systems).
4. Introduces a Smart Readiness Indicator (SRI).

Revised EPBD - 19. June 2018

5. Supports the rollout of the infrastructure for e-mobility in all buildings (recharging points for electric vehicles in new buildings and buildings undergoing major renovation).

6. Mobilises public and private financing and investment (e.g. the aggregation of projects, including by investment platforms or groups, and by consortia of SME-s, to enable investor access as well as packaged solutions for potential clients)

7. Helps combatting energy poverty and reducing the household energy bill by renovating older buildings.

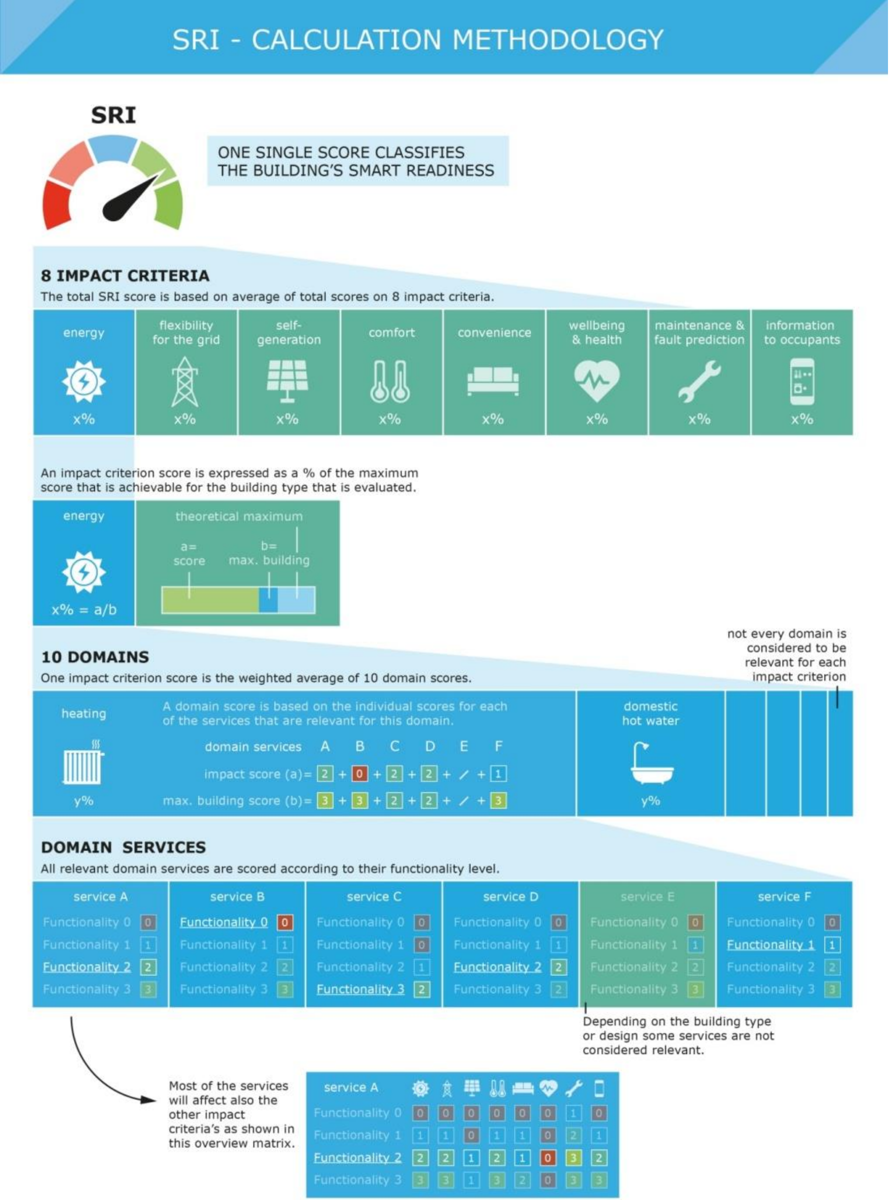
Revised EPBD - 19. June 2018

Long-term building renovation strategy

- Each Member State (MS) shall establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into **a highly energy efficient and decarbonised building stock by 2050.**
- In the strategy Each MS shall set out a **roadmap** with measures and measurable progress indicators. The roadmap shall include indicative **milestones for 2030, 2040 and 2050**.
- The strategy is in relation with the long-term 2050 goal of **reducing greenhouse gas emissions in the EU by 80-95% compared to 1990**.
- Facilitates the cost-effective transformation of existing buildings into **nearly zero-energy buildings**.

Smart Readiness Indicator (SRI)

- By 31 December 2019 the Commission shall adopt a delegated act by establishing an **optional common Union scheme for rating the smart readiness of buildings**.
- The rating shall be based on an assessment of the capabilities of a building or building unit to adapt its operation to the needs of the occupant and the grid and to improve its energy efficiency and overall performance.



8 impact categories:

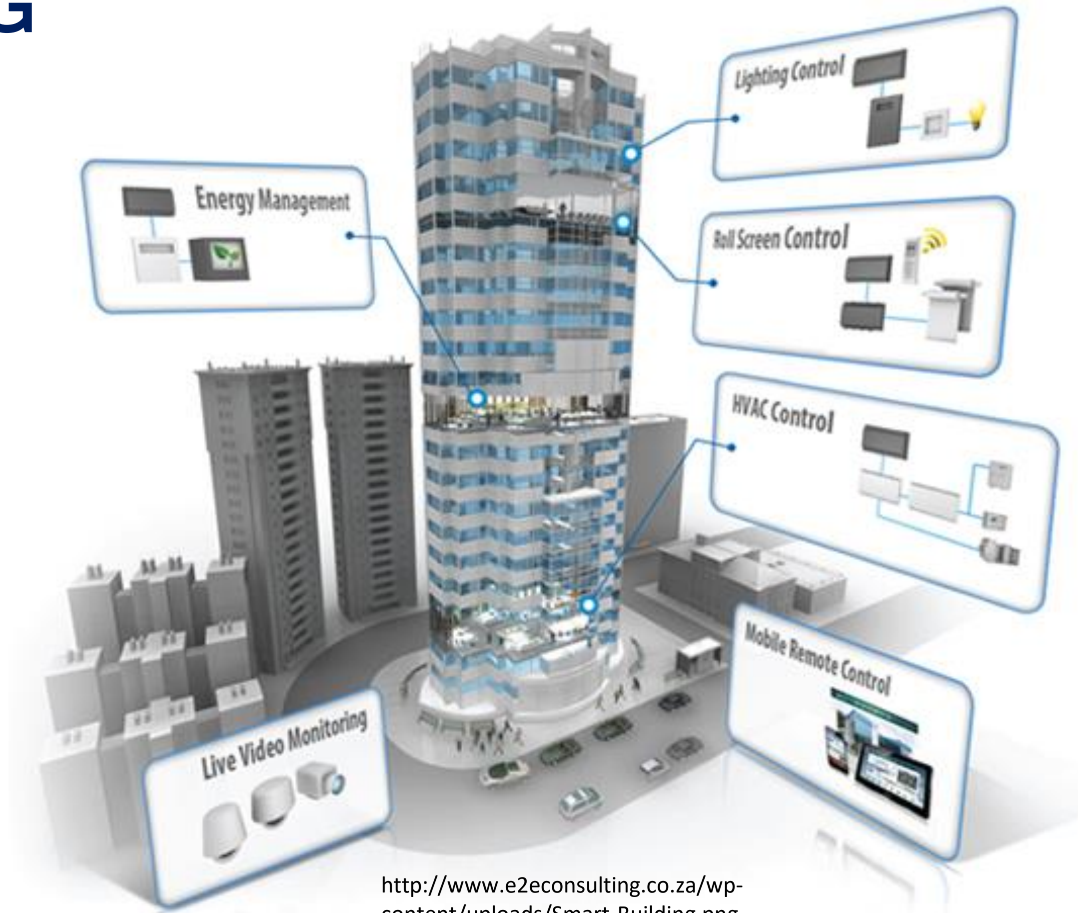
1. Energy savings on site
2. Flexibility for grid and storage
3. Self energy-generation
4. Comfort
5. Convenience
6. Well-being and health
7. Maintenance and fault prediction, detection and diagnosis
8. Information to occupants

SMART BUILDING

- Building envelope
- HVAC
- Informatics
- Energy management

+

- Lighting control
- HVAC control
- Security check
- Mobile remote control



http://www.e2econsulting.co.za/wp-content/uploads/Smart-Building.png

SMART CITY

http://www.konsys-international.com/images/landscape-smart-cities.jpg

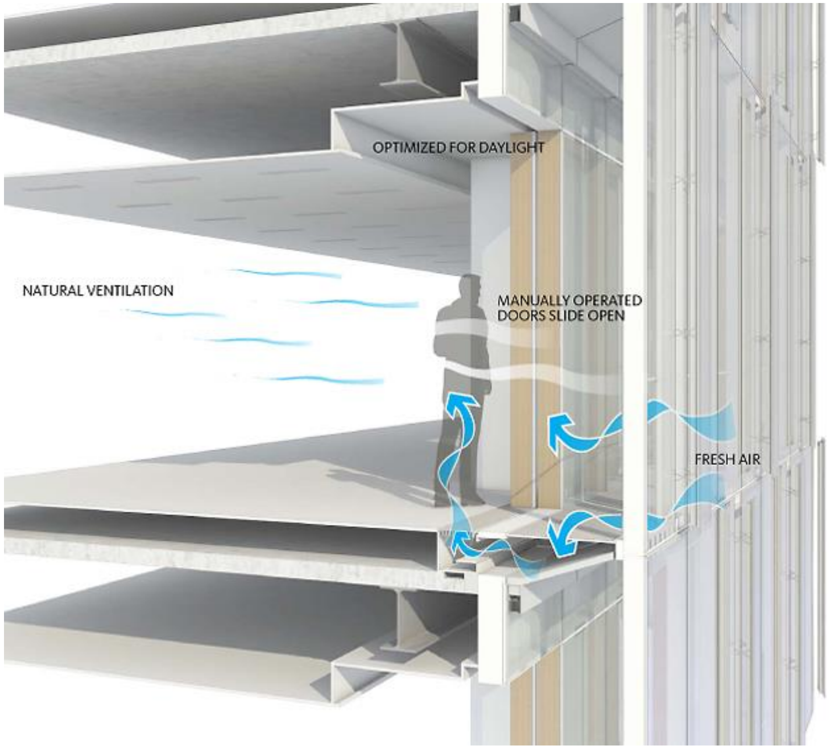
Smart buildings

- Adapt the operation to the needs of the occupants (eg. control of HVAC and lighting systems).
- Adapt the operation to the needs of the grid (eg. demand response, smart meter).
- Smart buildings use information and communication technologies and electronic systems to adapt the operation of buildings to the needs of the occupants and the grid (e.g. building automation system accessible via the internet).

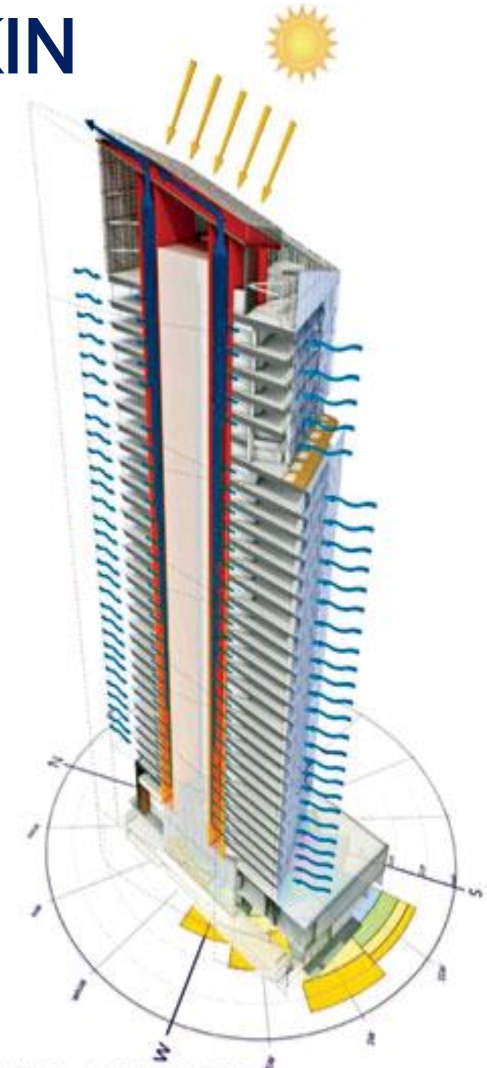
PNC Plaza, Pittsburg, USA

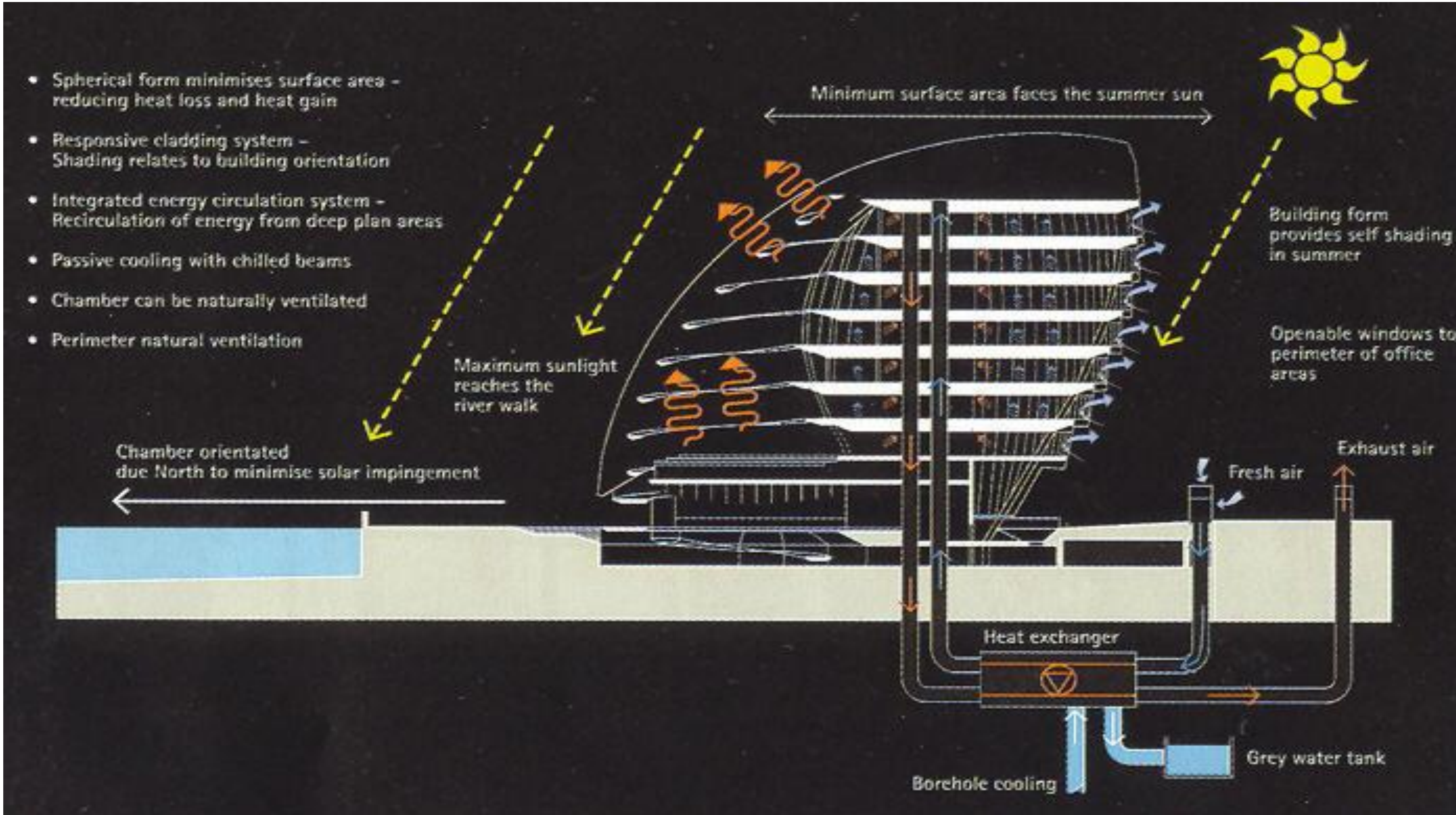
SMART SKIN

http://corporate.ppg.com/getmedia/6412a6f6-db79-442d-8724-92b7635022bb/TowerAtPNCPlaza_PPG_FifthAvenueS.jpg.aspx



http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2012/11/The-Tower-at-PNC-Plaza-Genlser-8.jpg





• Spherical form minimises surface area - reducing heat loss and heat gain
• Responsive cladding system - Shading relates to building orientation
• Integrated energy circulation system - Recirculation of energy from deep plan areas
• Passive cooling with chilled beams
• Chamber can be naturally ventilated
• Perimeter natural ventilation
Minimum surface area faces the summer sun
Building form provides self shading in summer
Openable windows to perimeter of office areas
Maximum sunlight reaches the river walk
Chamber orientated due North to minimise solar impingement
Exhaust air
Fresh air
Heat exchanger
Grey water tank
Borehole cooling

Heating and cooling systems

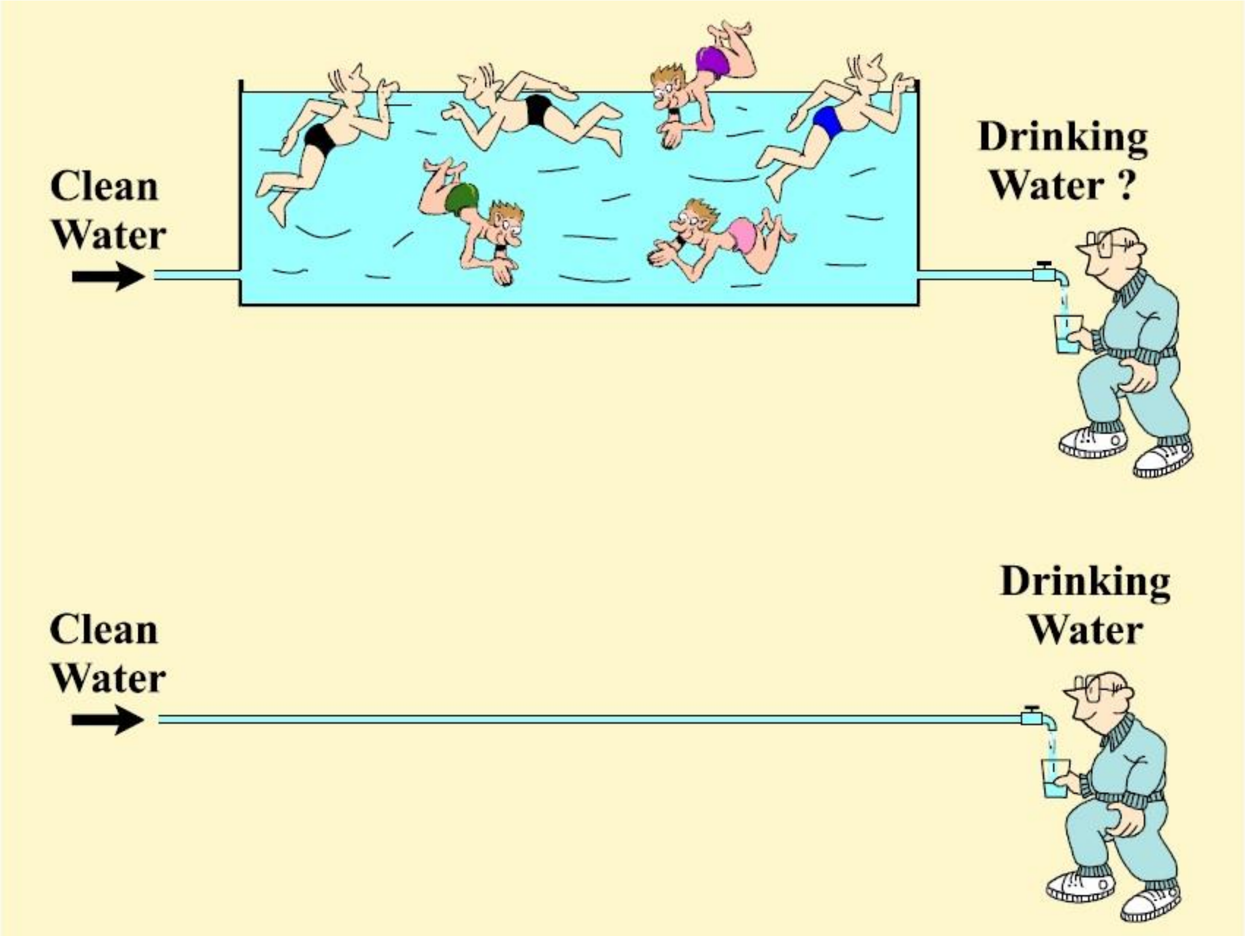
- Weather-based heating supply temperature control (outdoor temperature, wind).
- Intelligent thermostat: the self-learning thermostat takes into account the room's thermal characteristics to determine the time required for heating / cooling the room at a given temperature, and learns with presence attitudes to find out during which periods occupants in the building, thereby optimizing energy consumption for heating and cooling.

- Automatic operation of shutters in accordance with heating and cooling systems, and depending on external influences (eg. solar radiation intensity on the façade, nighttime thermal protection below a given outdoor temperature).
- Monitoring and analysis of heating energy consumption based on heating degree day and other data (benchmarking).
- Consideration of the dew point temperature in the operation of the cooling system.
- Window opening detection: heating / cooling system + protection against intrusion.
- Taking into account the possibility of free cooling (eg. if the outside temperature is below the room temperature by 6°C).

Ventilation system

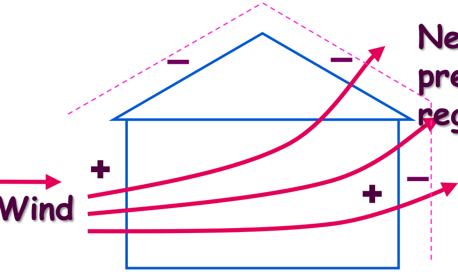
- Using of mechanical ventilation systems with heat recovery.
- Using a Variable Air Volume systems: fresh air volume changes automatically depending on the presence, CO_2 concentration, or humidity.
- Registering and displaying Indoor Air Quality (IAQ) parameters for users: indoor temperature, relative humidity, CO_2, VOC.
- Free cooling: 100% outdoor air operation below a given outdoor temperature.

Source: Bjarne Olesen, DTU, Denmark



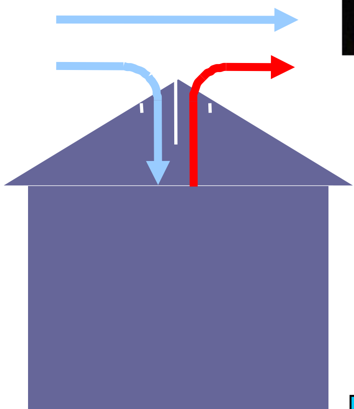
Source: Bjarne Olesen, DTU, Denmark

Wind Driven Ventilation



Wind driven flow

Wind tower



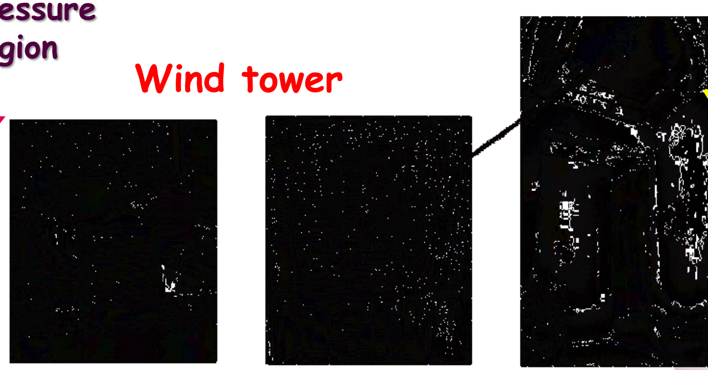
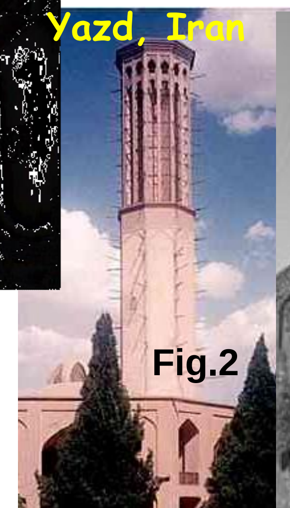
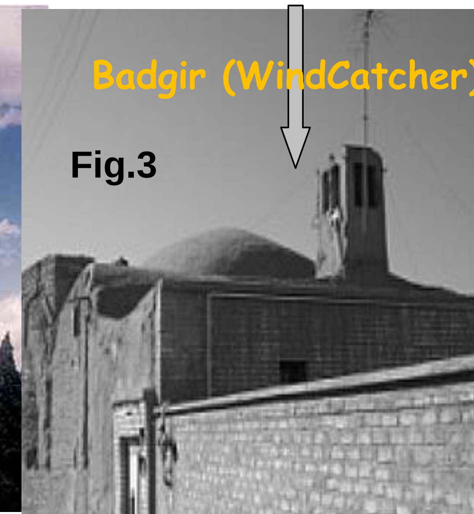


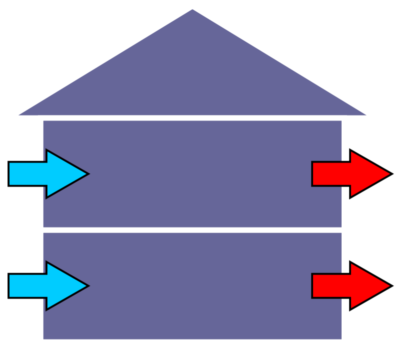
Fig.1 (a,b,c)

Yazd, Iran





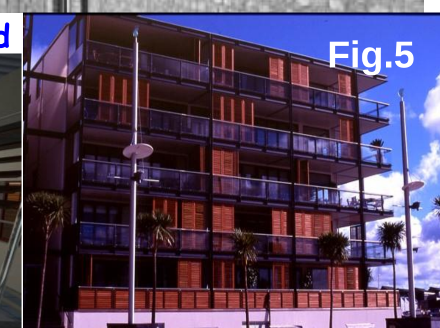
Cross Flow Wind



$$p_w = C_p \rho v^2 / 2$$

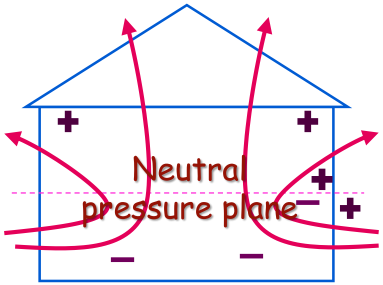
IUT building La Réunion Island

Natural ventilation cross tropical climate



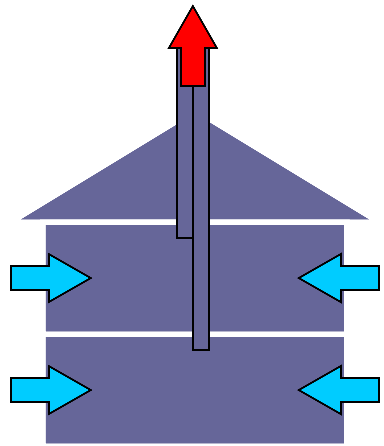
Natural ventilation system single sided type tropical climate

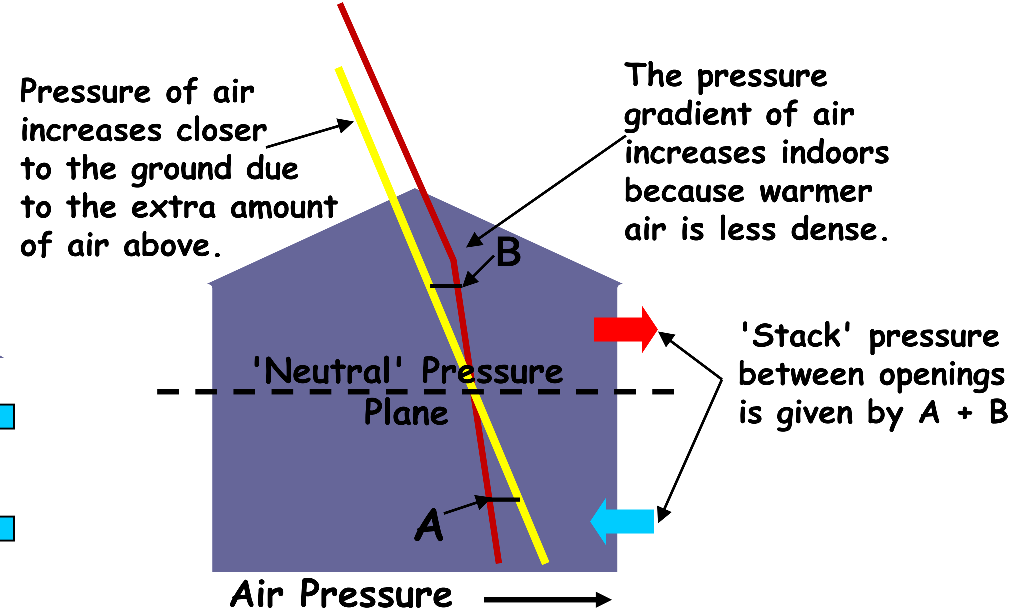
Stack Driven Ventilation



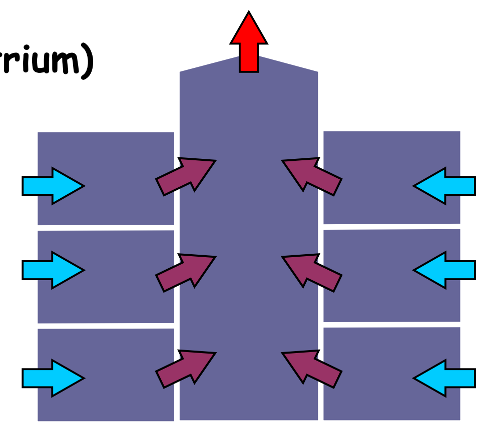
Temperature driven flow

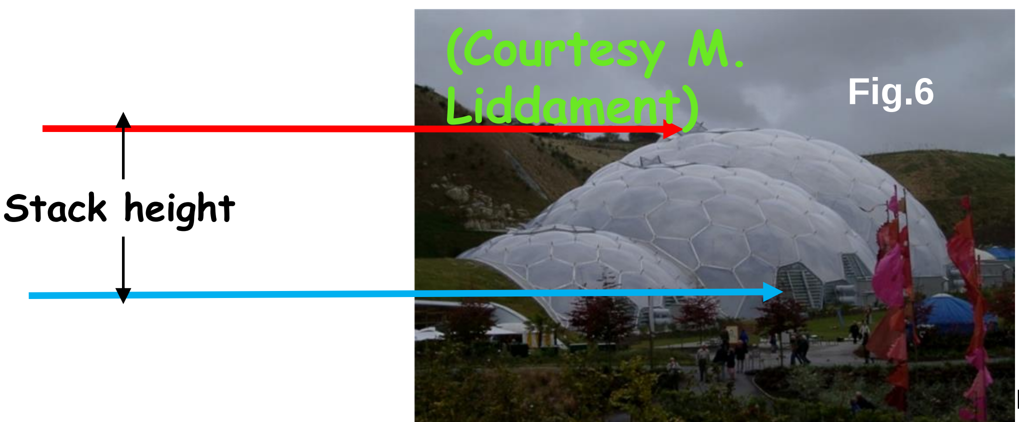
Stack (Flue)





Stack (Atrium)





Denma

Lighting system

- LED light fixtures - longer life, adjustable illumination, lower energy consumption up to 60%.
- Controlling the brightness of lamps based on the outdoor illumination or according to the occupants' needs.

Smart metering

- The smart meter is suitable for transmitting and receiving data.
- The data covers the amount of consumption and the price of the service used.
- Provides real-time information on the use of the service for both consumers and service providers.
- Consumers can keep track of their current consumption and change it based on the data.

Recharging points for electric vehicles

- The revised EPBD encourages the use of electric vehicles.
- In new buildings and buildings undergoing major renovation, recharging points for electric vehicles must be provided, when the conditions set out in the EPBD are met.

Energy audit

- **Energy audit** is mandatory and regular for large enterprises, as energy savings can be significant according to EED, i.e. **Directive on Energy Efficiency, 2012/27/EU.**

- Enterprises that are not SMEs had to make energy audit by 5 December 2015 and shall make it at least **every four years** from the date of the previous energy audit.

- Relevant standard for building energy audit is EN 16247.

Minimum criteria for energy audits:

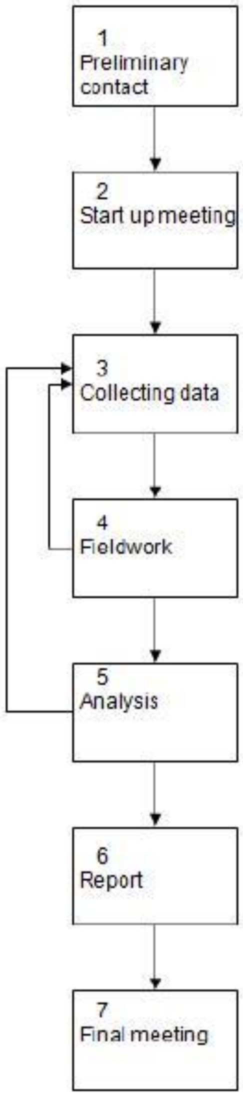
- **Measured, traceable operational data on energy consumption** and (for electricity) load profiles.
- **Detailed review of the energy consumption profile** of building, industrial operations , including transportation.
- **Whenever possible it is built on life-cycle cost analysis (LCCA)** in order to take account of long-term savings, residual values of long-term investments and discount rates.
- **Proportionate, and sufficiently representative** to permit the drawing of a reliable picture of overall energy performance and the reliable identification of the most significant opportunities for improvement.

Packages of standards for energy audits

- EN 16247-1 Energy audits. Part 1:General requirements
- EN 16247-2 Energy audits. Part 2: Buildings.
- EN 16247-3 Energy audits. Part 3: Processes
- EN 16247-4 Energy audits. Part 4: Transport.
- EN 16247-4 Energy audits. Part 5: Competence of energy auditors.

The process of the energy audit

- **Preliminary contact** between the auditor and the organization: fixing the subject of the audit, objectives, depth and accuracy of the audit.
- **Start up meeting** on the practical implementation of the audit: names of responsible persons, safety and security rules, work schedules, etc.
- **Collecting data**: relevant executive or implementation plans, documents, energy consumption, monitoring data, etc.
- **Fieldwork:** necessary on-site surveys and measurements.
- **Analysis**: existing energy performance, possibilities for increasing energy efficiency and their evaluation.
- **Report**: Presentation of the process and results of the prepared energy audit.
- **Final meeting**: presentation of the audit report.



Energy audit – case study

Energy audit – case study

- Date of construction: from 1993, several phases
- The useful floor area of the plant is currently ~ 42,000 m^2
- 9 production halls + their warehouses
- 7 serving buildings (office, social block, etc.)

Existing status

Building envelope

- Wall : U=0,58 Wm2K
- Roof: U=0,39-0,45Wm2K
- Doors and windows:
  - new 1,15-1,5 W/m^{2}K
  - old: 3,5-5 W/m^{2}K

Heating

Workshops

- Central heating: 1120 kW low temperature boiler + 700 kW oil boiler. Blow heaters. Control with non-programmable thermostats.
- Gas fired blow heaters. Control with programmable thermostats.

Existing status

Heating

Office building:

- Air/water heat pump
- Underfloor, wall and ceiling heating/cooling system
- variable speed pump

Social building:

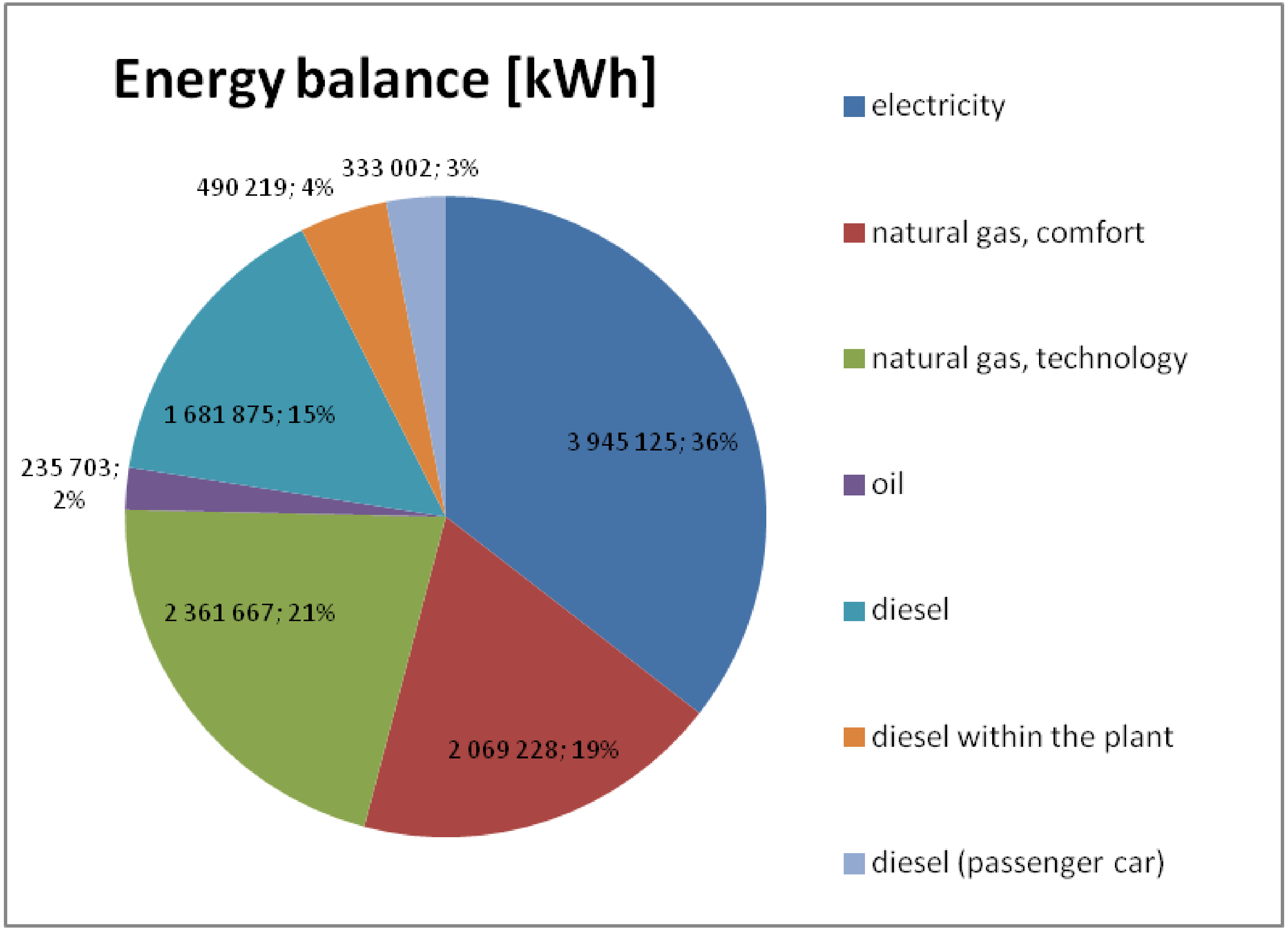
- 24 kW condensing boiler
- underfloor heating system with programmable room thermostats
- variable speed pump

Lighting

- Typical light fixtures in the halls:
  - Mercury-vapor lamps
  - fluorescent lamps
- The energy demand of lighting is about one-third of the total electricity demand.
- Within the lighting energy demand, the demands of the production halls are significant.

Technological consumers

- Folding machines
- Welding machines
- Robots
- Painting cabins
- Compressors
- …

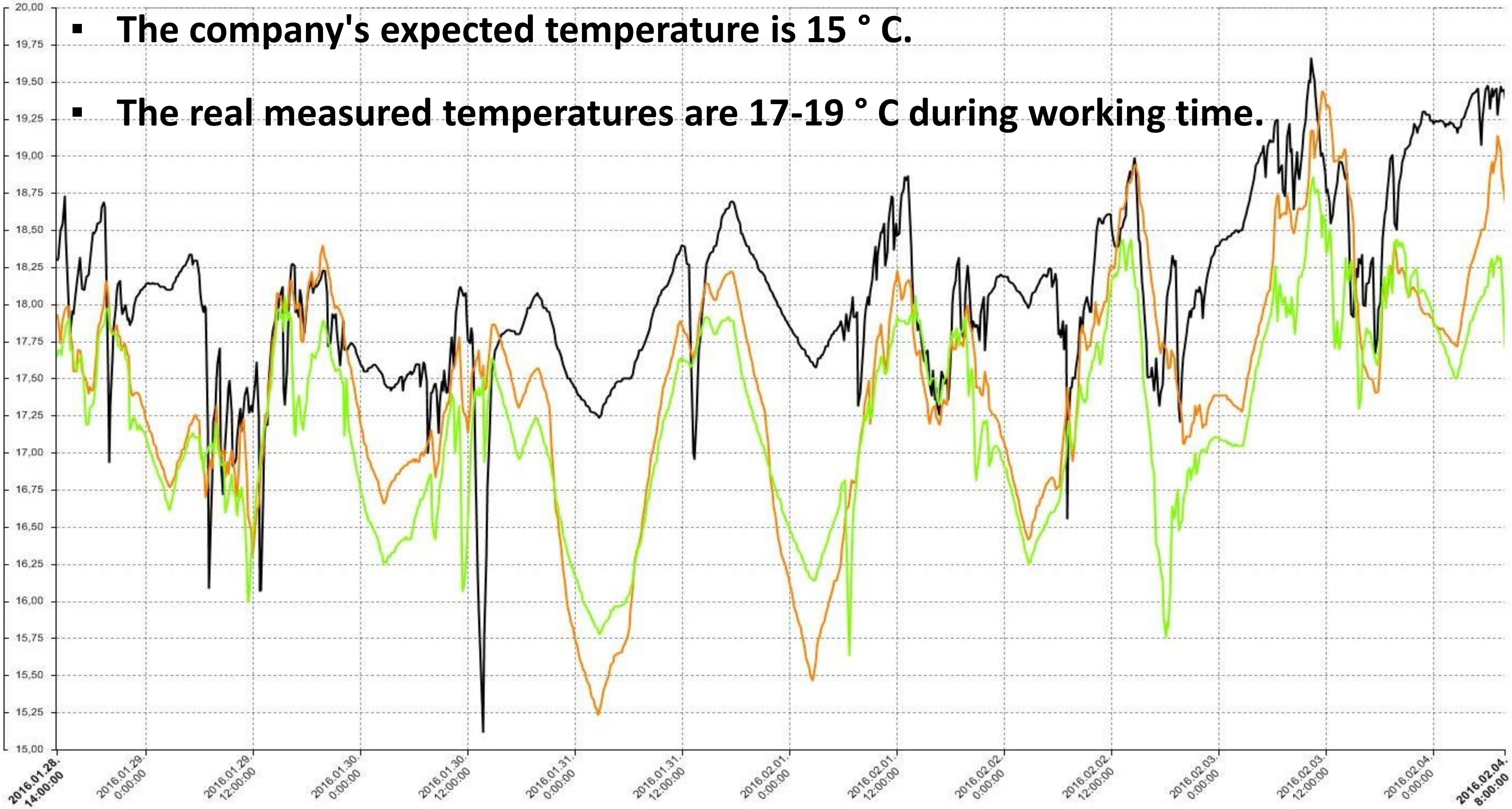

Energy balance [kWh]
333 002; 3%
490 219; 4%
1 681 875; 15%
3 945 125; 36%
235 703; 2%
2 361 667; 21%
2 069 228; 19%
electricity
natural gas, comfort
natural gas, technology
oil
diesel
diesel within the plant
diesel (passenger car)

Indoor temperature measurements

- Temperature dataloggers
- Measuring time: in every 10 minutes for 2x1 weeks
- Total 13 places were measured
- Measuring instruments used:
    - KIMO KH-100
    - KIMO KH-110

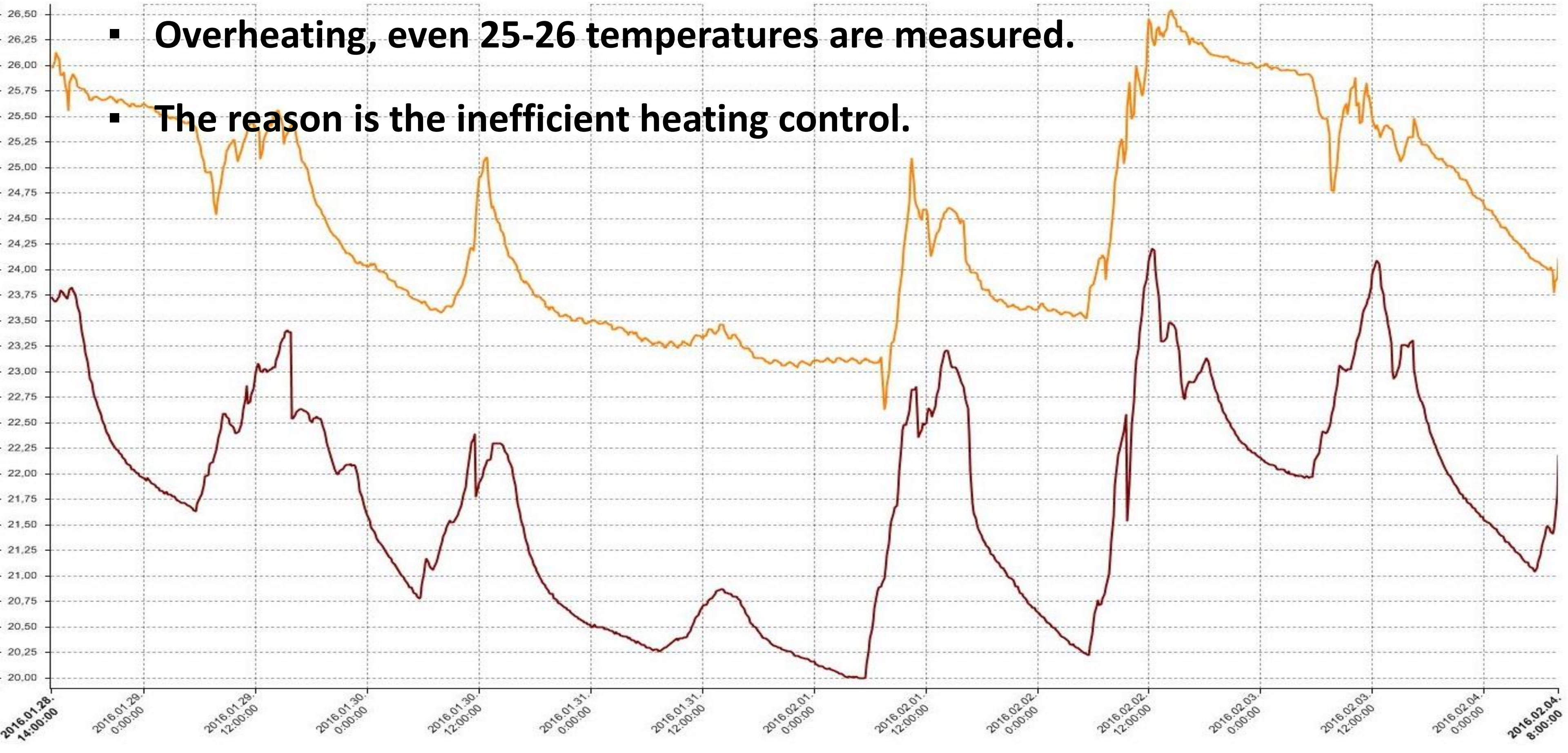
Overheating in the production halls

- **The company's expected temperature is 15 ° C.**
- **The real measured temperatures are 17-19 ° C during working time.**



Overheating in the offices

- **Overheating, even 25-26 temperatures are measured.**
- **The reason is the inefficient heating control.**



Indoor air quality measurements

- During the site visits, the air quality is measured:
  - Temperature [°C]
  - Relative humidity [RH%]
  - CO_2 concentration [ppm]
- The CO_2 concentration in the halls were good, while in the offices was high due to the lack of mechanical ventilation system and inefficient natural ventilation

Nr.	Place of measurement	Temperature [°C]	Relative humidity [RH%]	CO_2 concentration [ppm]
1.	„G1" workshop	18,6	48,3	488
2.	„G2" workshop	18,4	48,5	530
3.	Outdoor	10,3	69,3	402
4.	„F" painting workshop	17	49,3	539
5.	„F" component painting workshop	16,8	53,5	440
6.	„I" workshop	18,5	48,3	420
7.	„D" workshop, 1.	15,4	59,9	581
8.	„D" workshop, 2.	16,4	55,9	547
9.	„E" workshop	15,9	57,1	580
10.	„D" workshop, 3.	15,2	59,5	500
11.	„B" service station	14,5	69,3	612
12.	„B" brake testing workshop	16	63,6	453
13.	„C" warehouse	15,8	59,7	593
14.	„B" canteen	18,8	61	403
15.	**„A" office, groundfloor**	22,1	45,4	**1720**
16.	„A" office, 1st floor	21,2	46,8	950
17.	**„I" office, groundfloor**	21,8	43,8	**1280**
18.	**„I" office, 1st floor**	20,1	47	**1650**

Development opportunities

Nr.	Development	Investment cost [HUF]	Payback time (year)
1	Reduce of contracted electric capacity	0	Immediatly
2	Programmable thermostats in G, F workshops	60 000	<1 year
3	Minimizing leaks in the compressed air systems, consumers should be excluded if they are not in use.	900 000	<1 year
4	Instlling LED light in the workshops	76 200 000	3,1
5	"D" workshop, compressor waste heat recovery for DHW production	3 750 000	7
6	Condensing boiler for social block in G workshop	3 800 000	7,6
7	Condensing blower heater in G workshop	23 000 000	17,6
8	Photovoltaic system	177 000 000	22,2

Thank you for your attention!

Dr Magyar Zoltán

Tel: +36-30-964-2500

zmagyar@invitel.hu