



REHVA Seminar: Operation of Energy Efficient Buildings

Heating of Energy Efficient Buildings

Learning Objectives

- 1. Distinguish the different heating systems and select the most adequate one for a given building, taking into account the building, its use and the local weather characteristics.
- 2. Analyse the heating billing histories and define the best corrective measures to reduce the related energy demand
- 3. Explain the main influences of the occupants' behavior on the energy performance of a building
- 4. Distinguish the impact of the human factors on the energy demand and on the indoor environmental quality of a building
- 5. Define accurately the ventilation requirements of a building, using both prescriptive or analytic methods.
- 6. Identify the possible gains resulting from the use of a modulated infiltration rate on a nearly zero energy building

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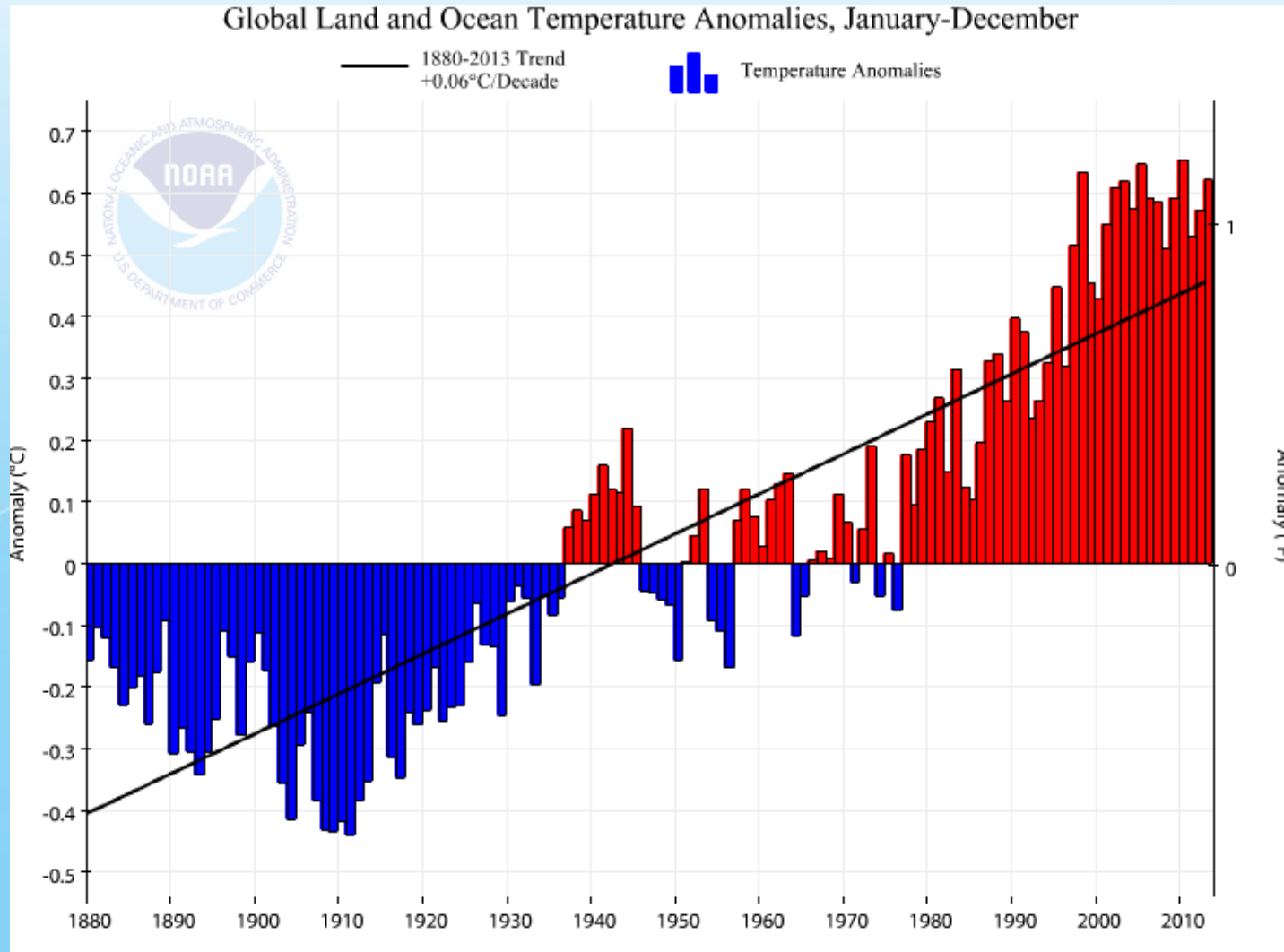
Outline/Agenda

- Climate changes and energy performance of buildings – EU approach
- Heating of energy efficient buildings in european continental climate
- Case study – refurbished office building



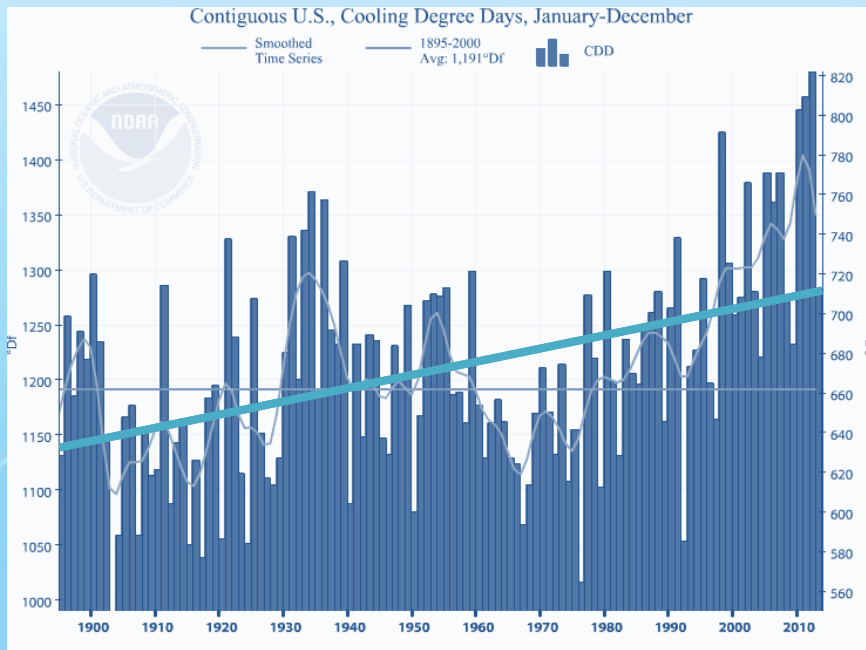
CLIMATE

Global warming...

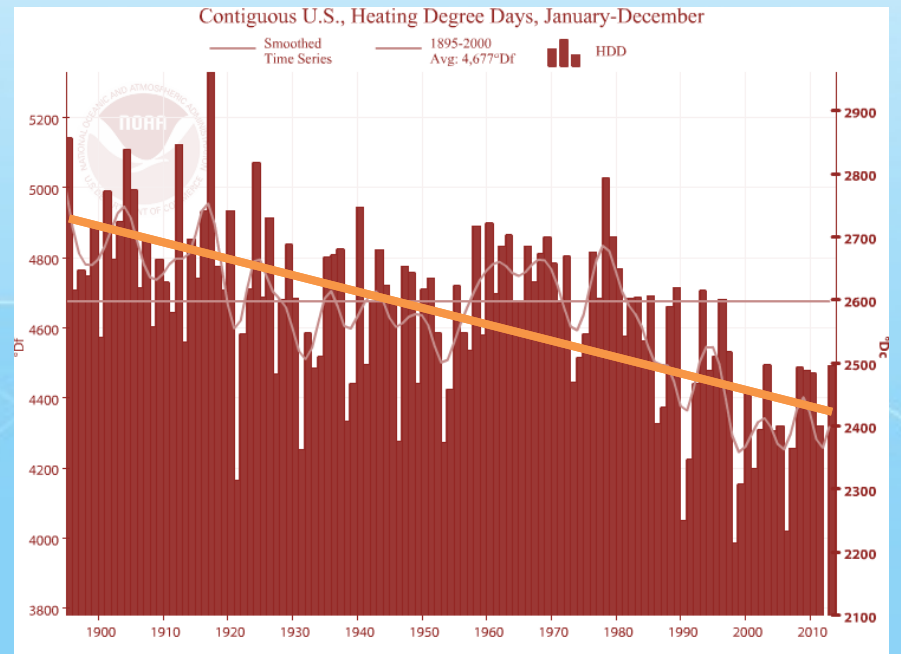


Global warming...

Cooling degree days

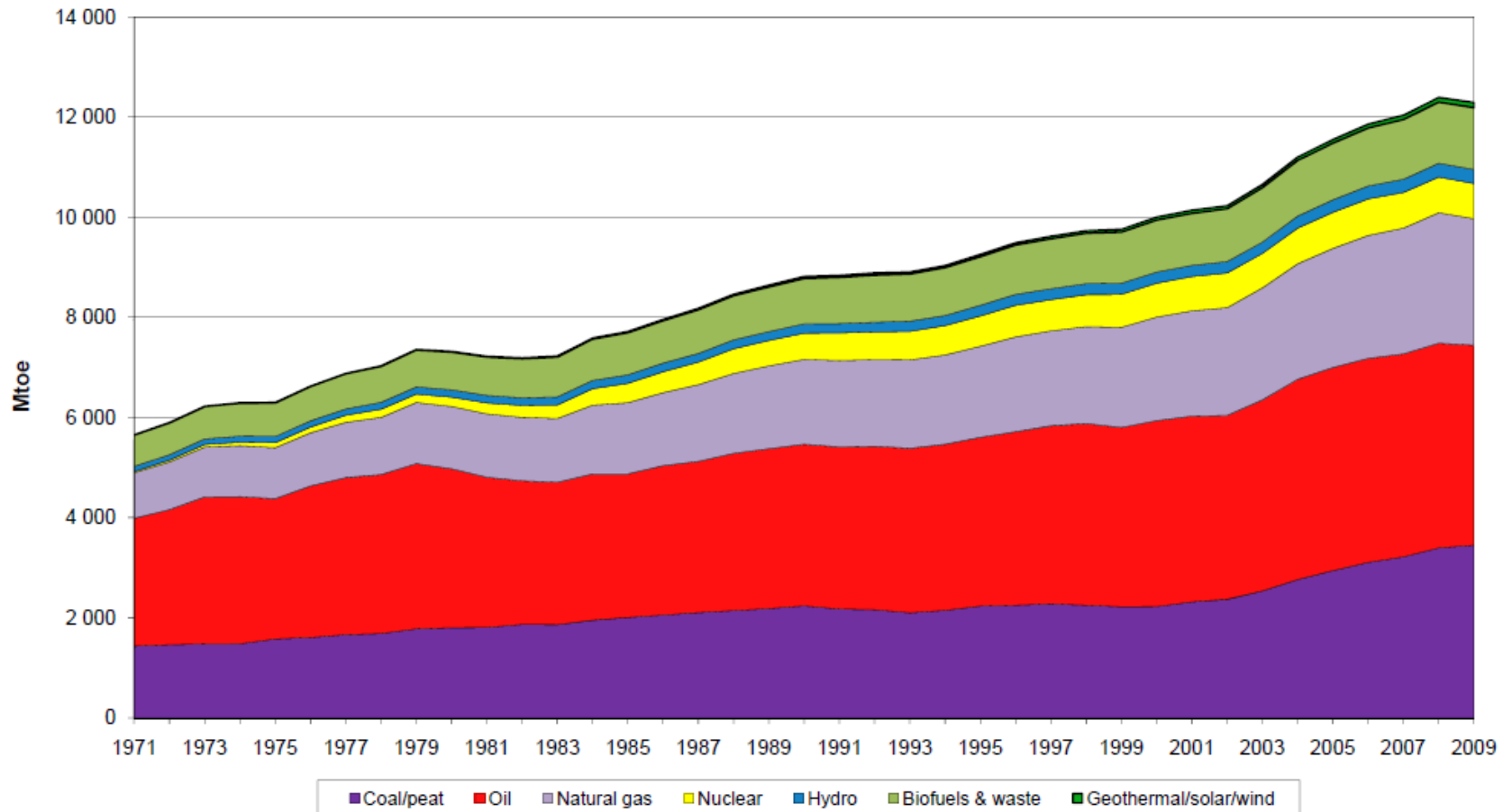


Heating degree days

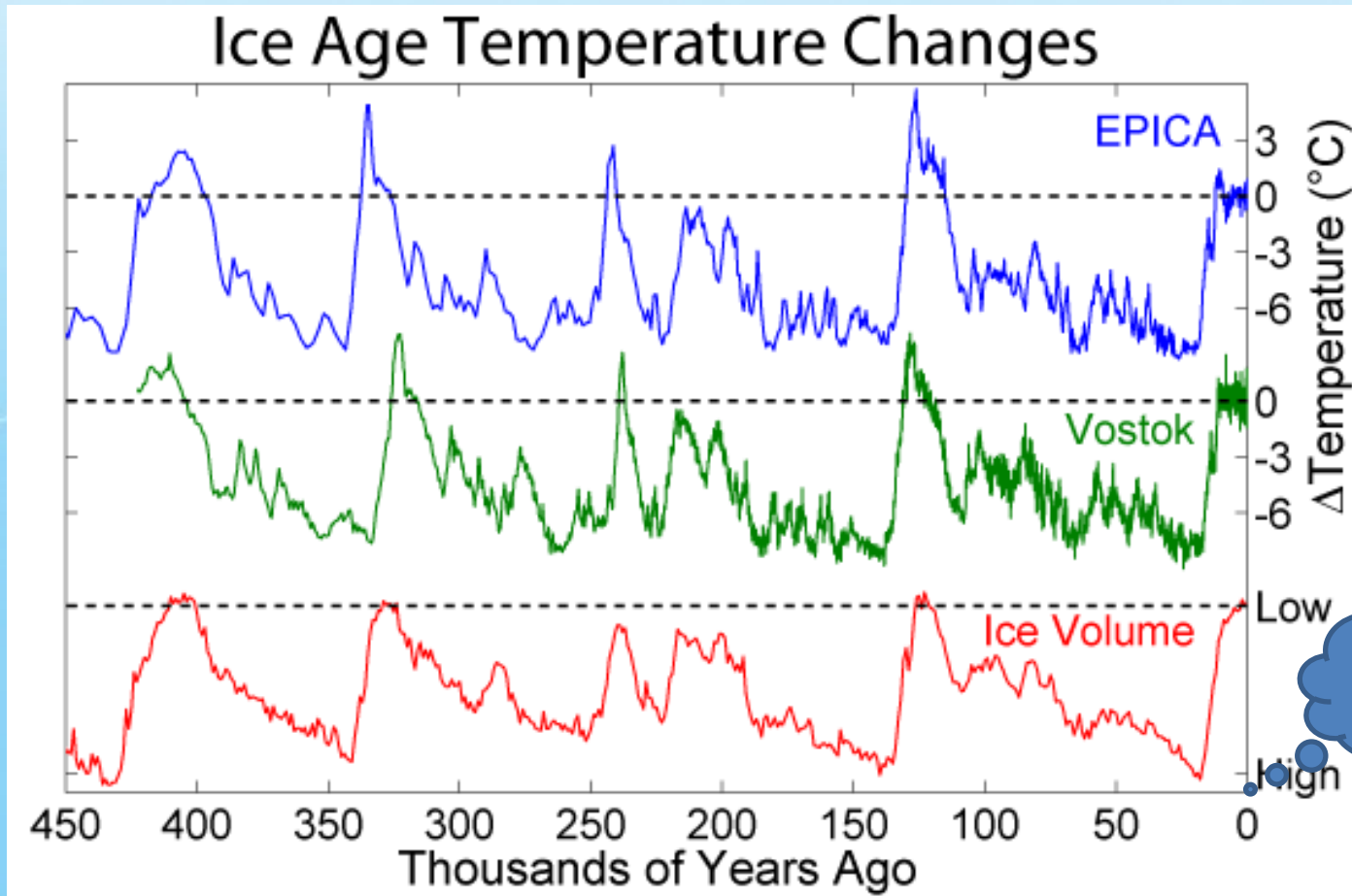


1880 – 2014

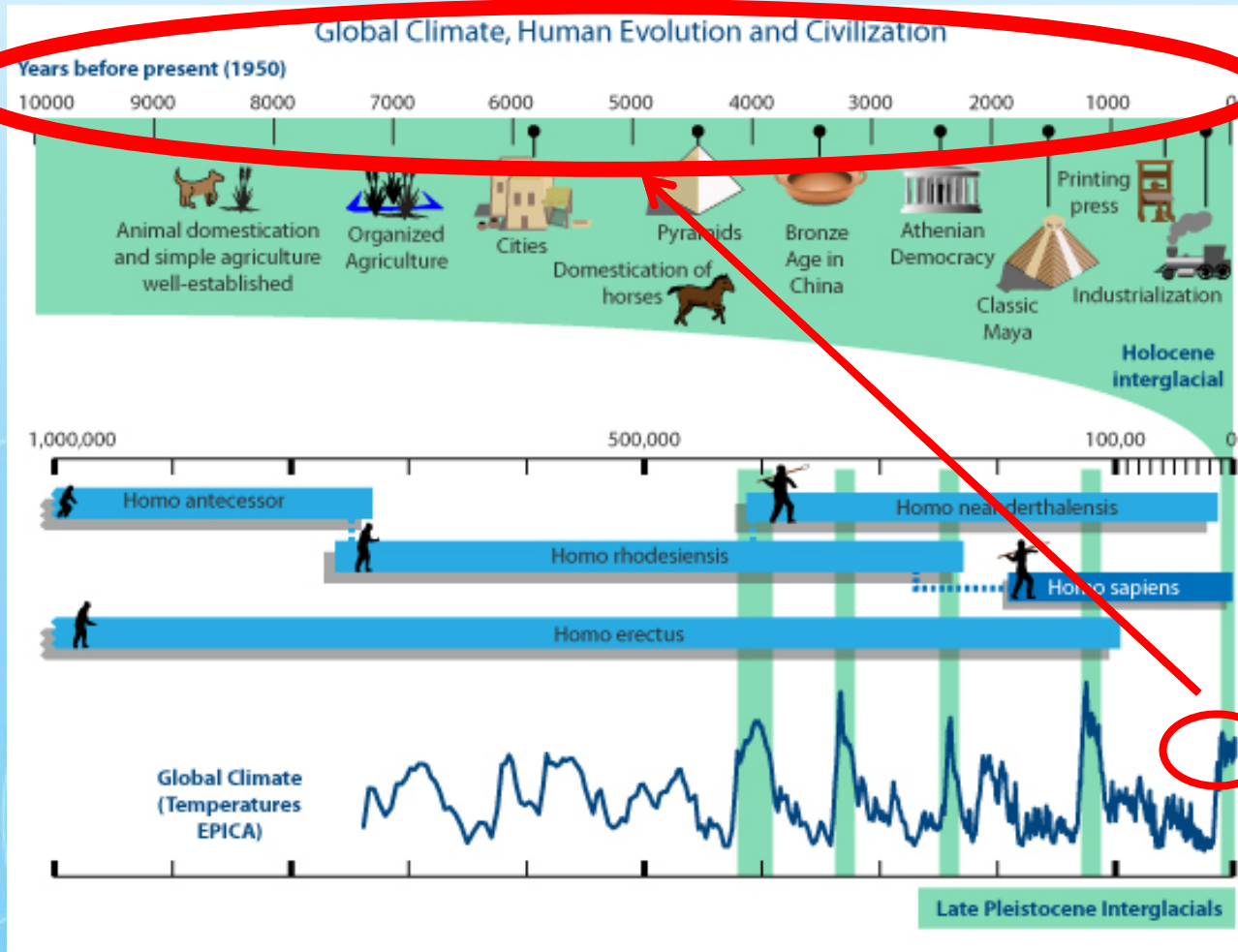
Energy production *World*



Global warming...last 450 thousand years



Global warming...last 10 thousand years



Buildings

- Hi-tech
- Environmentally friendly



Lotte Super Tower 123
Burj Khalifa

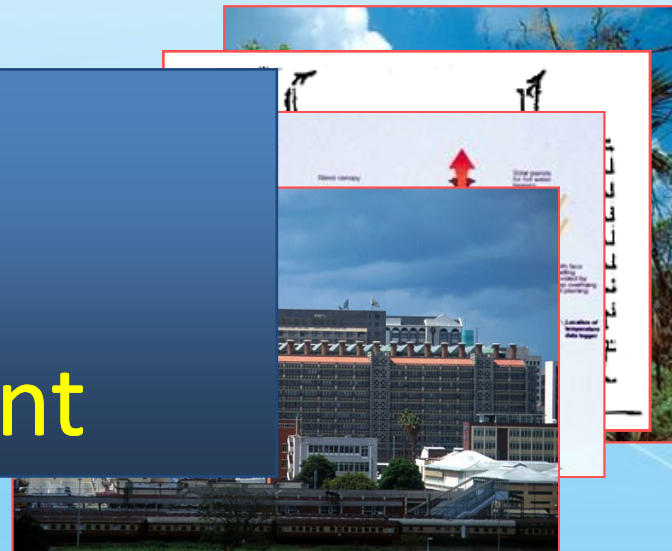
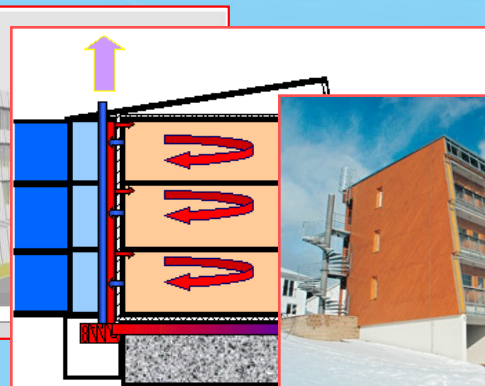


Sušice

Energy
X
Environment



• NIZKOENERGETICKÝ NIZKONAKLADOVÝ BYTOVÝ DŮM
• PERSPEKTIVNÍ POHLED JIHOZÁPADĚ



Eastgate Harare

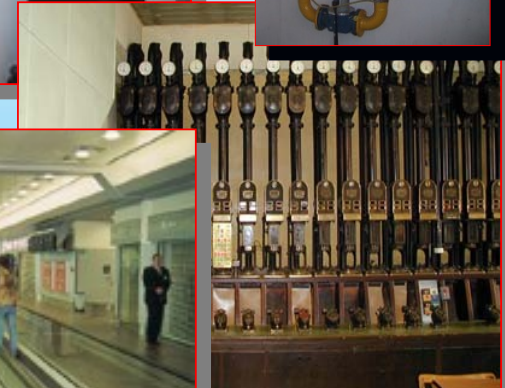
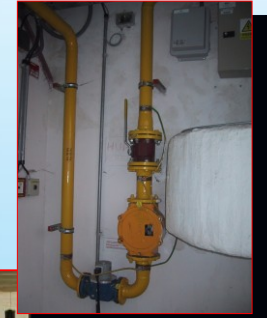


- Energy saving

ENERGY

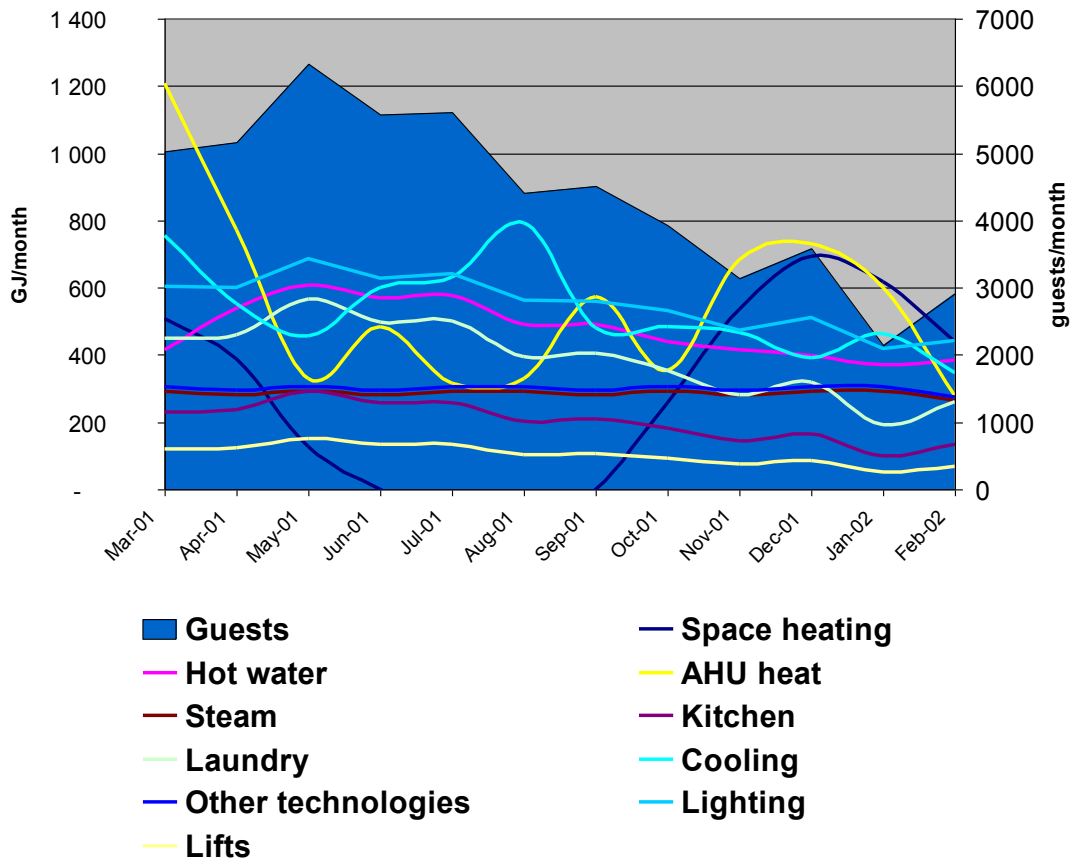
Building and energy

- Indoor environmental quality (temperature, indoor air quality, lighting)
- Hygiene requirements (hot water)
- Energy distribution networks (wiring, gas supply, technical gases)
- Operating and control systems in buildings (fire, control, security)
- Systems of transport (elevators, escalators, travelators, tube post)
- Technological equipment (central vacuum cleaner, kitchen, laundry, pool)

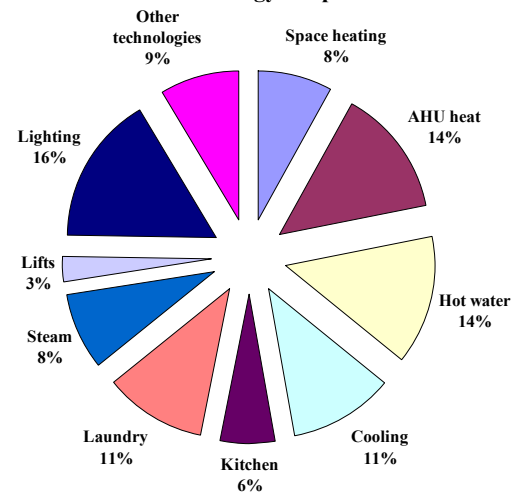


Building and Energy

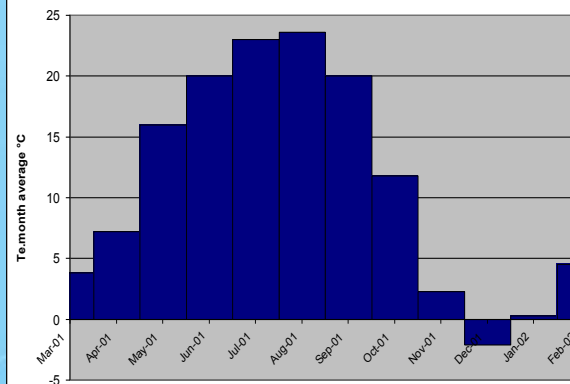
Annual energy use in the hotel (322 beds)



Annual energy use pie



Average month temperatures in 2001

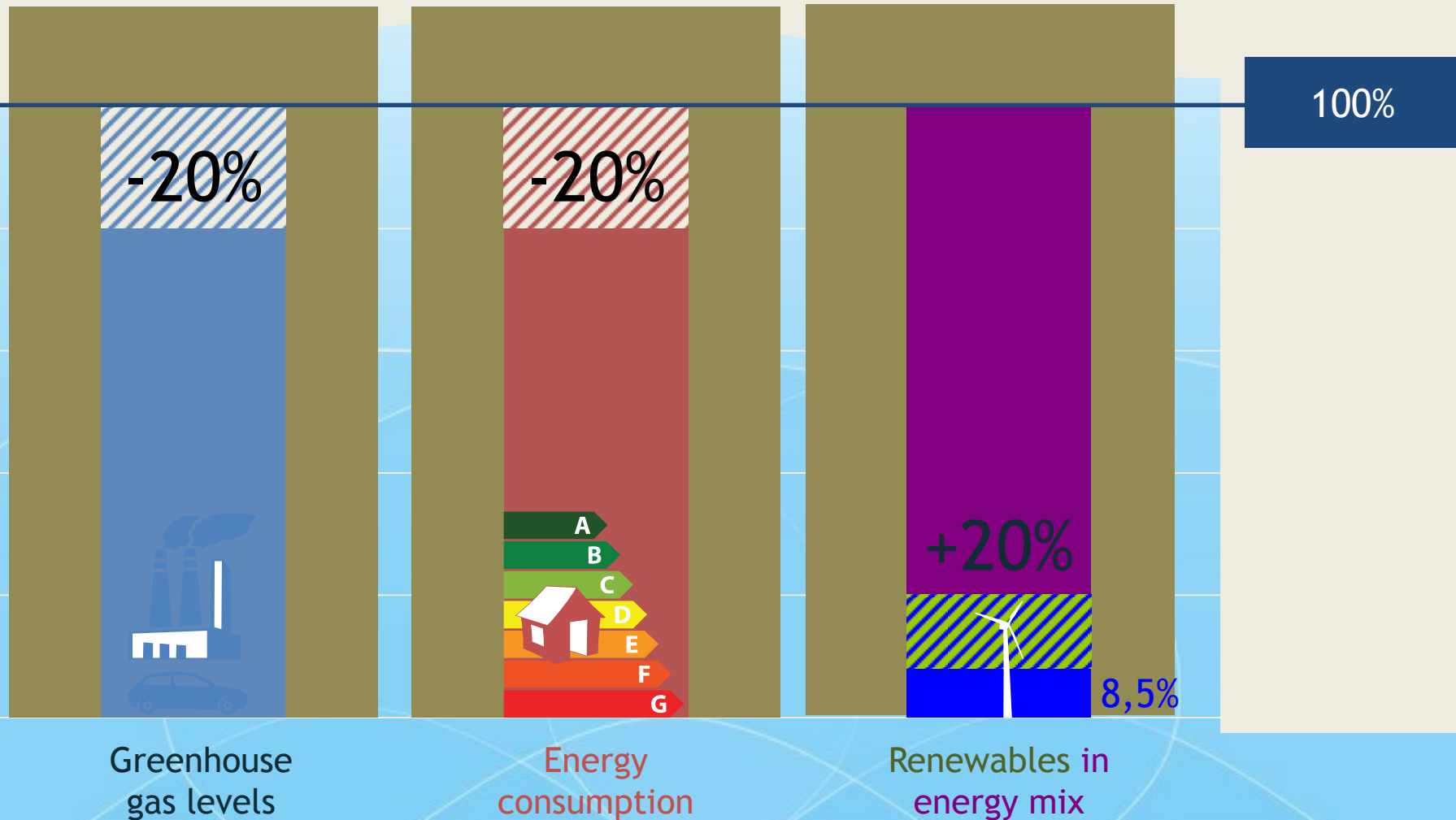




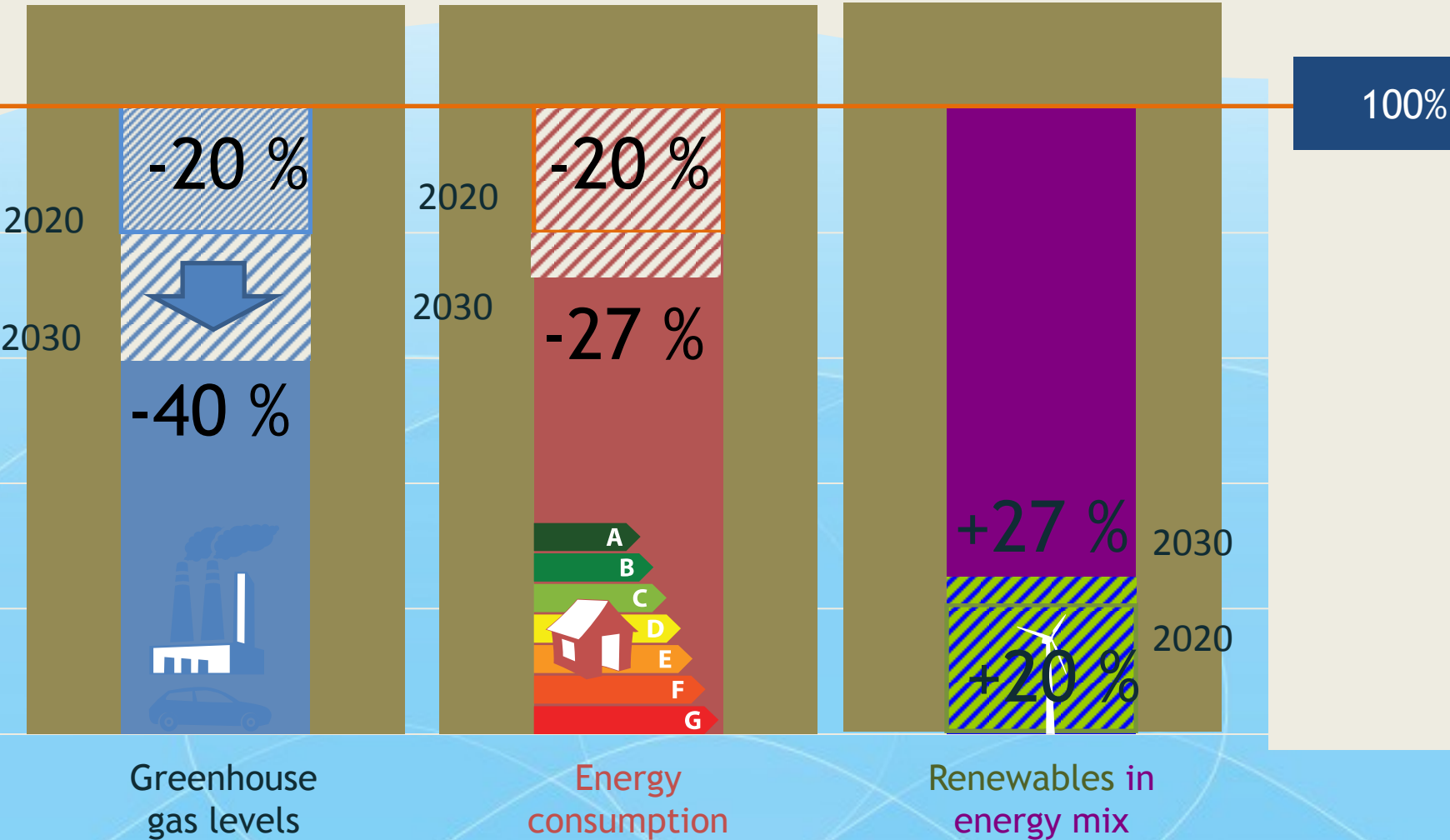
EUROPEAN ENERGY POLICY

The 20-20-20 EU policy

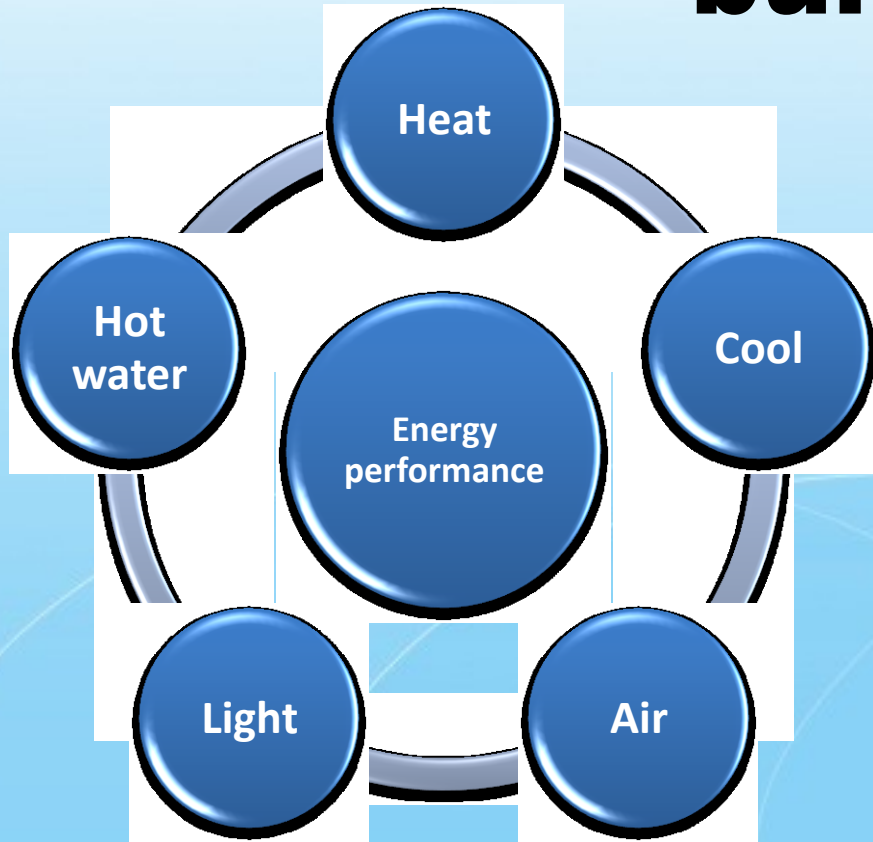
by 2030



The EU policy 2030



Energy performance of building

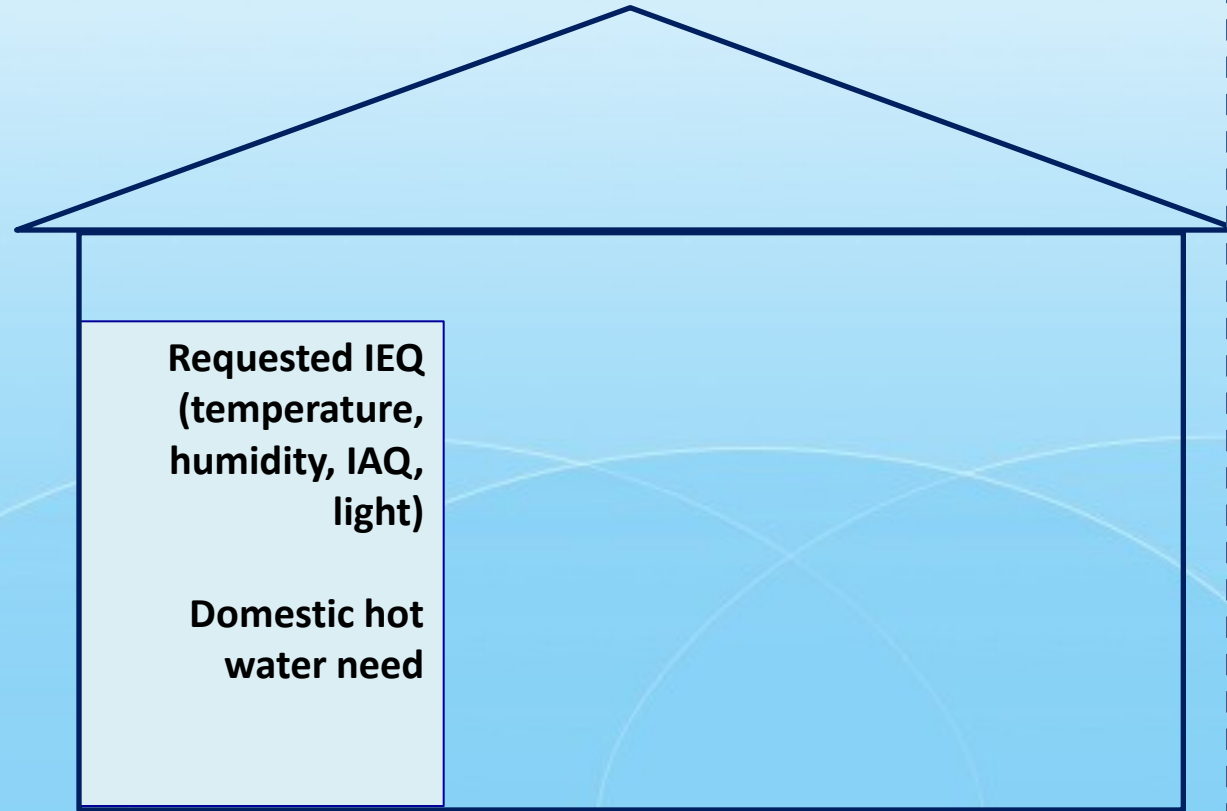


... means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, **inter alia**, energy used for:

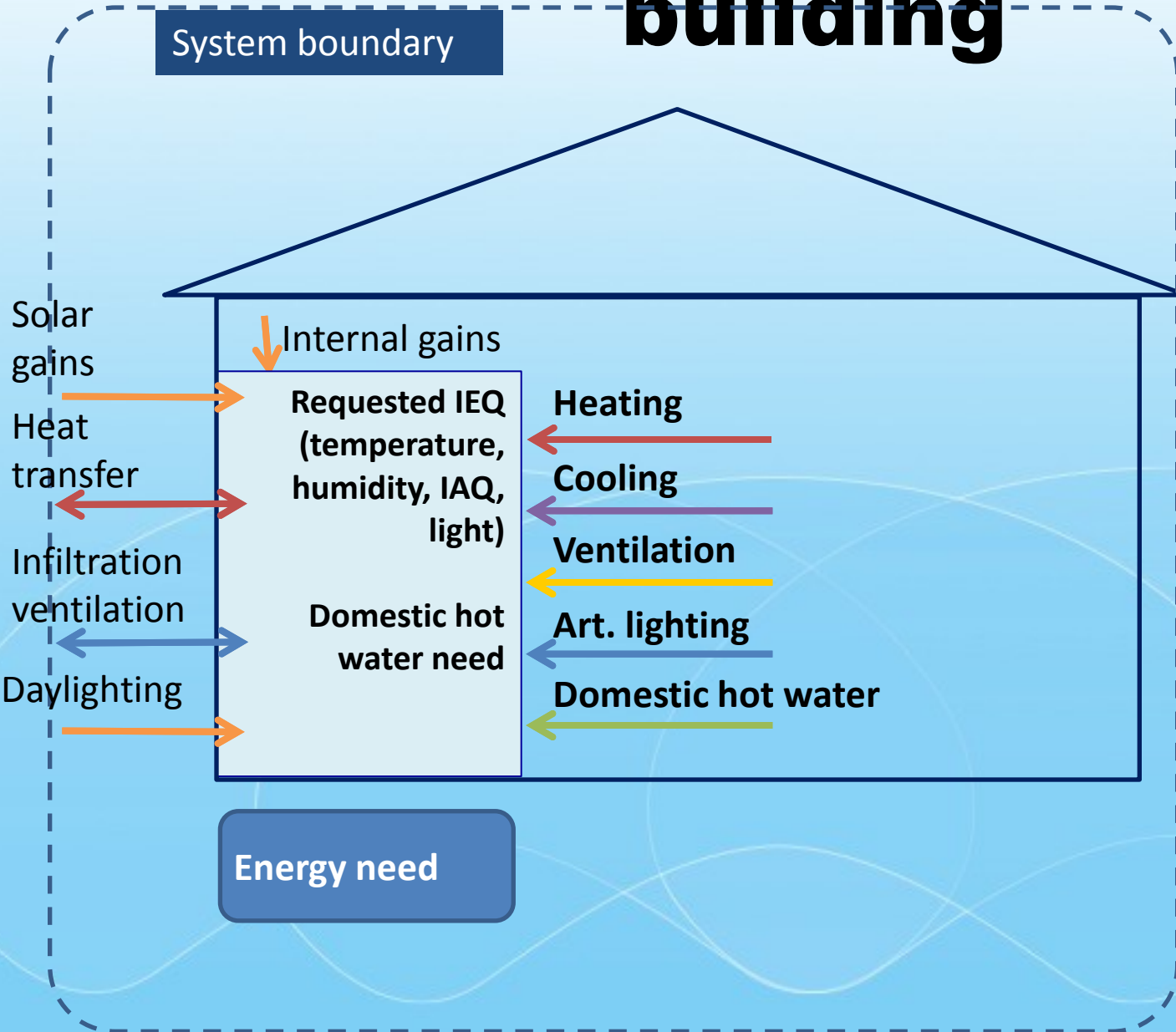
- **Heating**
- **Cooling**
- **Ventilation**
- **Hot water**
- **Lighting....**

Energy performance of building

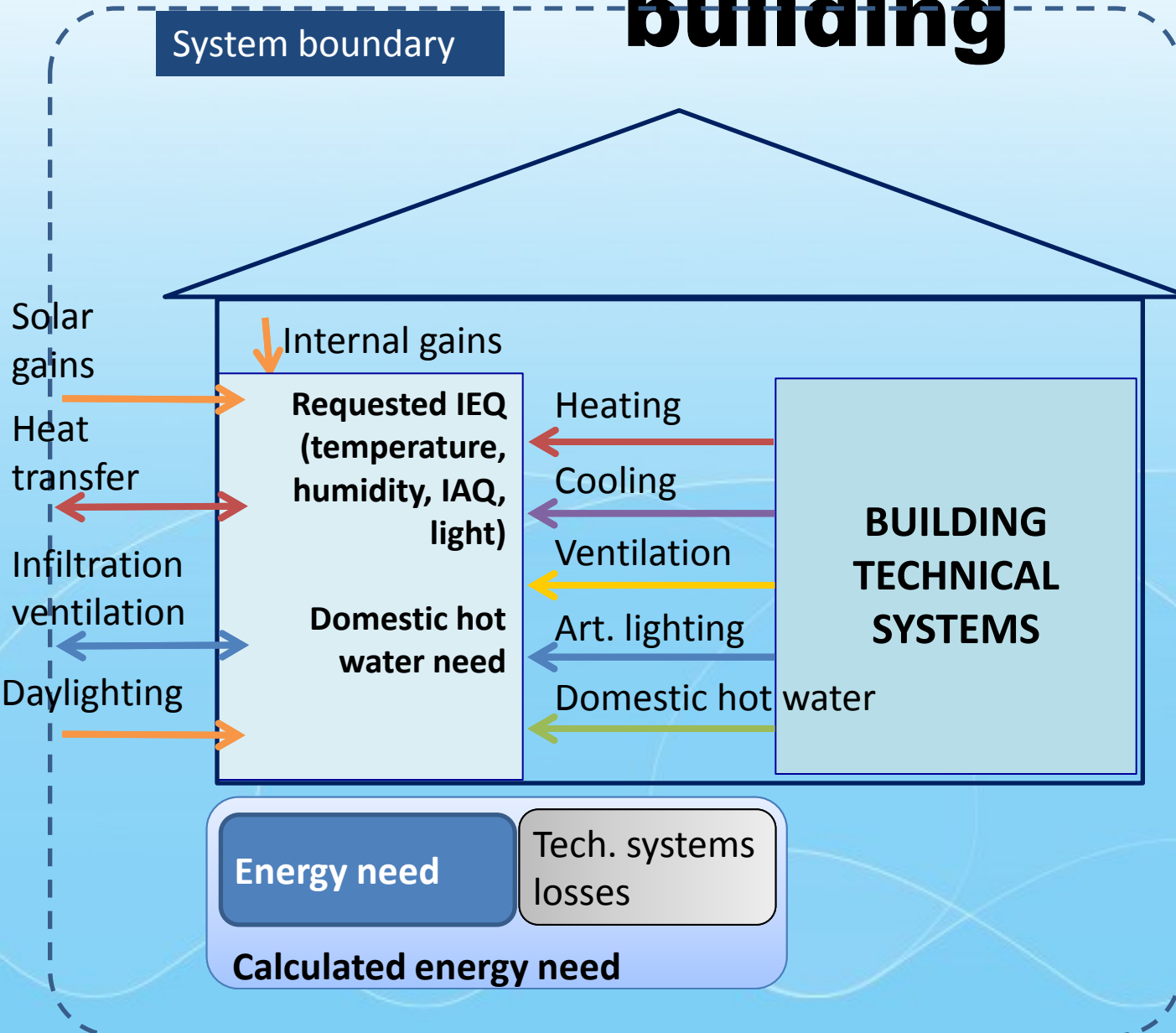
System boundary



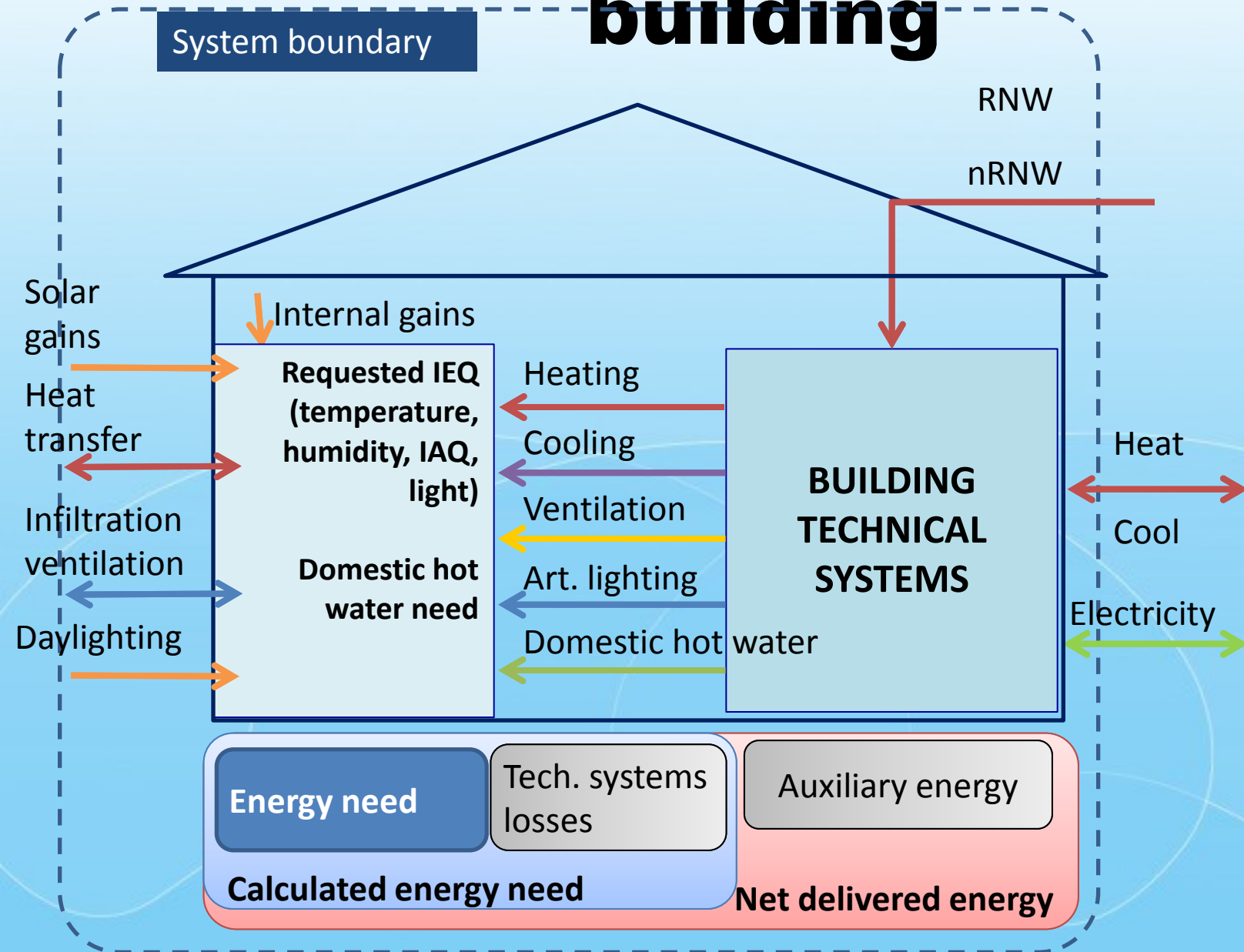
Energy performance of building



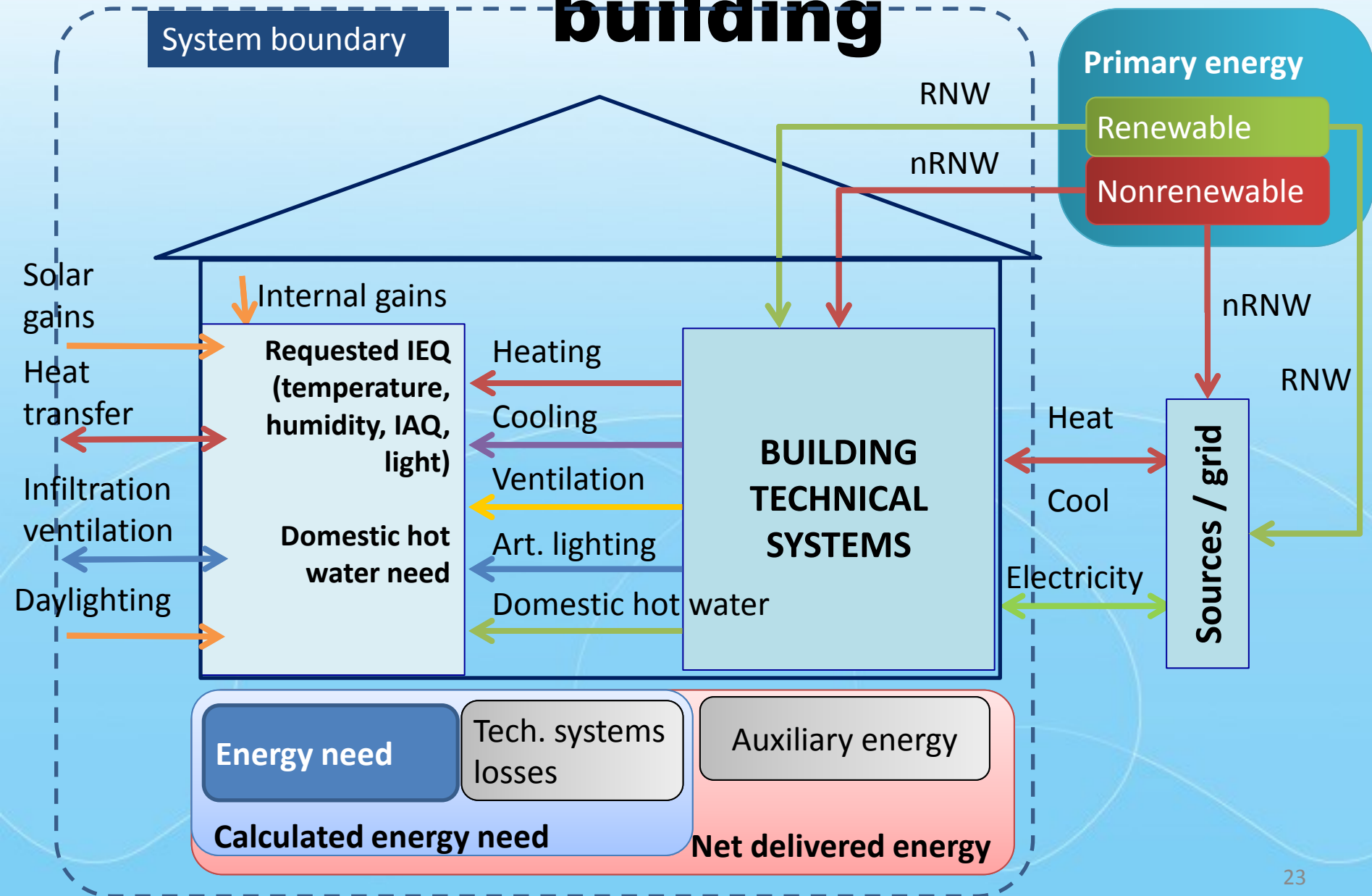
Energy performance of building



Energy performance of building



Energy performance of building



Primary energy

Energy, that has not been subjected to any conversion or transformation process.

| Market agent | Factor of PE(-) | Factor of Non-RNW PE(-) |
|---|-----------------|-------------------------|
| Natural gas | 1,1 | 1,1 |
| Black coal | 1,1 | 1,1 |
| Brown coal | 1,1 | 1,1 |
| Propan-butan/LPG | 1,2 | 1,2 |
| Oil | 1,2 | 1,2 |
| Electricity | 3,2 | 3,0 |
| Wooden pellets | 1,2 | 0,2 |
| Wood | 1,1 | 0,1 |
| Energy of the environment | 1,0 | 0,0 |
| Electricity – export | -3,2 | -3,0 |
| Heat – export | -1,1 | -1,0 |
| District heating with more than 80% RNW | 1,1 | 0,1 |
| District heating with less than 50% RNW | 1,1 | 1,0 |
| Others | 1,2 | 1,2 |

Czech example

Conversion factors are given by local conditions !!!!

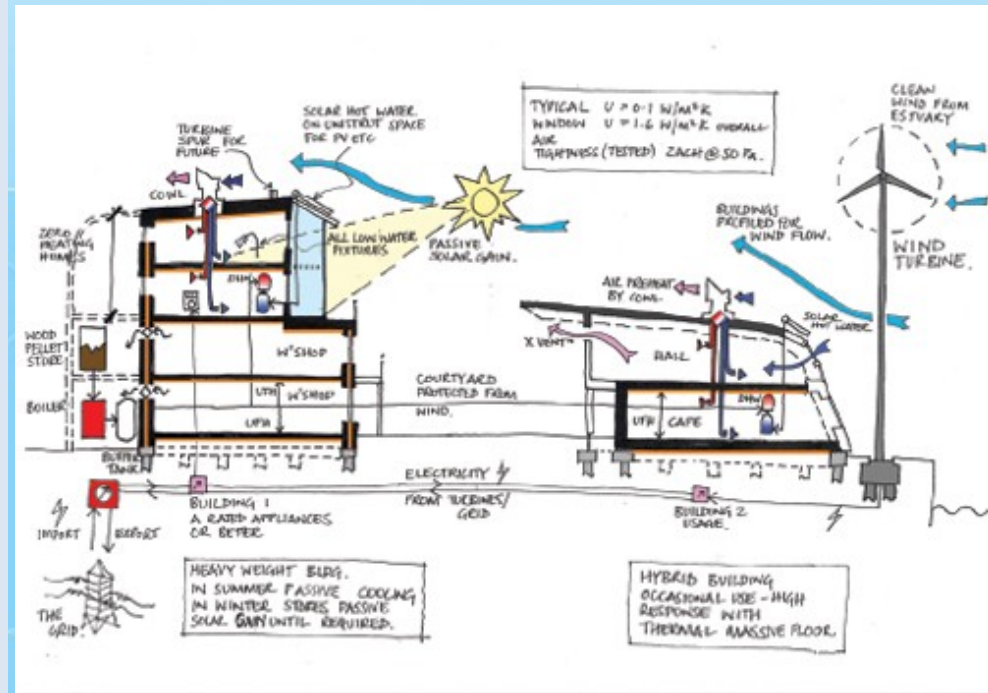
Directive 2010/31/EC

On Energy Performance of Buildings

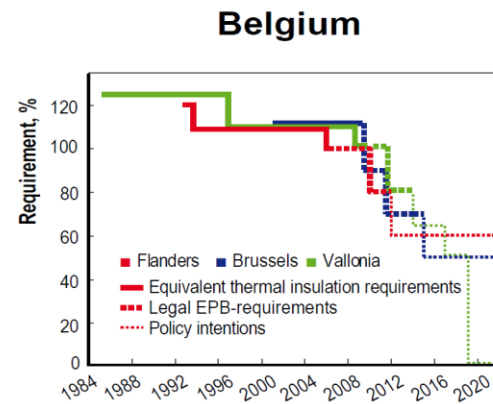
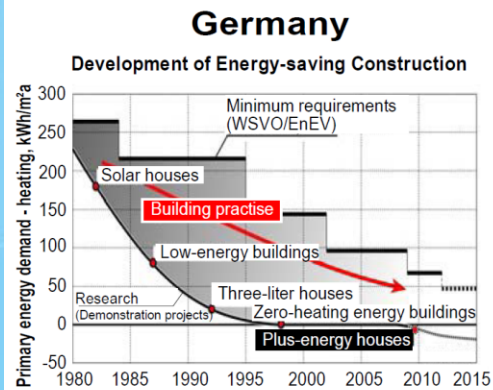
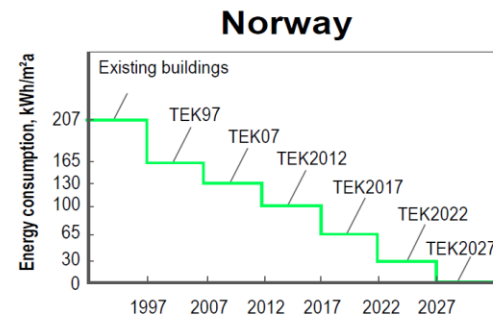
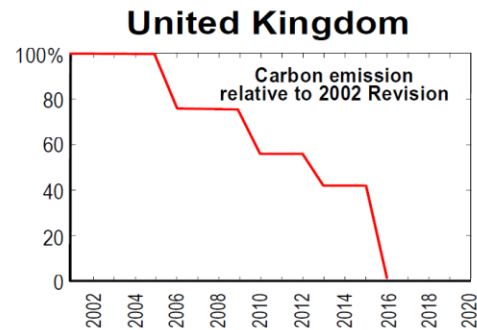
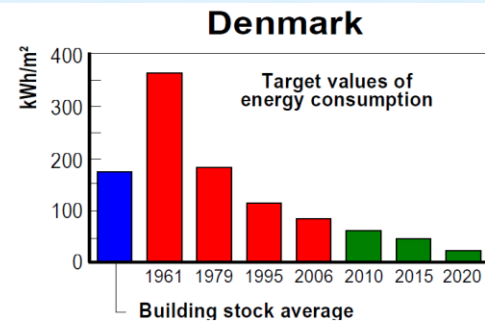
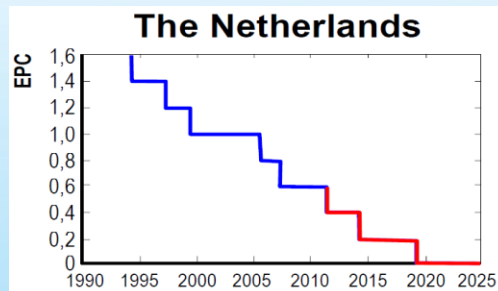
Nearly zero energy building

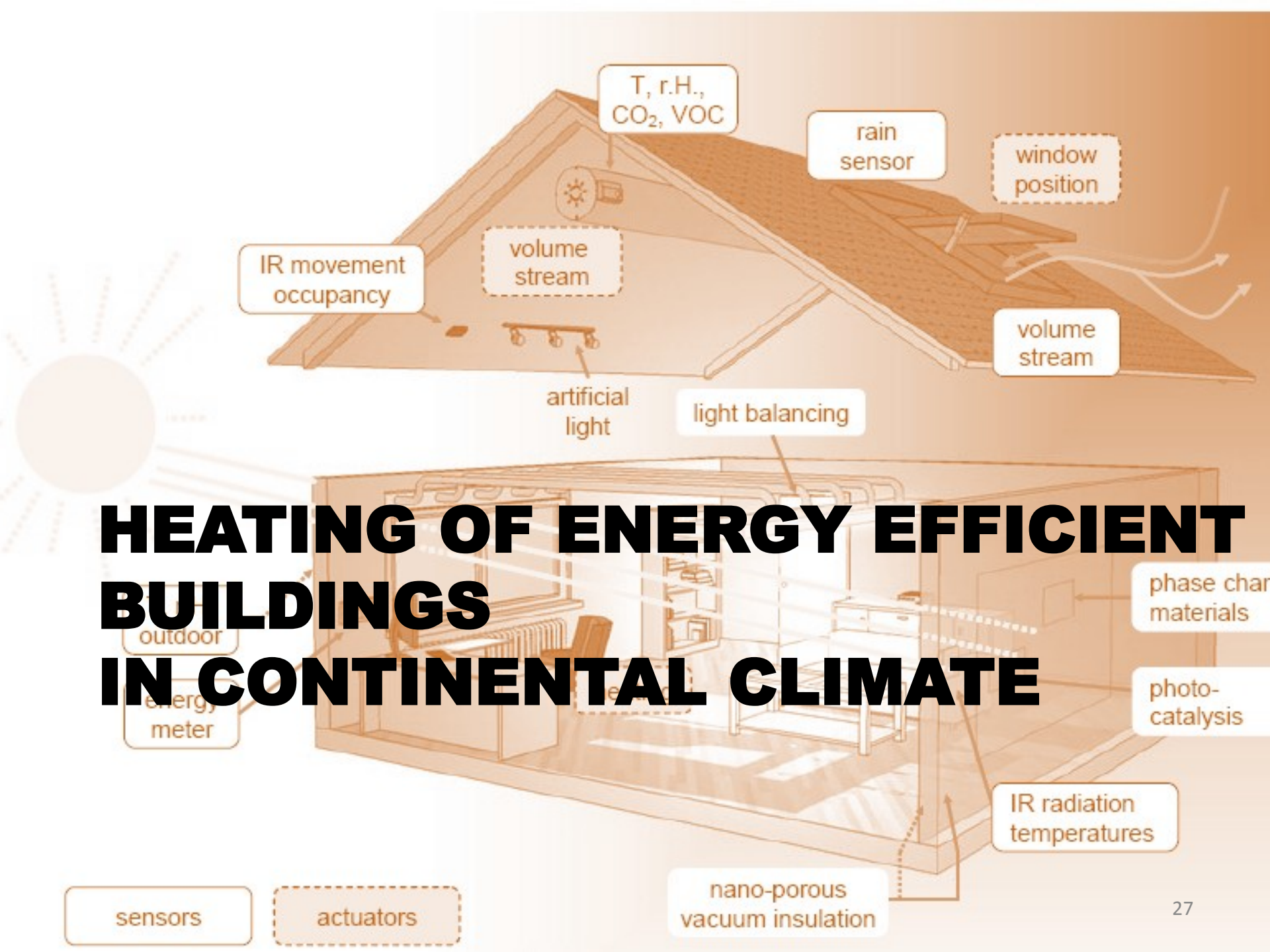
...means a building that has a very high energy performance.

The **nearly zero** or **very low amount of energy required** shall to a very significant extent be covered by energy from **renewable sources**, including renewable energy produced on-site or nearby....



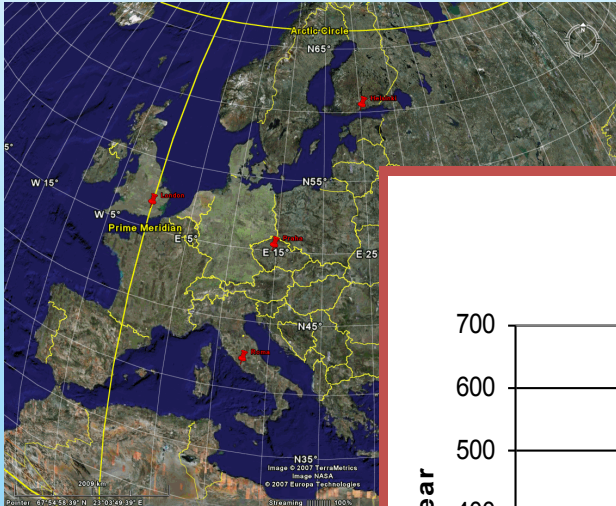
Roadmap to nZEB



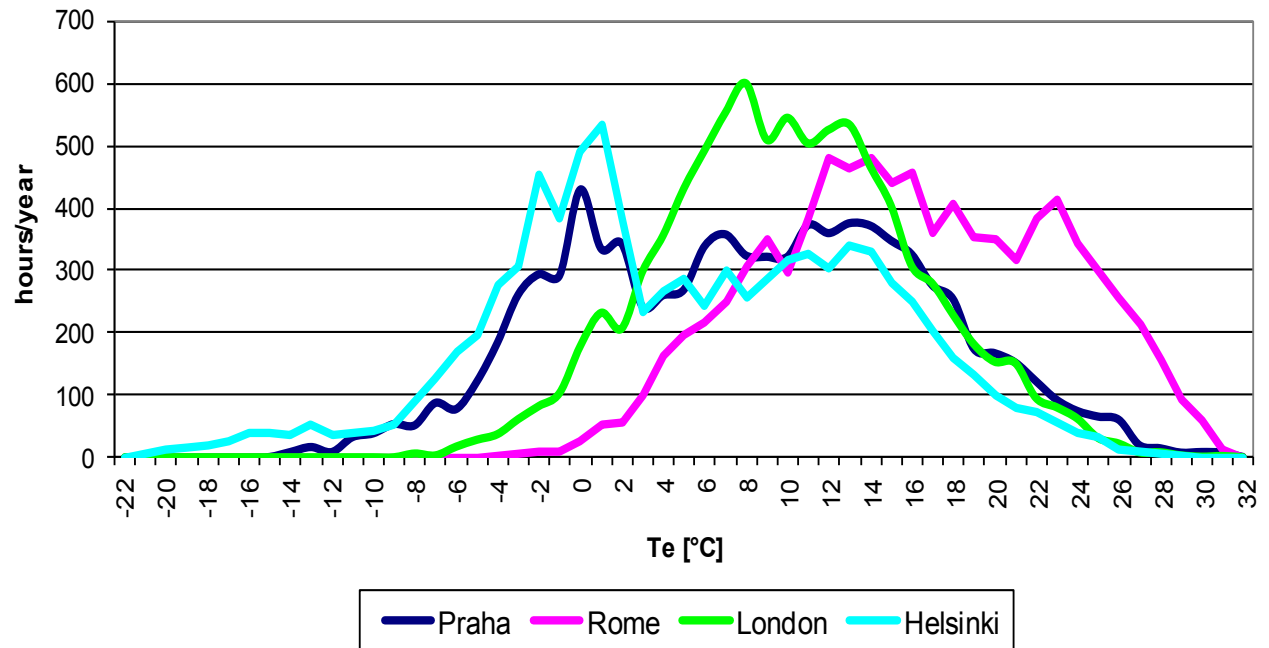


HEATING OF ENERGY EFFICIENT BUILDINGS IN CONTINENTAL CLIMATE

EU climate



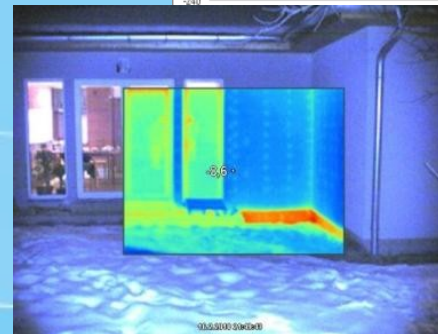
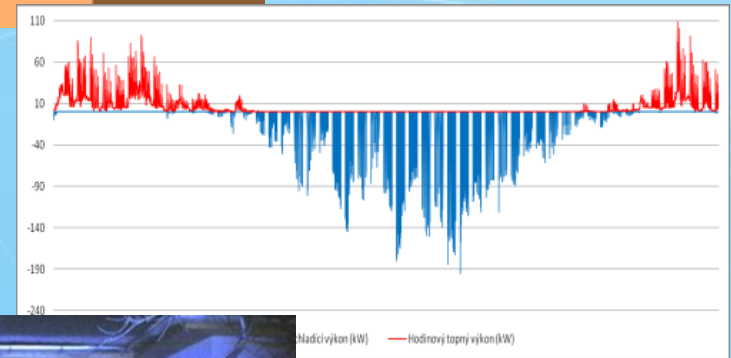
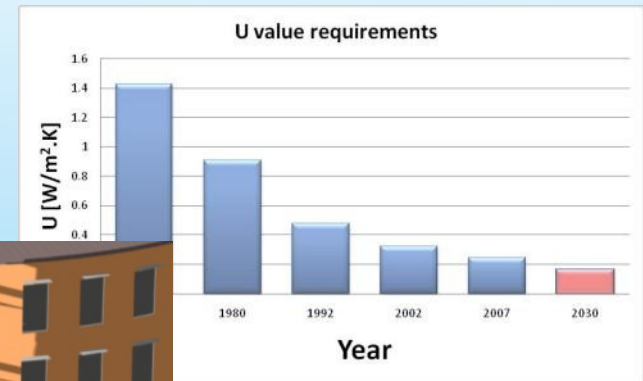
External temperature distribution (IWECC)



Building Envelope

Facade

- Thermal insulation - limit?
- Advanced materials
 - Vacuum insulation
 - PCM materials
 - Glazing
- active facades
 - Double facades
 - Smart "shading",
 - Integrated PV, PT systems

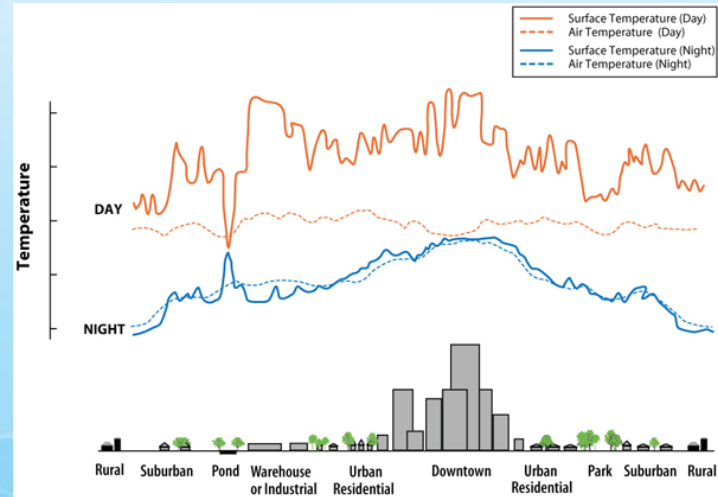


Low energy approach - Urban scale

Master plan

Transportation
distance

Heat islands

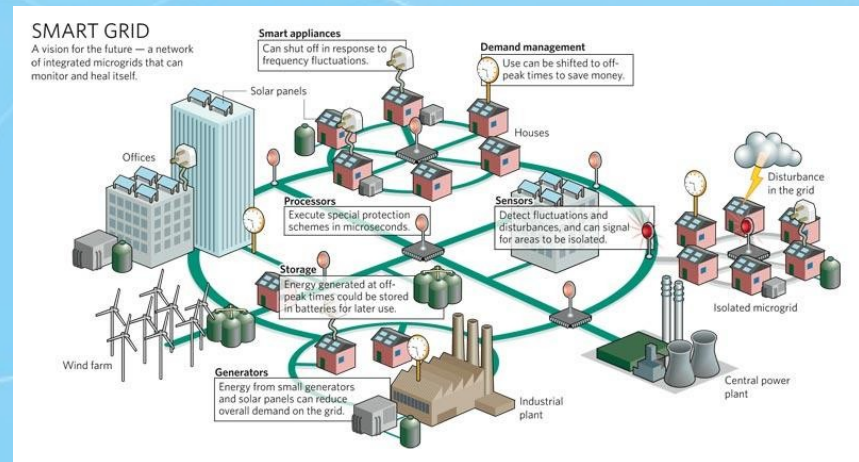


Energy concept

Local or district energy
„sources“ ?

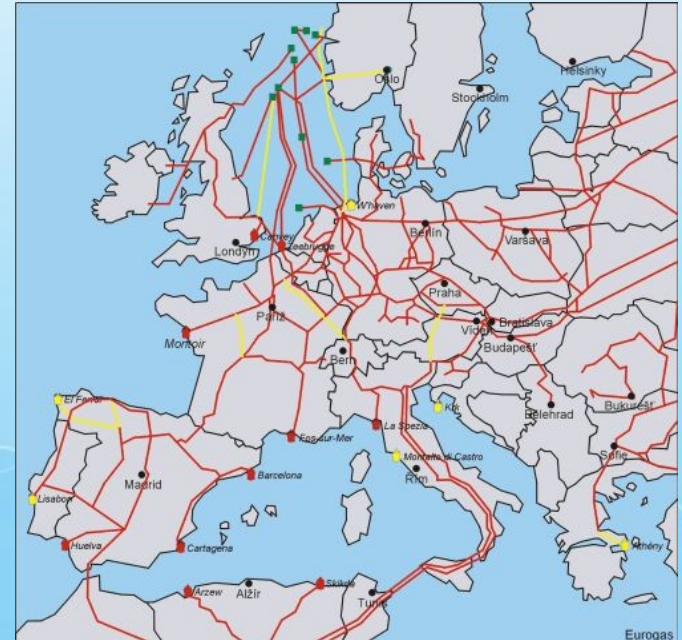
District cooling/heating

Smart grids

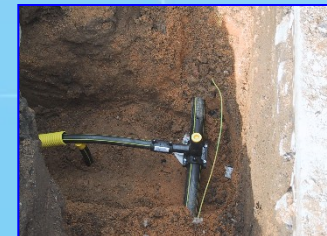


Heat sources

- Gas
- Coal
- Oil
- Electricity
- Renewables



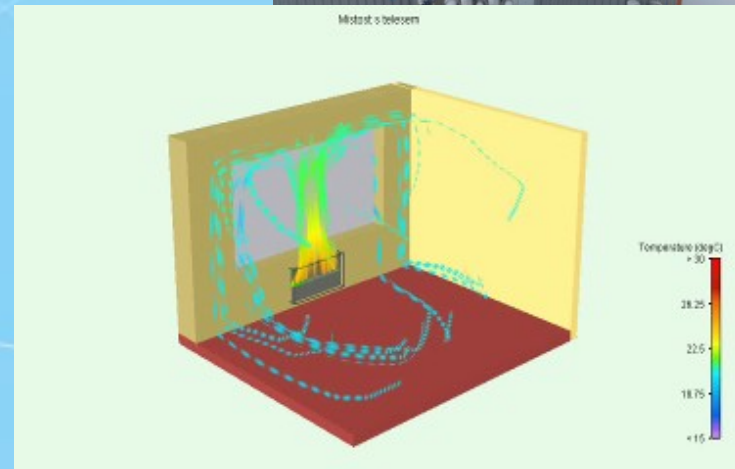
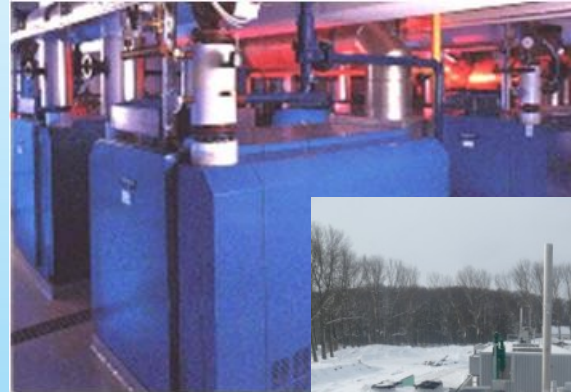
European gas network



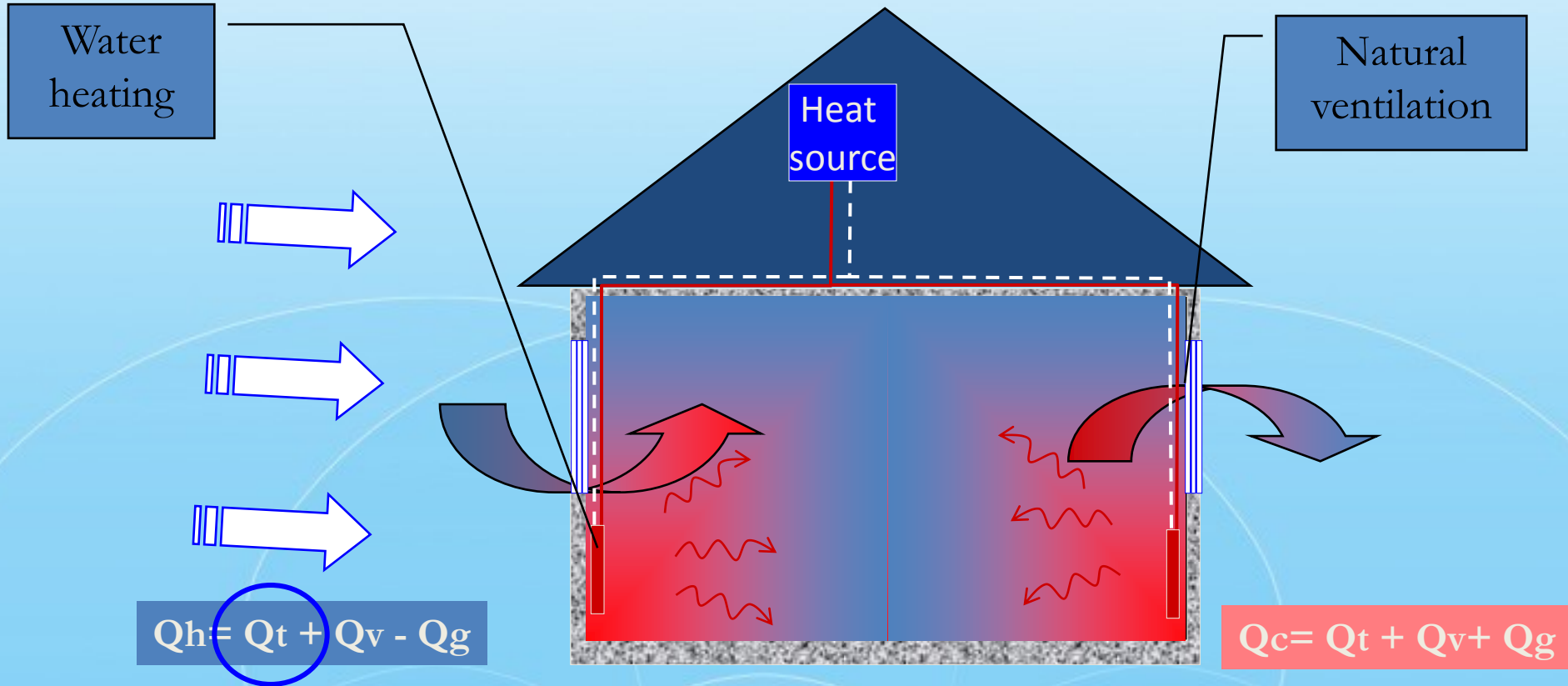
Heating of buildings

Heating

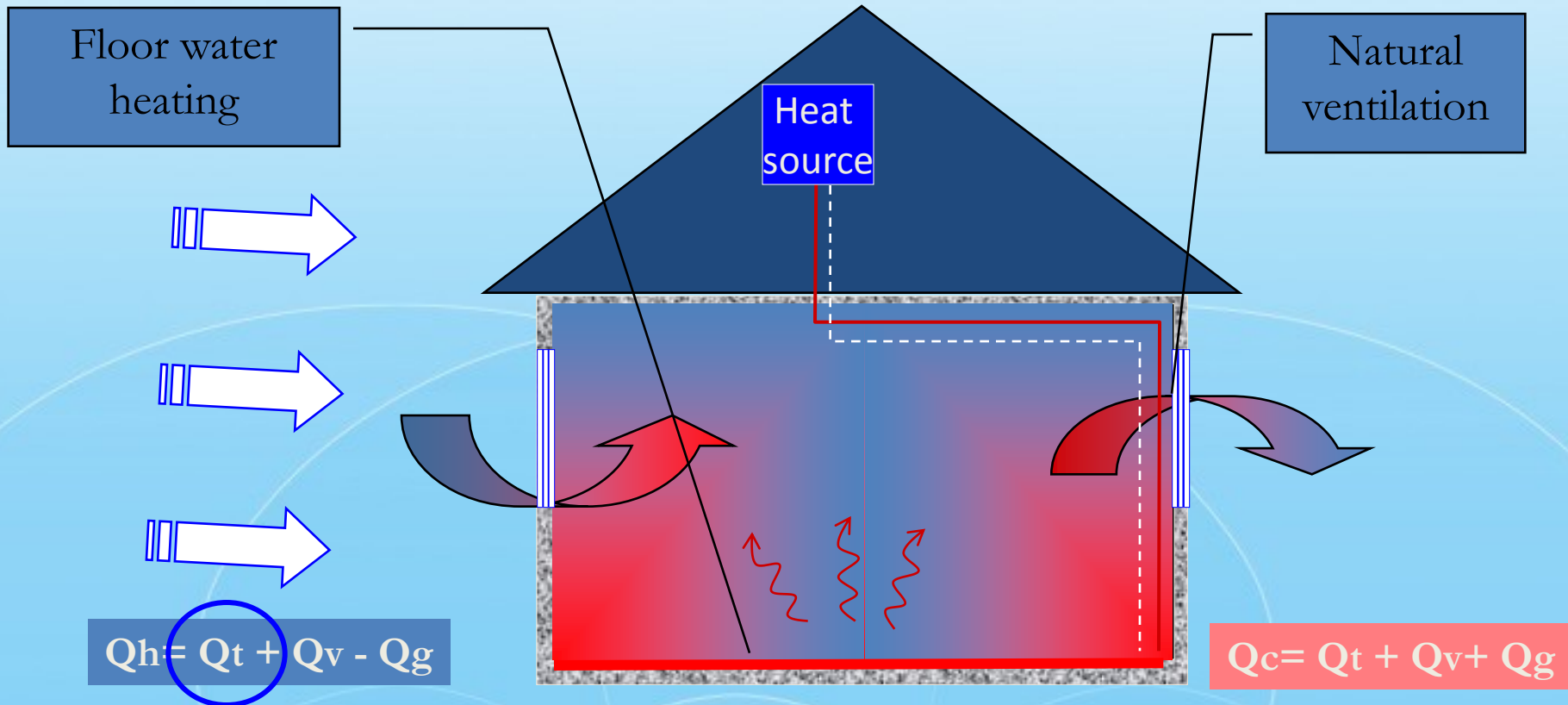
- Renewable sources
- Efficient sources
- Heat storage
- Efficient heat distribution (pumps)
- Heat emission
- Measurement and control



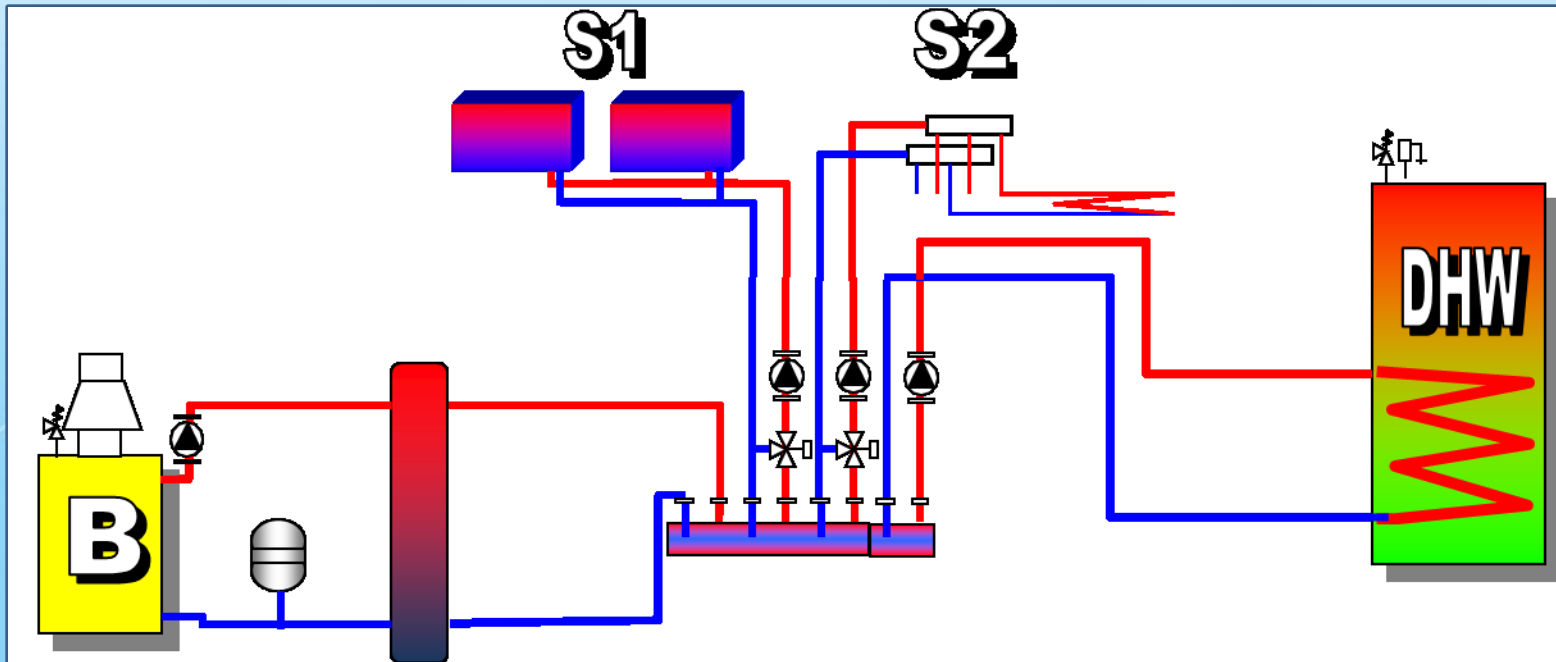
Energy distribution - alt 1



Energy distribution alt. 2

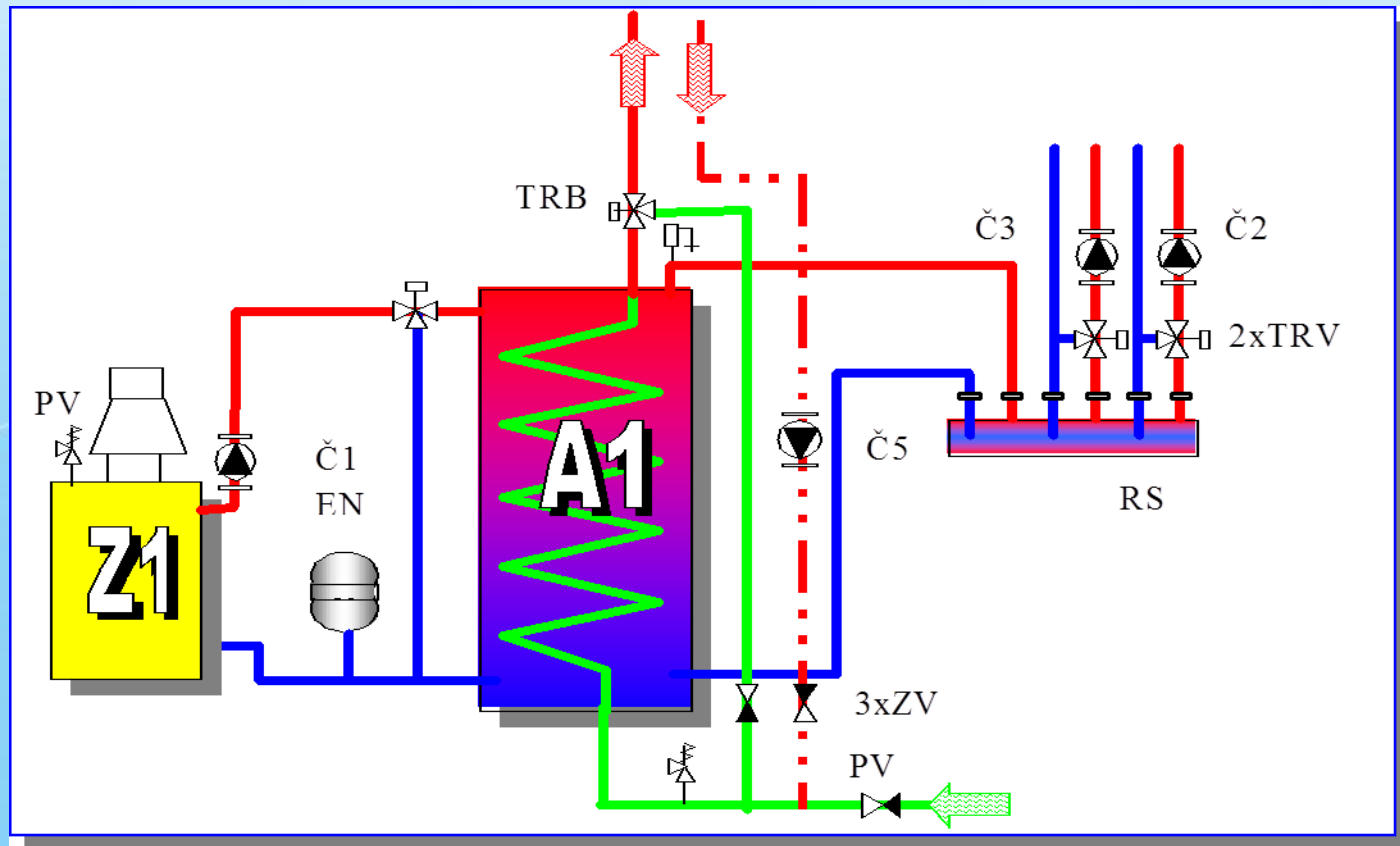


Traditional heat source



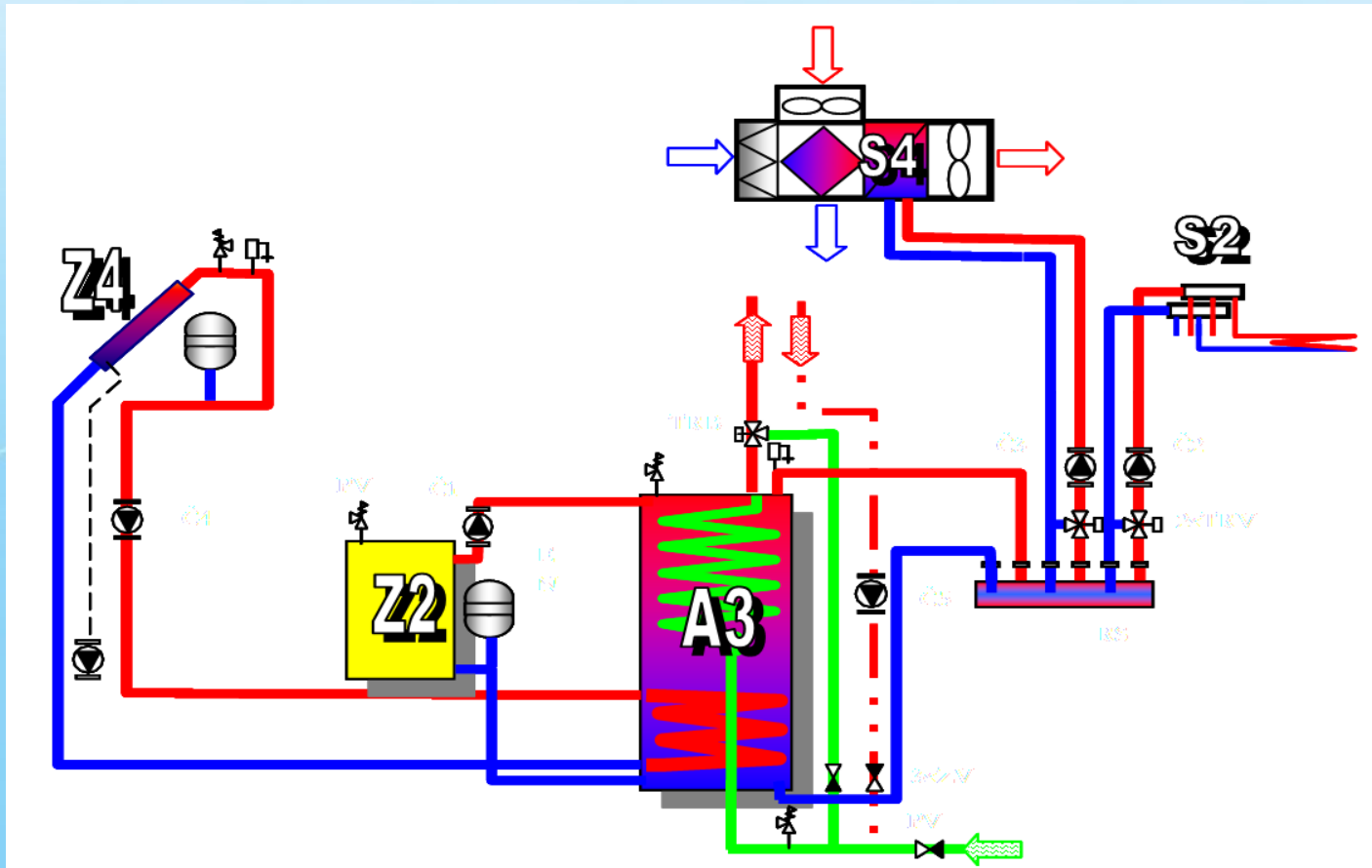
Traditional heat source – gas boiler. Radiator + floor heating, DHW generation.

Traditional heat source with integrated DHW



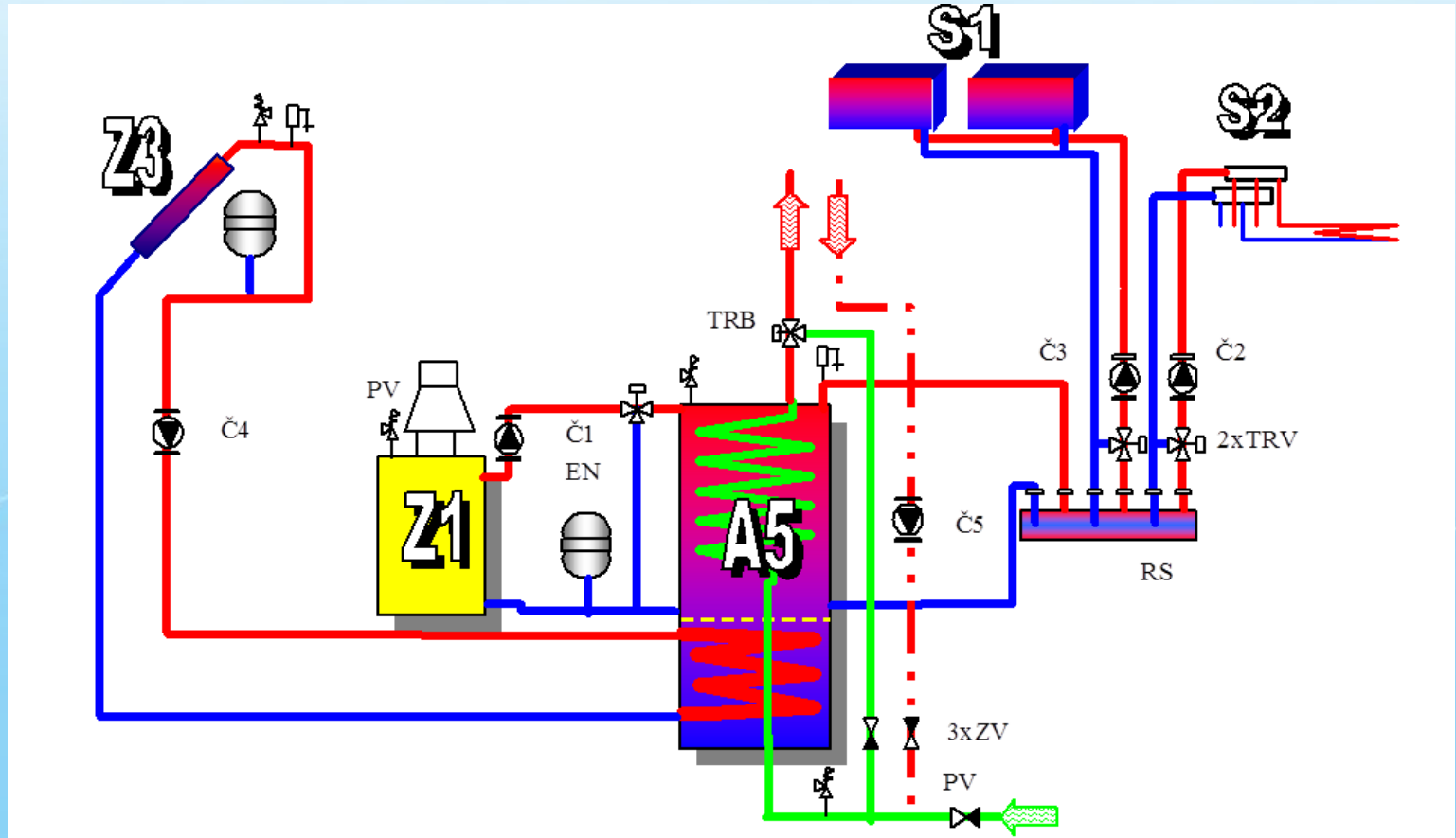
Traditional boiler, heating + DHW generation,

Bivalent heat source - 1



Bivalent heat source – i.e. heat pump + solar collectors . Warm air ventilation + low temperature heating, DHW generation.

Bivalent heat source - 2



Bivalent heat source – i.e. gas boiler + solar collectors . Radiator + low temperature heating, DHW generation.

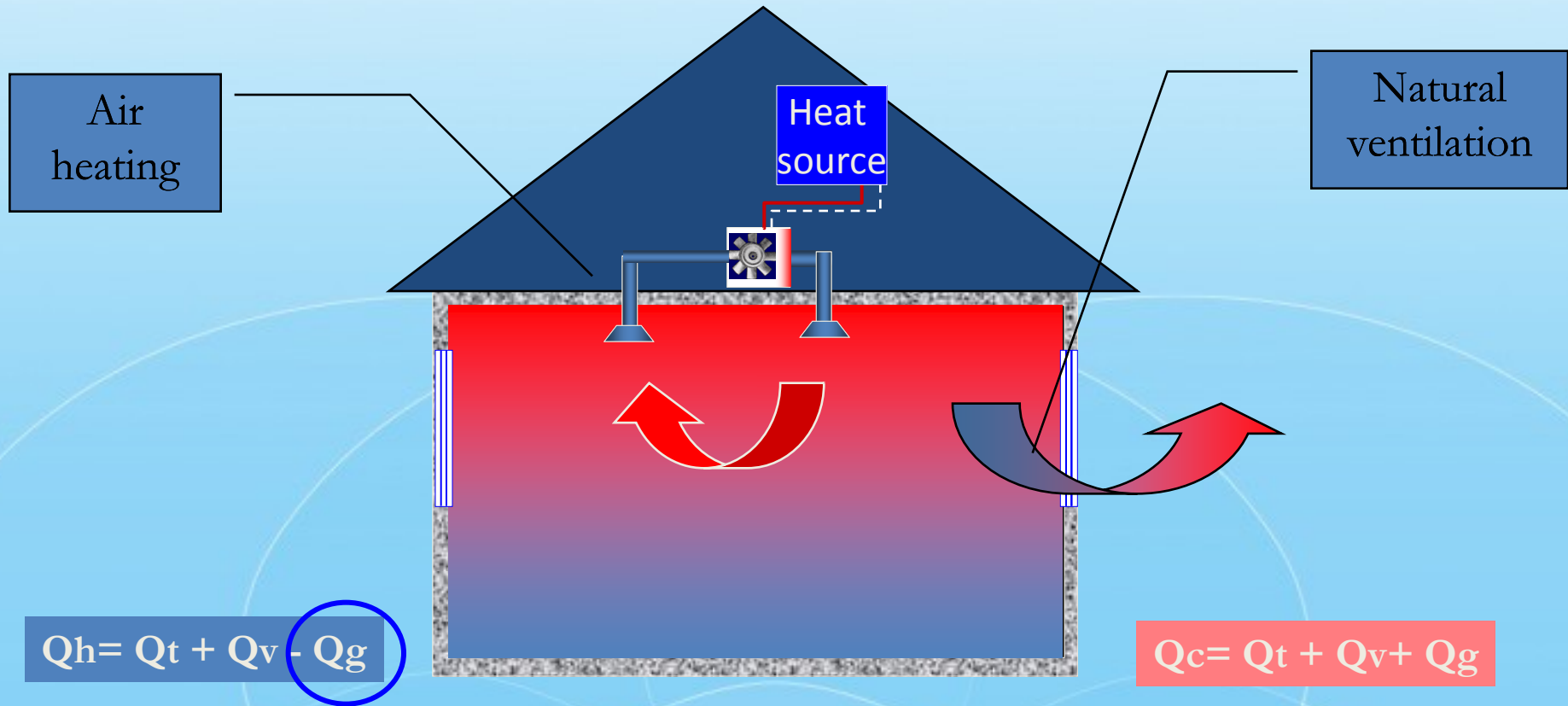




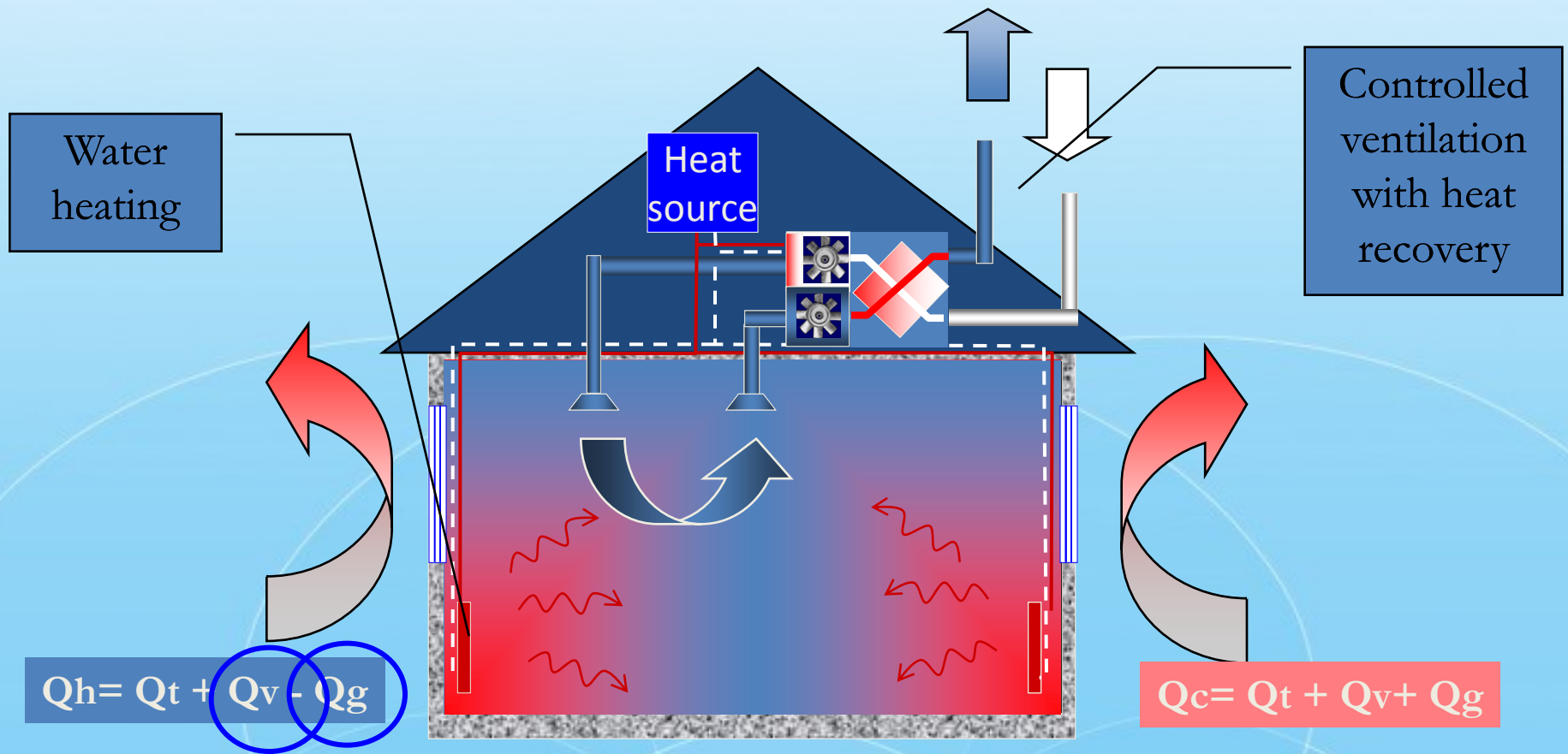




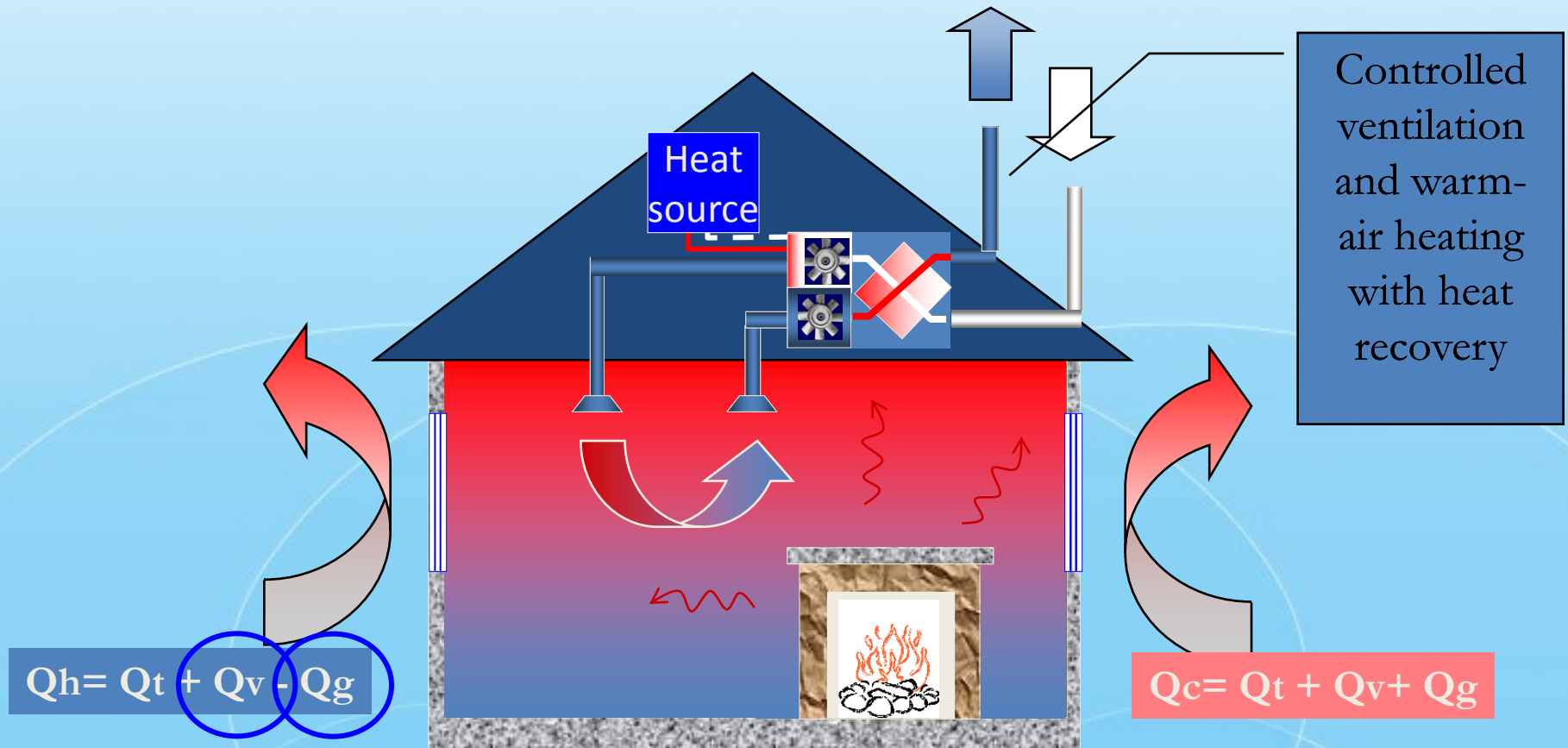
Energy distribution 3



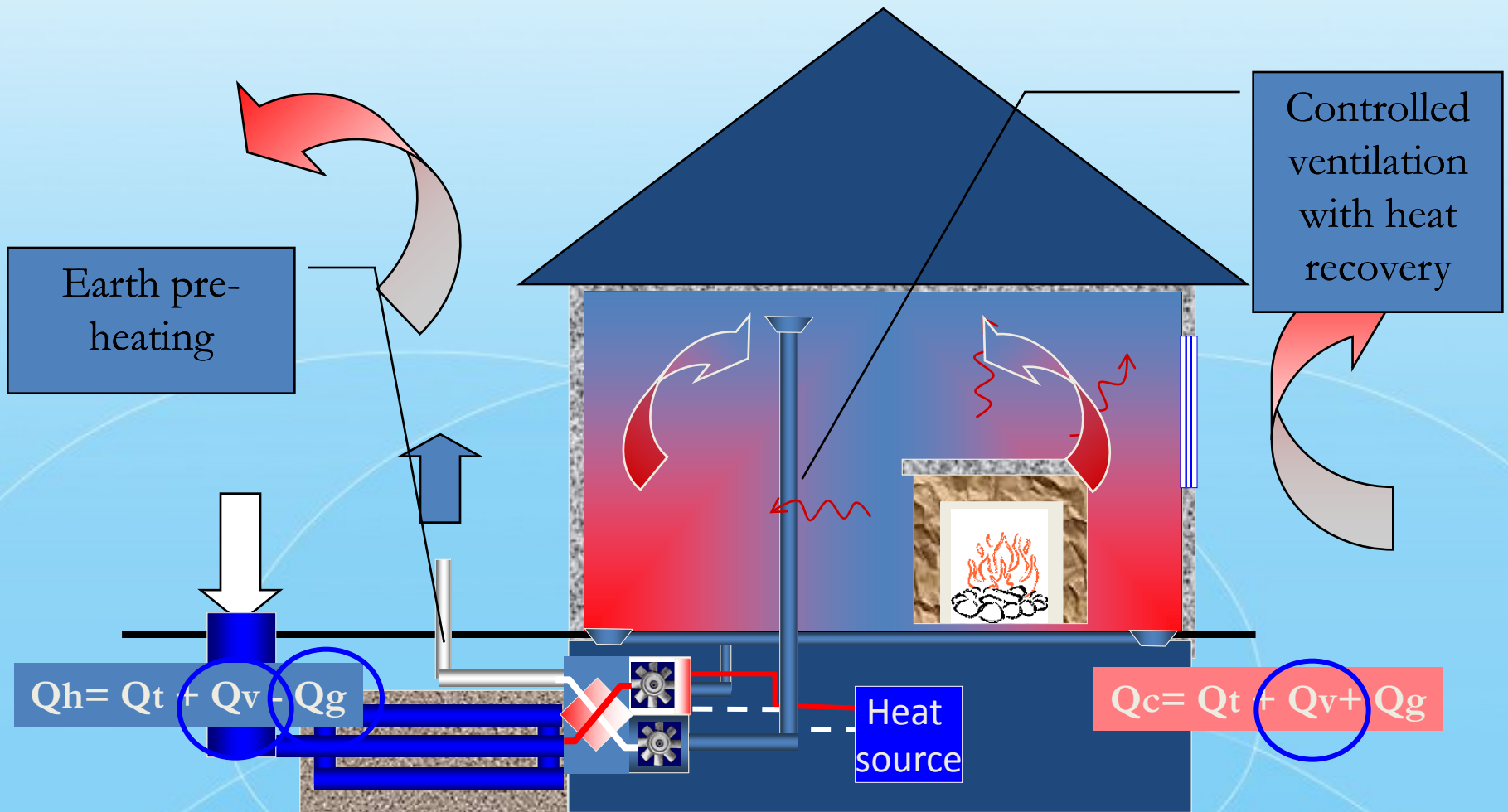
Energy distribution 4



Energy distribution 5



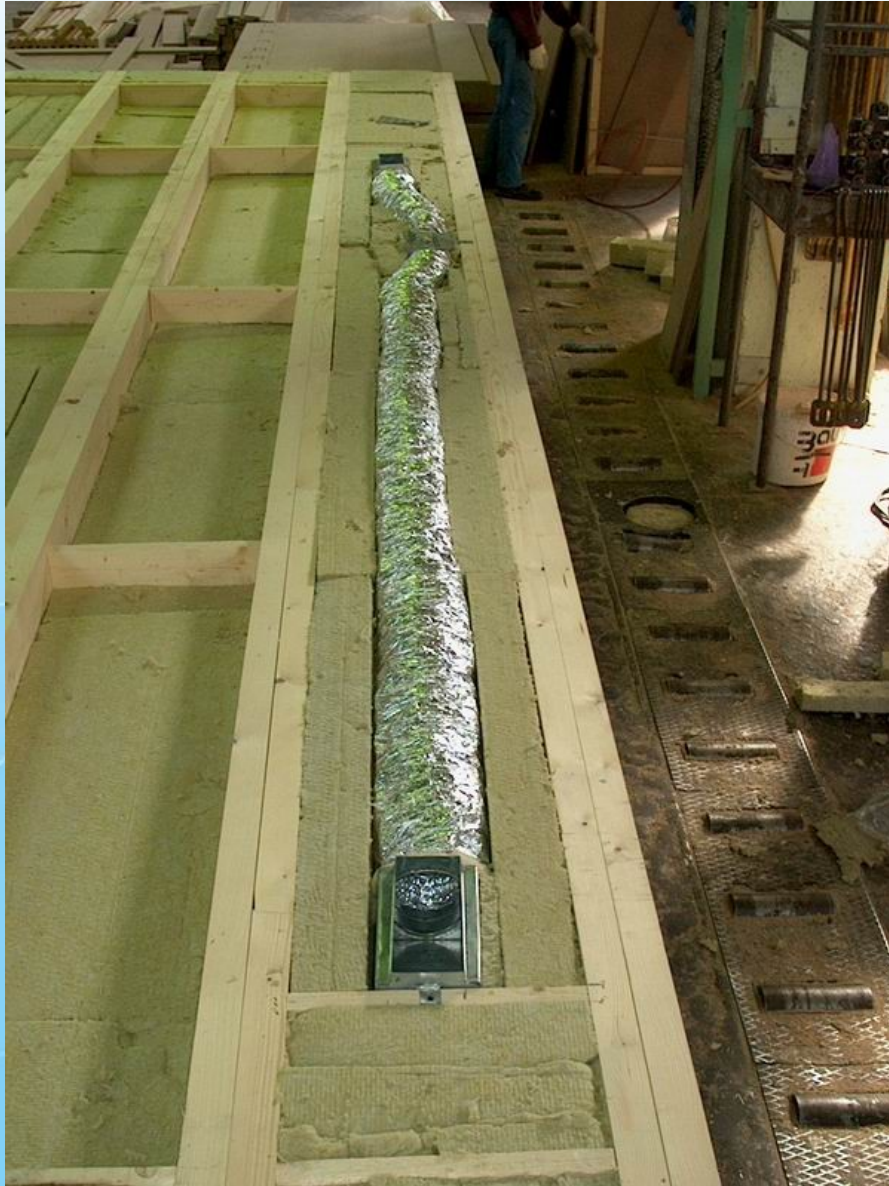
Energy distribution 6















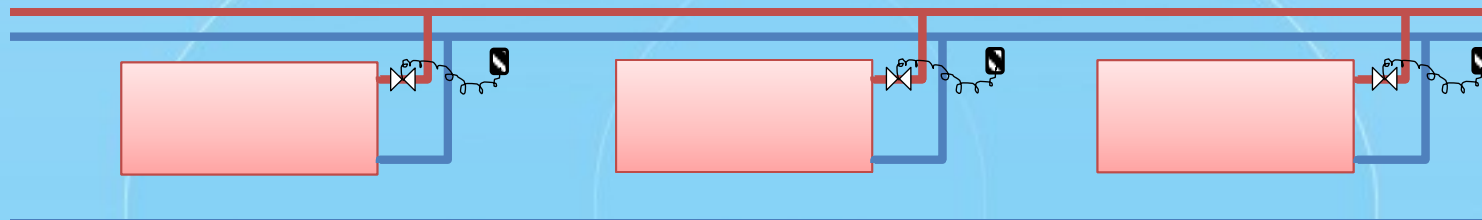
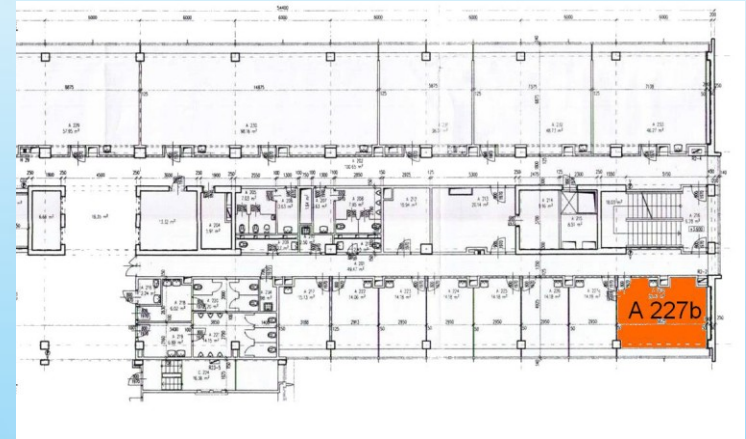






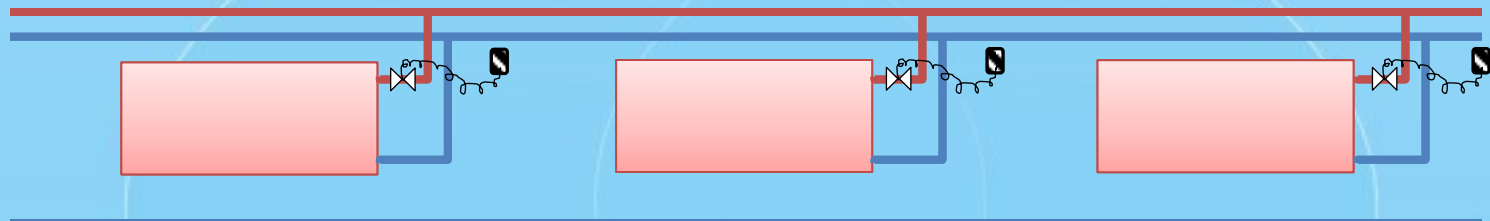
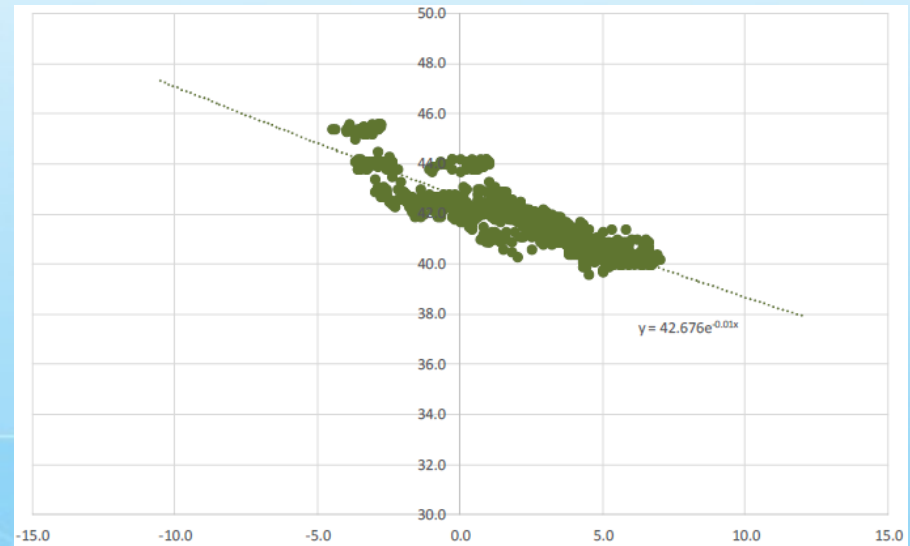
Case study

- Refurbished office building
- Facade U-value $4.2 \text{ W/m}^2\text{K}$ \rightarrow $0.68 \text{ W/m}^2\text{K}$
- Hydronic heating system
- Equitherm control + thermostatic valves at radiators



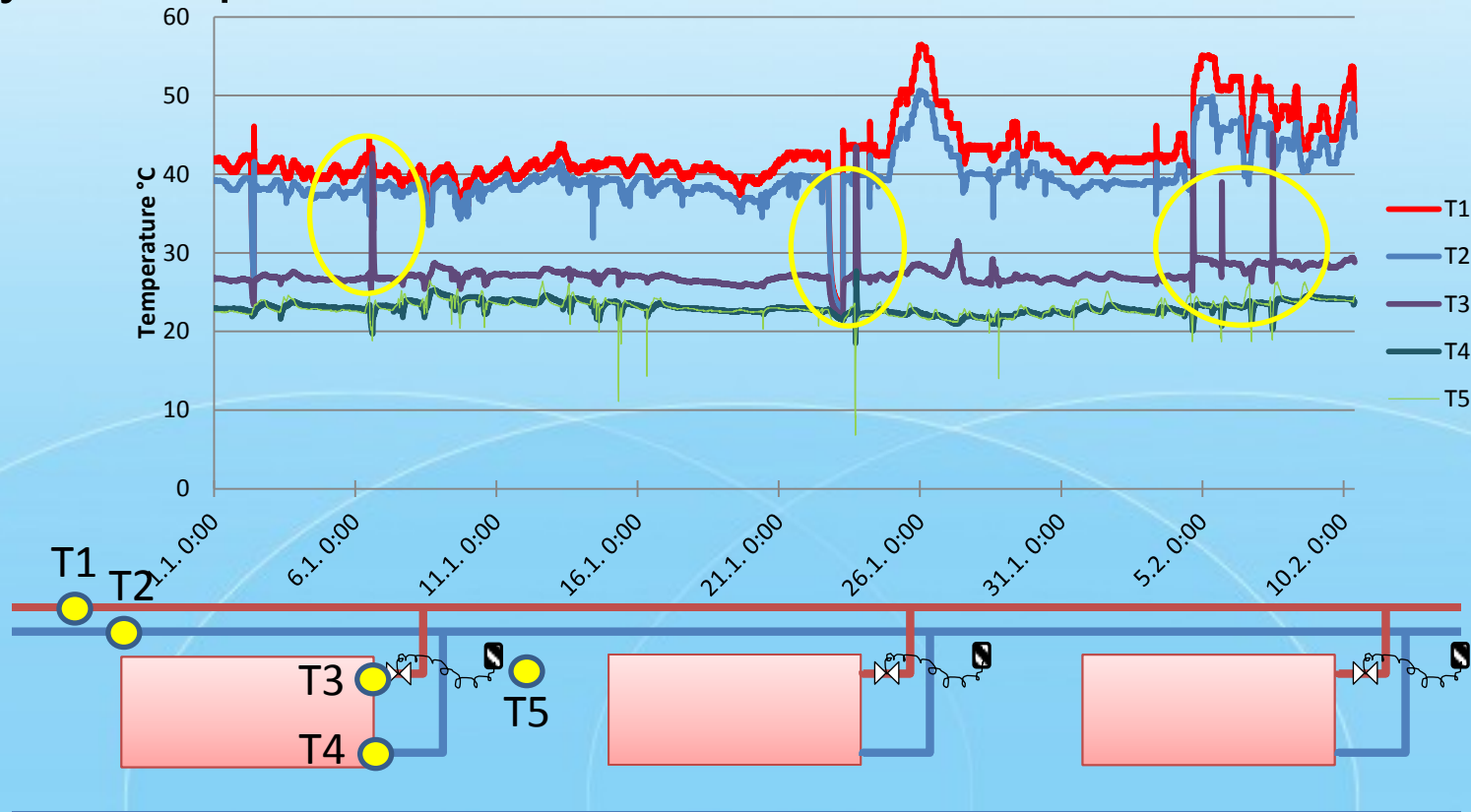
Case study

- Control system
- Equitherm control of water temperature + thermostatic valves at radiators



Case study

- System operation after installation



Case study

- System operation after pipe insulation and valves setup



Conclusions

- Energy performance of buildings certification brought attention also to heating systems
- Heating system efficiency is related to envelope, source but also to control!!
- Heat sources – primary energy related
- Distribution network systém
- Heat emmision control

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Questions?

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