Improving Energy Efficiency in Residential Buildings in the Republic of Belarus

IV International Conference
on Energy Efficiency in Buildings

Design, Construction and Operation of Energy Efficient Multi-storey Residential Buildings

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Introduction

- ☑ **Thermal Comfort**
- ☑ **Acoustic Comfort**
- ☑ **Indoor Air Quality**
- ☑ **Keep Construction free of Damage (preventing moisture and mold)**

☺ **Minimization of Energy Input**

The principle:

Keep energy demand as low as possible, cover as efficiently as possible.

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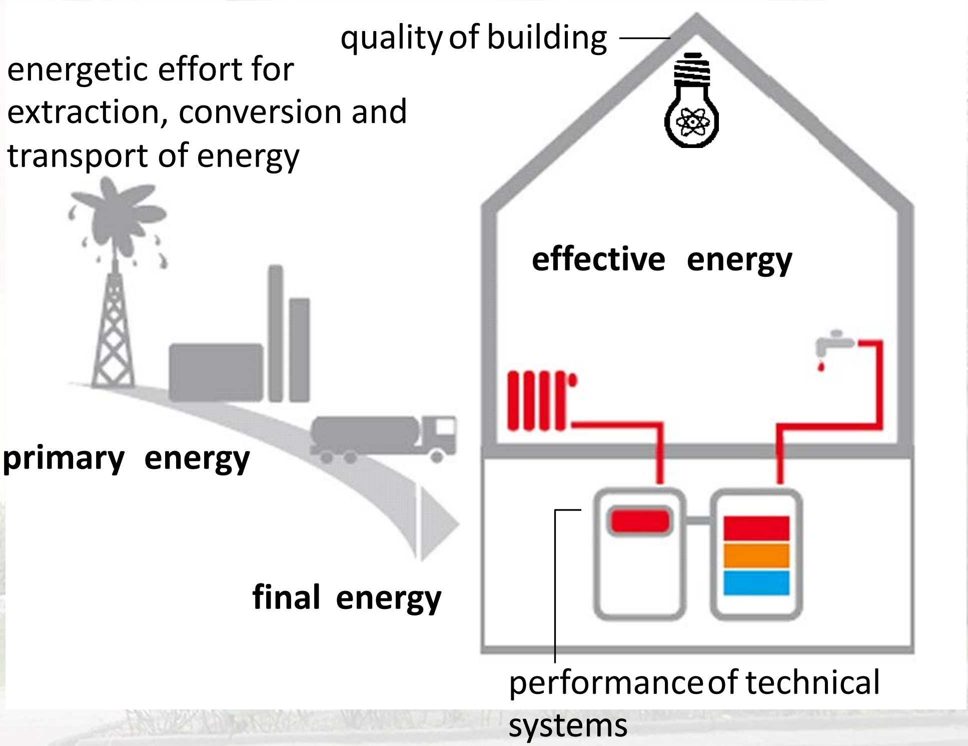
Introduction

Definitions:

Net or Effective energy
is available to the residents in forms of heat, cold or light

Final or Delivered energy
is provided by technical systems and includes losses by conversion, storage, distribution and transfer

Primary energy
is the total amount of energy including all of the energy used in the process of production and transport



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Introduction

Definitions:

demand	→	**consumption**

demand

Expected values (theoretical)

- Space heating
- Water heating
- Electrical power supply
- Model calculation with standard boundary conditions:
  - indoor climate
  - outside climate
  - user behavior
  - system parameters

consumption

Practical values (actual)

- Space heating
- Water heating
- Electrical power supply
- Evaluation of accounting

  (adjustment for outdoor climate and vacancy)

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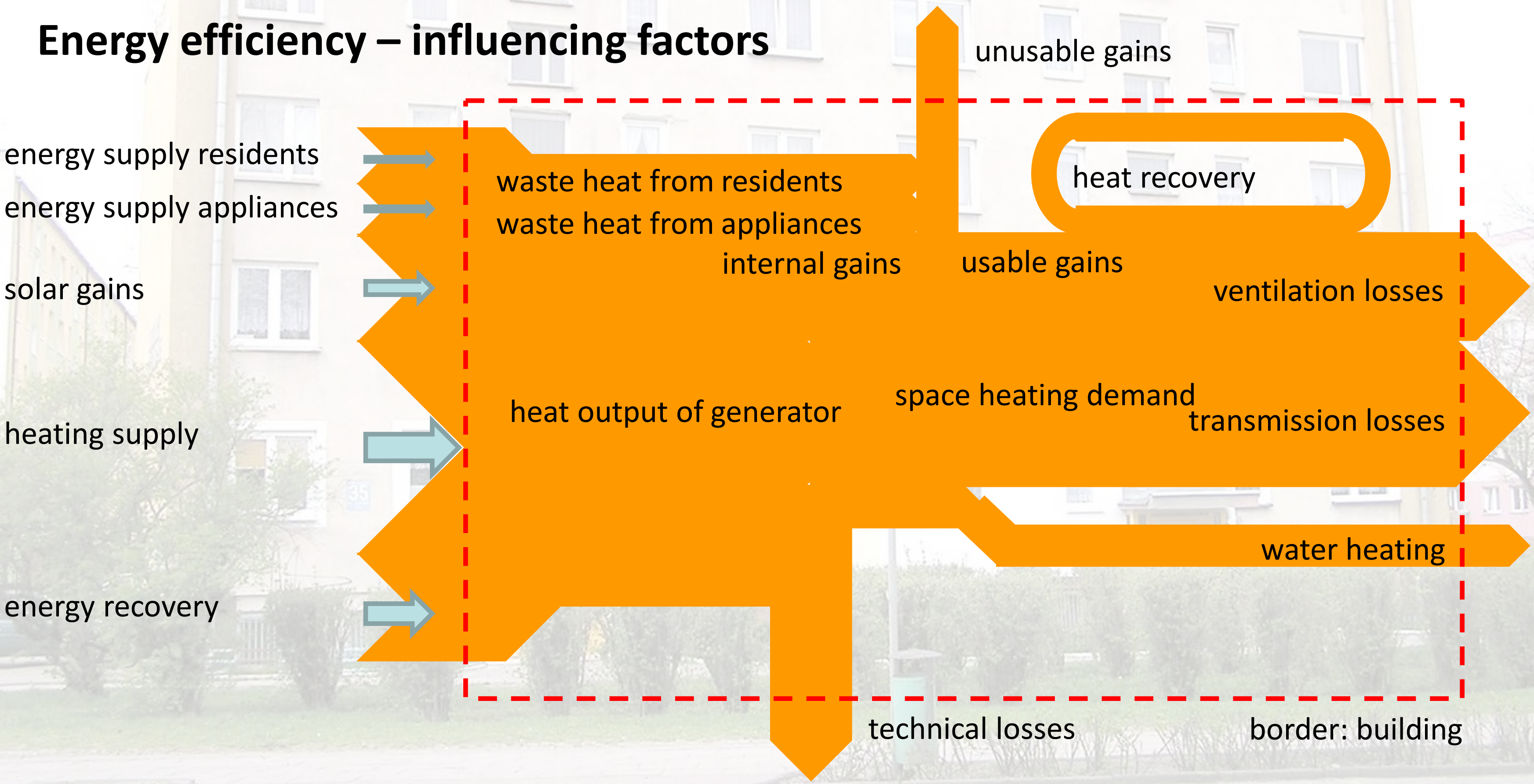
Introduction

Energy efficiency – influencing factors



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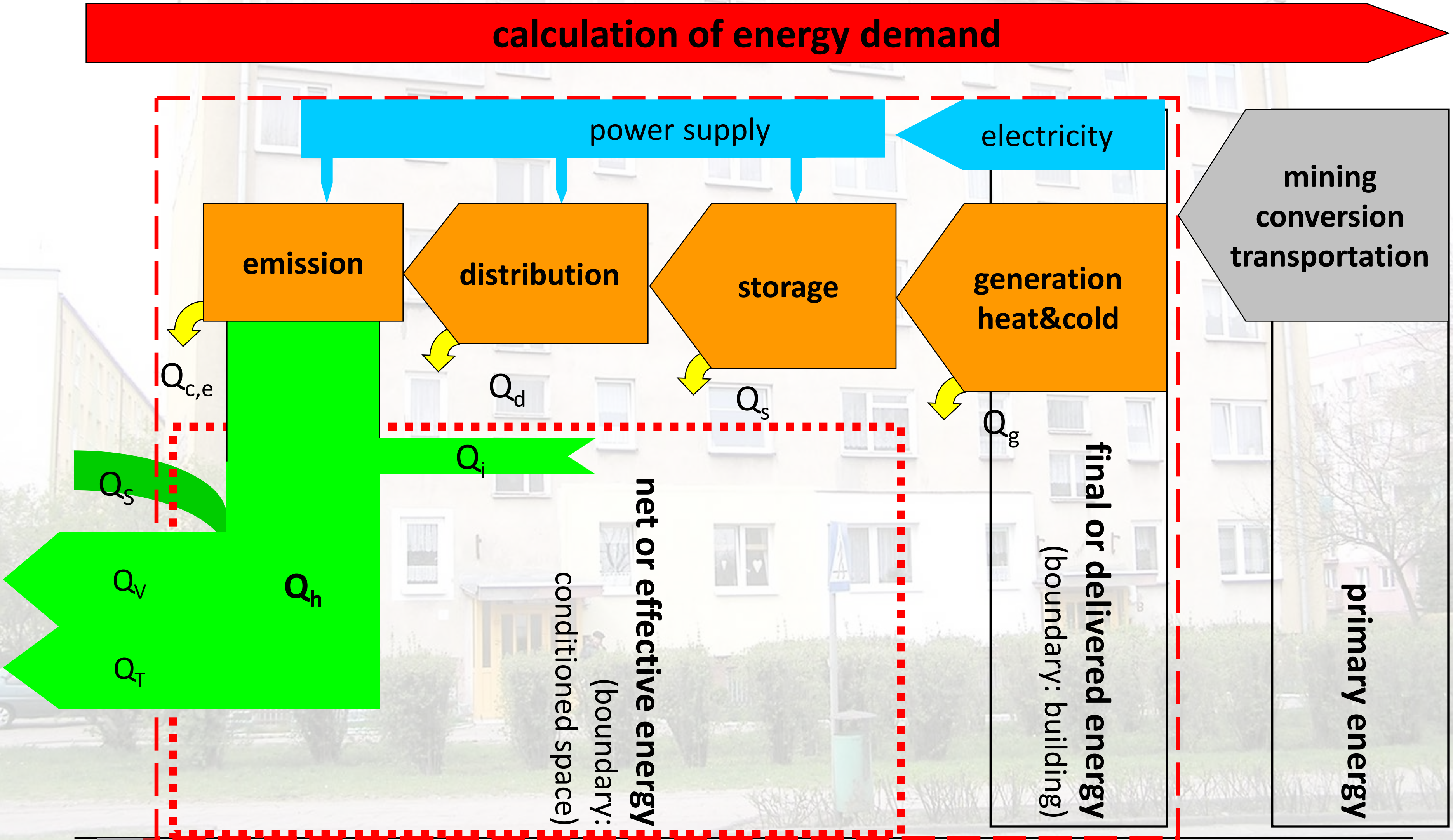

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Energy efficient solutions

Passive Side	Active side
Air tightness	Heating
Ventilation	Ventilation
Insulation	Water heating
Heat transfer coefficient	Air Conditioning
Orientation and location	Cooling Strategy
Passive solar architecture	Illumination
Glazing and surface	Efficient Appliances
Shading	Renewable Energy
Passive measures on heating	
Accumulation of heat and thermal buffers	

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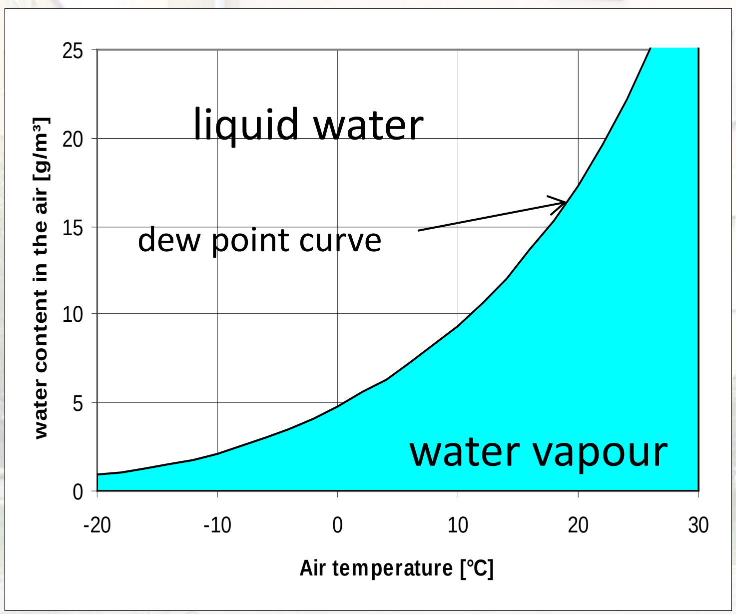
Energy-efficient solutions

Air tightness

- **Minimizing infiltration losses**
- **Comfort**
- **Preventing Mold**



Pressure test (method Blower Door) for detecting air leaks. Acceptable level of air tightness:

natural ventilation $n_{50} \le 3{,}0\ h^{-1}$

mechanical ventilation $n_{50} \le 1{,}5\ h^{-1}$

n_{50} = air change rate at 50 Pa pressure difference (air change per hour)

Internal dew point for the building

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Energy-efficient solutions

Ventilation

Natural (passive) ventilation:

- Thermal buoyancy operates on the principle that warm air rises inside the building.
- Pressure difference is using the effect of wind and pressure over the building and around it.

These ventilation techniques are used by following design strategies as:

- Solar chimney
- Louver vents for ventilation and shading
- Window
- Atriums

Mechanical (active) ventilation includes components such as fans, ducts and hoods. In well-insulated buildings , especially in cold climates , we use mechanical ventilation with heat recovery (MVHR).

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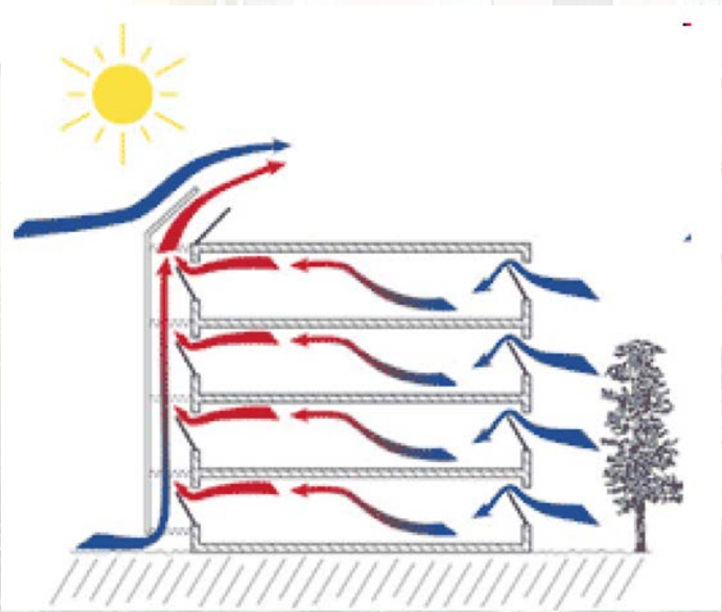
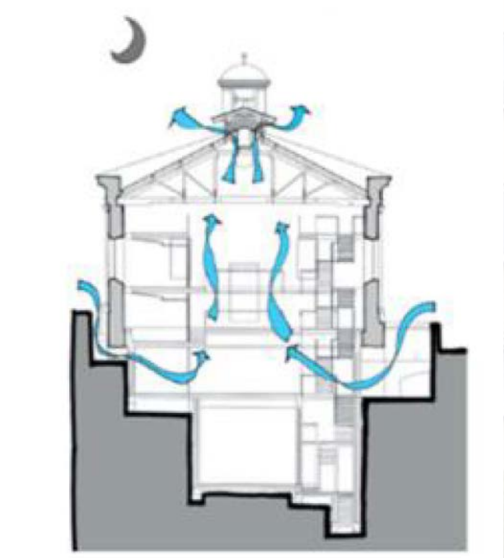
Energy-efficient solutions

Ventilation





summer night cooling
strategy using convective night
ventilation

Source: Тренинг по энергоэффективности – TrEff 2012/13

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Energy-efficient solutions

Insulation

Appropriate and sustainable building materials.
Choice of insulating materials:

- **Thermal Properties**
- **The durability and wear resistance**
- **Encased in material energy: the lower, the better.**
- **Costs**
- **Easy to install**
- **Fire resistance**

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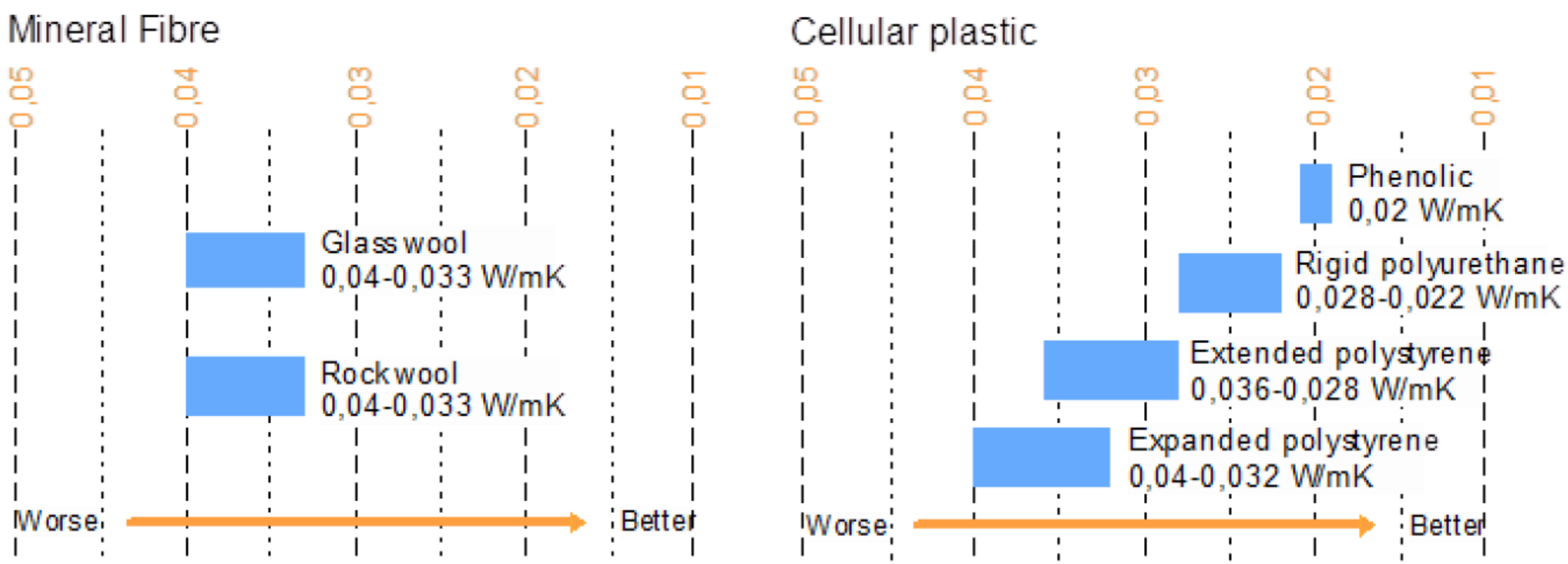
Energy-efficient solutions

Insulation

- **Thermal Properties**



Source: Тренинг по энергоэффективности – TrEff 2012/13

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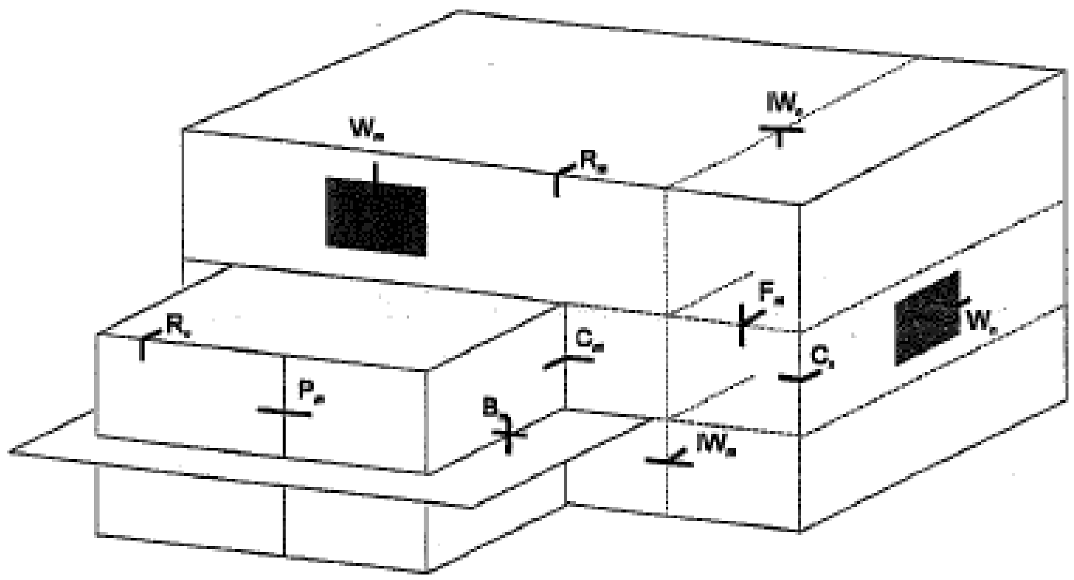
Energy-efficient solutions

Insulation

- **Thermal bridges**



Source: DIN EN ISO 14683:1999-09

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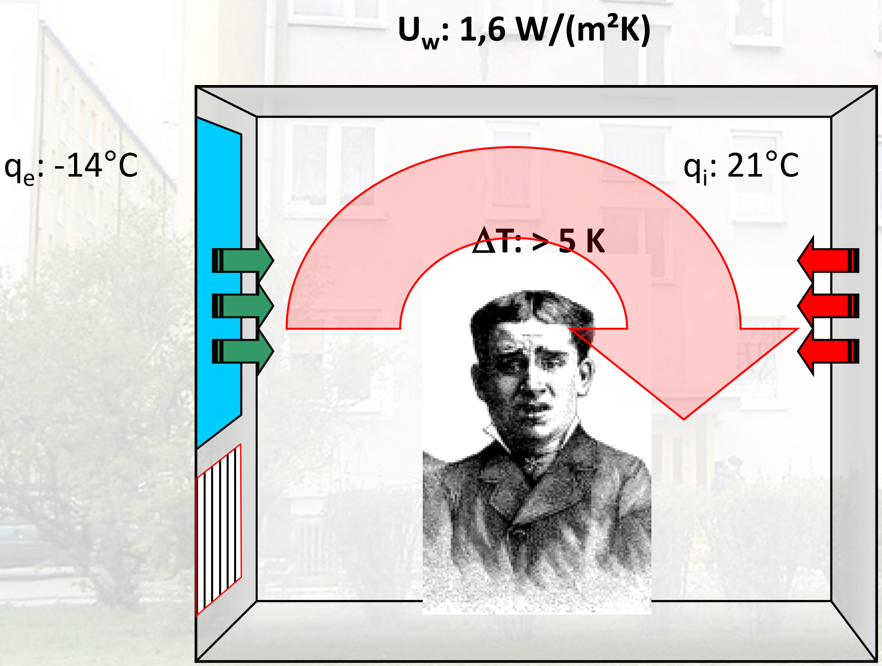
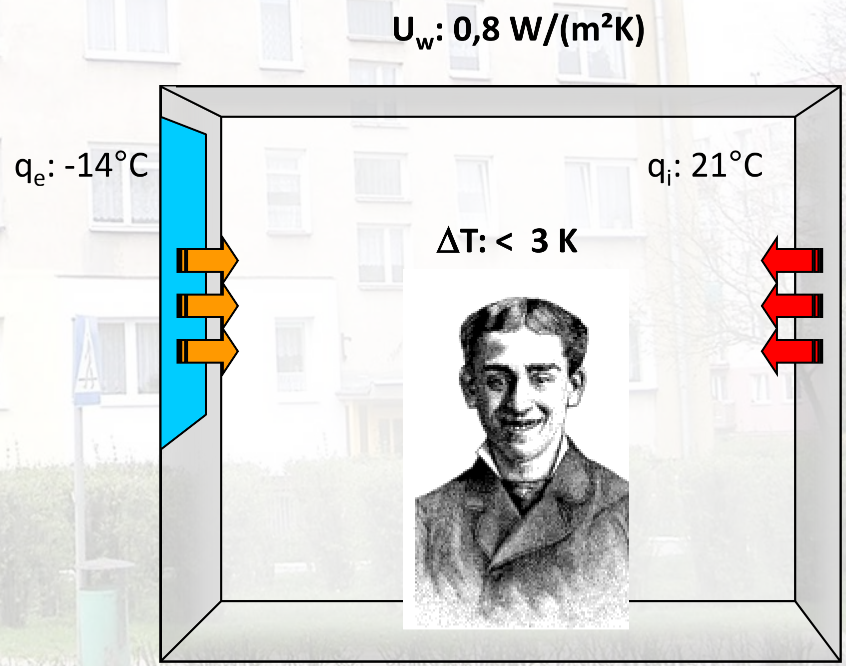
Energy-efficient solutions

Insulation - Asymmetry of Heat Radiation





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Energy-efficient solutions

Requirements

- **Thermal Properties**

Component	Belarus	Germany		Passive House	
Outer wall	0,31 W/(m²K)	12 ... 15 cm	0,28 W/(m²K)	22 ... 26 cm	0,15 W/(m²K)
Windows	1,00 W/(m²K)	Double glazing	1,30 W/(m²K)	Triple Glazing	0,80 W/(m²K)
Roofing	0,17 W/(m²K)	15 ... 16 cm	0,20 W/(m²K)	32 ... 33 cm	0,10 W/(m²K)
Floor	0,40 W/(m²K)	12 ... 14 cm	0,35 W/(m²K)	25 ... 26 cm	0,15 W/(m²K)
Thermal bridges		$\Delta U \leq 0{,}05$ W/(m²K)		$\Delta U \leq 0{,}01$ W/(m²K)	
Air tightness		$n_{50} \leq 1{,}5\ h^{-1}$		$n_{50} \leq 0{,}6\ h^{-1}$	

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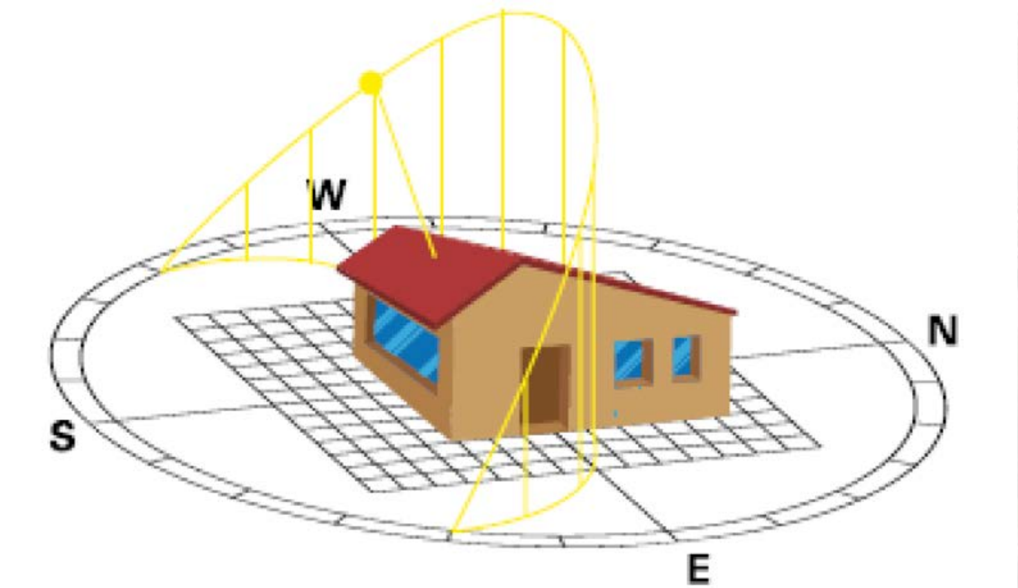
Energy-efficient solutions

Orientation and Shading

- Compact building envelope, optimization of the surface - volume ratio (A / V ratio).
- Minimum envelope at maximum energy reference area / heated space.
- Low pitched roofs allow an optimization.

- Effect of heating and cooling loads
- Orientation of the main facade with living space as possible between southeast and southwest.
- Avoid shadowing on the main facade by other buildings, vegetation, etc.



Source: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

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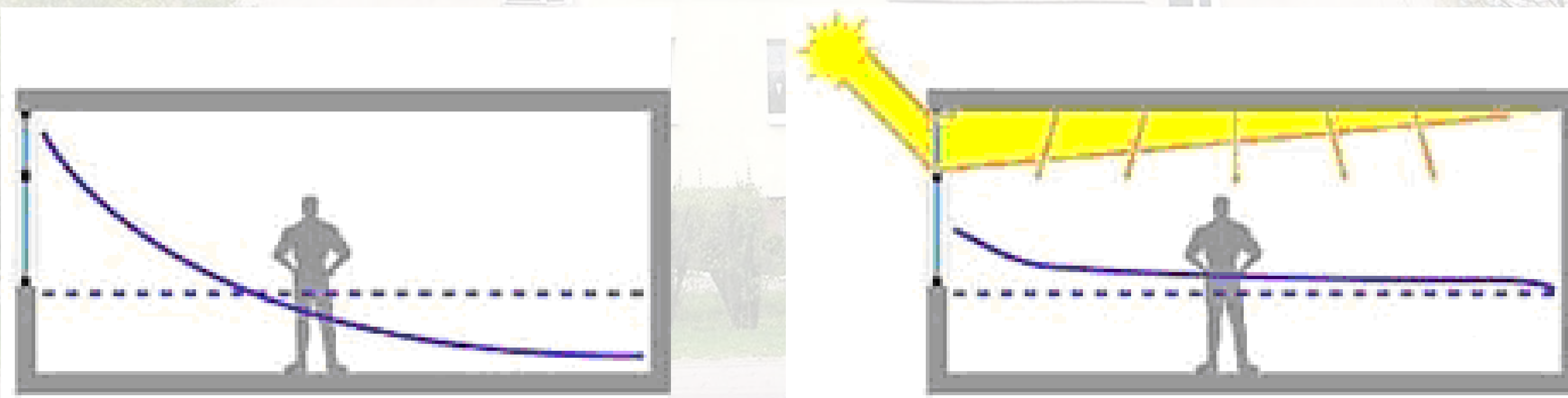
Energy-efficient solutions

Glazing and Surface

Daylight factor - the ratio between the light level at a certain point and the level of the building, accessible from the outside at the same time. Measured as a percentage. A good daylight factor is:

kitchen	2%
living room	1%
bed room	0,5%



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Energy-efficient solutions

Passive solar design

Passive solar design can provide the most heating requirements of the building where heat loss is minimized through good insulation and air tightness of the building.
Design strategies for solar heating is very dependent on local climatic conditions.
There are three different strategies for passive solar heating:

- Direct heat gain from direct solar radiation of sunlight coming through windows, glass roof or greenhouses.
- Indirect heat gain: use of the mass of the building, which accumulates energy and radiates heat.
- Isolated getting heat: solar radiation in an off-site place can be used selectively for heating other parts of the building

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Energy-efficient solutions

Passive Solar Design

Which options for passive heating and cooling do you have?
For example, large glazed windows can be used to increase the solar heat gains in winter, but shading or reducing the area of windows can be necessary to avoid overheating in summer.

The simplest method - put majority of glazed elements towards the equator.
Using windows with double glazing the window's area can be up to 50% of the entire façade, but if the surface of windows is too large, the heat losses through the windows may outweigh the benefits of getting extra warmth.

⇨ Studies are required to determine the optimal size of windows.

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Energy-efficient solutions

Shading

**Mobile forms of shading (such as blinds, awnings, sun screens)
are better suited for different seasons. In warmer climates courtyards can also provide shade and enhance natural ventilation in warm humid regions.
In cold climates, even the most advanced glazed windows will lose heat faster than an insulated wall.
Natural shading in the form of trees and vegetation can also be used to prevent penetration of the sun and wind.**

Solar shading:

- **plants**
- **projections of balconies / roof**
- **Shutters, blinds**
- **glass**

Source: Тренинг по энергоэффективности – TrEff 2012/13

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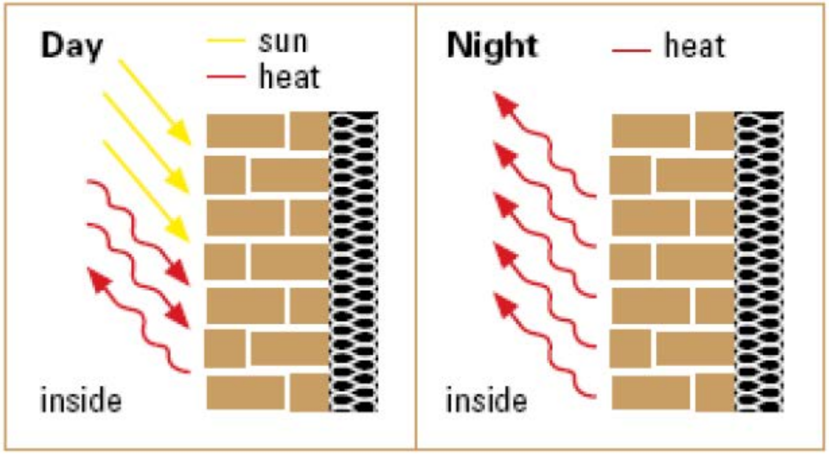
Energy-efficient solutions

Accumulation of heat and thermal buffers

Accumulation of heat is often accompanied by the above-mentioned measures to passive reception of heat. The capacity for accumulating heat - the amount of heat which the material can absorb and retain.
Materials such as concrete, masonry and water - common materials for thermal storage – can keep warmth in the winter and cool in the summer.



Source: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

- **Thermal buffer: buffering by the thermal mass**
- **Functions as a cooling element in the afternoon and a heater at night**

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Energy-efficient solutions

Technologies	Energy carriers / source	Use
Condensing boiler	Natural gas / Biogas Wooden pellets / Woodchips Vegetable oils	Heat
Combined heat and power	Natural gas / Biogas Wooden pellets / Woodchips Vegetable oils	Heat + Power
Solar thermics	Solar radiation	Heat
Photovoltaics	Solar radiation	Power
Heat pump	Near surface geothermal / Power Groundwater / Power Waste water / Power Internal heat sources / Power Air / Power	Heat + (Cooling)
Direct heat supply + (Steam turbine)	Hot Water - Geothermal surface-remote	Heat + (Power)

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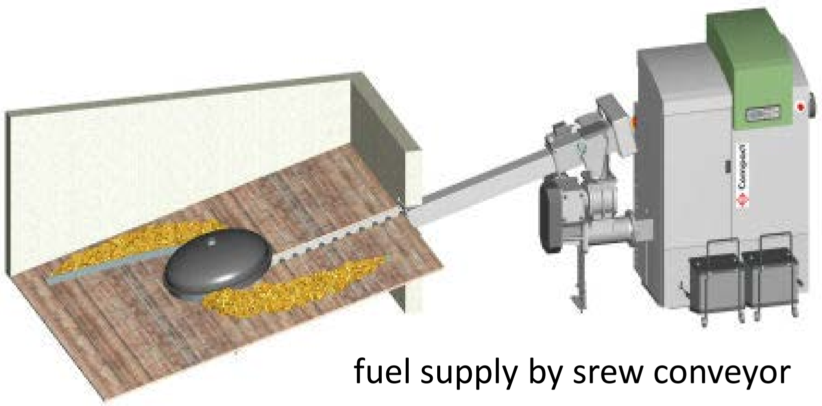
Energy-efficient solutions

- Pellet heating system

Earnings	Heat
Application	Base load and/or water heating
Temperature level	> 60°C possible
Efficiency	85%

- High operating comfort
- Fuel storage required



fuel supply by srew conveyor

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Energy-efficient solutions

• **Combined heat and power**

Earnings	Heat / Cooling
Application	Base load
Temperature level	> 60°C possible
Output	5 kW_{th} to 2 MW_{th}

• **Overall efficiency up to 85%**

• **Electrical efficiency depending on the combustion principle 31% ... 38%**

• **Fuel typically natural gas, biogas also possible**

CHP module: 50 kW_{el}
97 / 107 kW_{th} (without / with condensing)

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Energy-efficient solutions

- **Photovoltaics and solar thermics**

- **Photovoltaics**
  - **Earnings: 100 ... 130 kWh/(m²a) power, dependant on solar radiation**
  - **High cost**
  - **Multifunction desirable**

- **Solar thermics**
  - **Earnings: 300 ... 500 kWh/(m²a) heat, dependant on solar radiation**
  - **Temperature level: > 60°C possible**
  - **Application: Hot water (heating support)**

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Energy-efficient solutions

- Heat pump (electrically operated)

Earnings:	Heat / Cooling
Application:	Base load
Temperature level:	Preferably < 35°C
Coefficient of Performance:	4-6


Geothermal heat source

- specific heat extraction rate depends on geological conditions (30 W/m² area; 50 W/m depth)
- allows passive cooling

Wastewater heat source

- discontinuity of influent must be compensated
- specific heat extraction rate depends on biological treatment processes of waste water


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Energy-efficient solutions

Competition between different technologies

Space:	**e.g.: Photovoltaic und solar thermics** Both systems require a roof or façade areas with southern exposure
Economy	**e.g.: Geothermal energy** Geothermal energy provides renewable heat at a high temperature with high available services. - An additional heat generator is not necessary in this case and would only increase costs.
Operating periods:	**e.g.: CHP – Solar thermics** Solar gains during summer reduce the potential life of a CHP and thus its power generation. At higher investment costs they accomplish lower yields.

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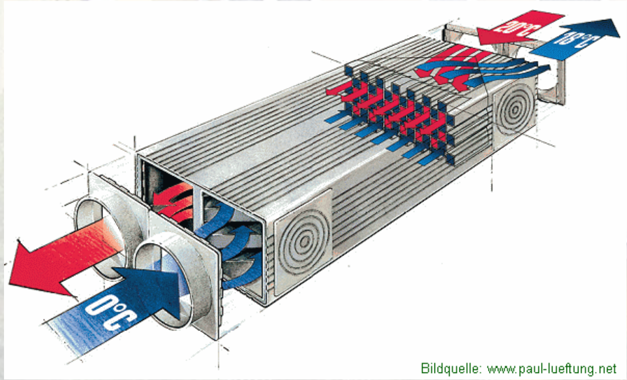
Energy-efficient solutions

Ventilation

- Free Ventilation
- Mechanical exhaust air system
- Supply and exhaust air system with heat recovery


source: www.regel-air.de



source: www.paul-lueftung.net


source: www.lunos.de


source: www.aereco.de

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Energy-efficient solutions

Heating - Cooling

- Heating systems can be also used for cooling
- Primarily: keep demand/load as low as possible
- Surface heating / cooling systems
- Appliances as possible inside the heated volume
- Well insulated pipes

- Demand-oriented control

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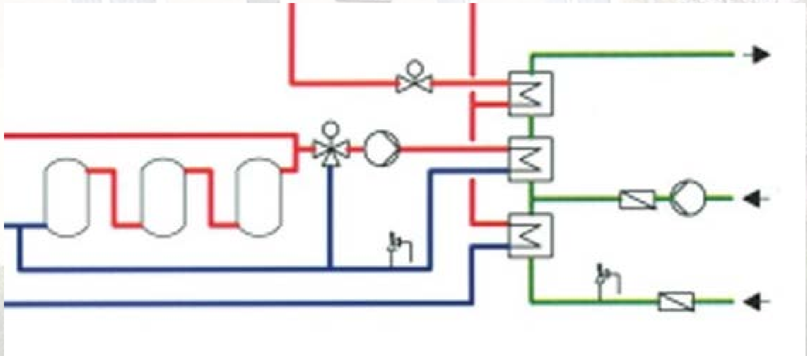
Energy-efficient solutions

Water heating

- **Minimized volume flow**
- **Excellent insulation**
- **Storage within the heated building envelope**
- **Minimized circulation losses (e.g. pipe-in-pipe – System)**
- **Combined energy and storage management**
  - multi-stage hot water in flow-through principle
  - buffer tank
  - power-controlled loading and unloading
  - demand hot water circulation
  - prophylactic network hygiene



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Energy-efficient solutions

Illumination

- **Maximum use of daylight as the natural lighting**
- **Energy-efficient lamps**

http://de-bug.de/medien/archives/australien-verbietet-gluhlampen.html

http://www.leuchtmittel-verkauf.de/Energiesparlampen/Energiesparlampen-Sockel-E-27/Philips-Tornado-ESaver-20W-827-E27::60969.html

- **Occupancy sensors in stairwells, elevators and hallways**

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Smart Metering

- Display of actual consumption and actual use time
- Dependent on the time of day and, possibly lower energy costs
- Opportunity for utilities to exploit existing power plant infrastructure and to avoid or postpone investment in better peak expansion
- Multi-utility systems for the detection of several different consumption data (electricity, gas, water, heat)

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Principles

- Selection of a suitable location of building
- High compactness,
- Massive structure,
- Excellent insulation of the envelope,
- High air tightness,
- Ventilation concept
- Use of solar gains,
- Efficient installations (small losses in the generation, distribution, transfer) thermal insulation of all pipes and fittings, demand-oriented control
- Use of renewable energy forms
- Monitoring

Thank You

for your attention!