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Training workshop "Studying international practices in implementation of innovative energy efficiency technologies in the electric power industry. Methodology, goal and objectives of electricity and heat consumers energy survey"

SEIT building, 62 Bayram Khan st, Mary, 13-19 March 2024

The concepts of near-zero energy building (nZEB) and passive house (PH)

Agris Kamenders,
International Consultant, SECCA

Stantec | intec | ACTED | European University Institute | FSR Energy Florence School of Regulation

Agenda

- Definitions of nearly zero-energy building (nZEB) and passive house (PH) buildings
- Construction principles
- Example of nZEB and PH buildings

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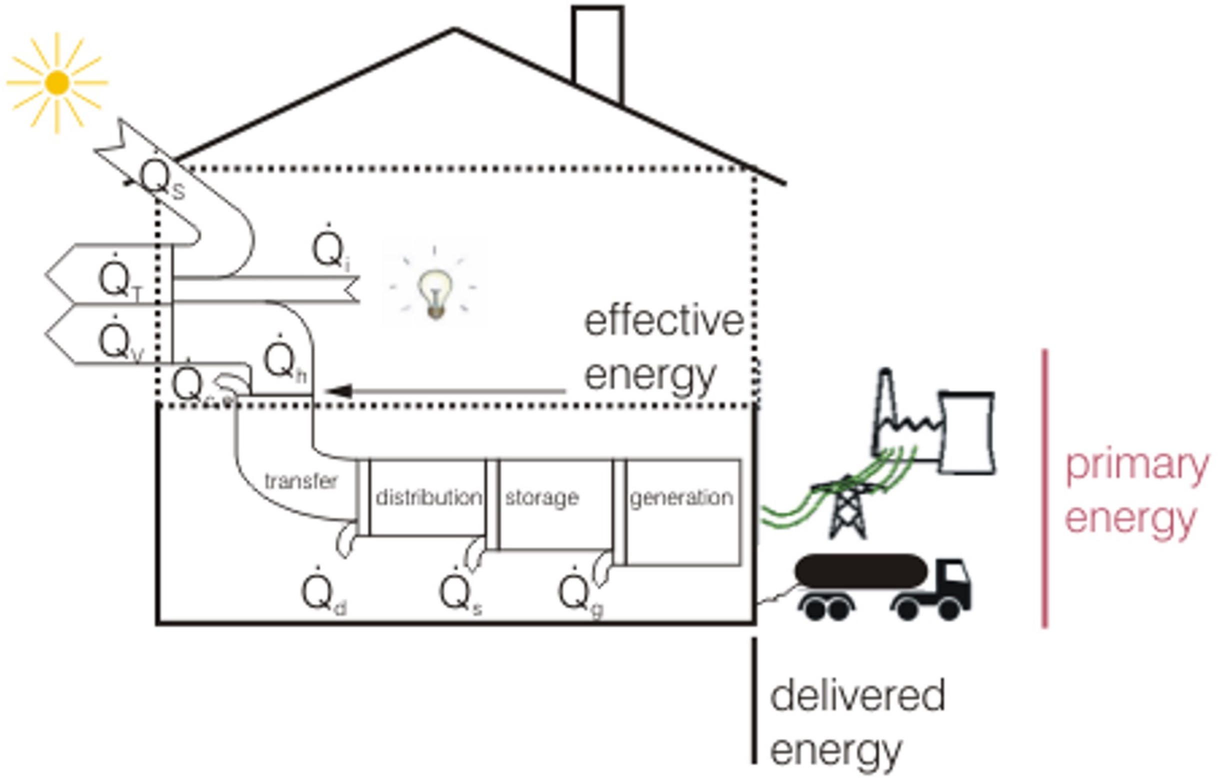
Nearly Zero Energy buildings

- Nearly Zero energy buildings (EPBD)
- Zero-emission buildings (EPBD)
- Passive house (PH)
- Other voluntary schemes



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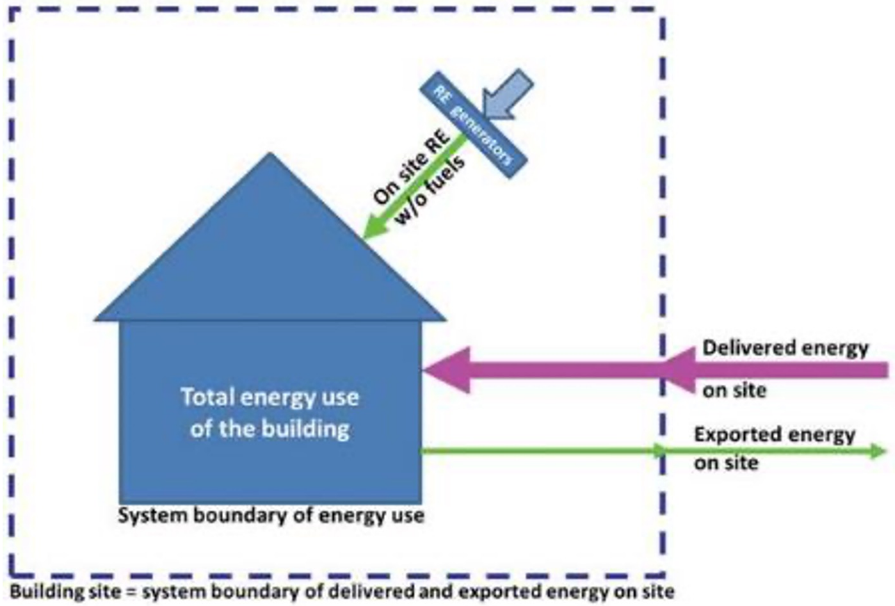
Nearly zero-energy building definition

- As per the Energy Performance of Buildings Directive (EPBD), energy performance cannot be lower than the cost-optimal level reported by Member States for 2023.
- Buildings must meet a nearly zero or very low energy requirement.
- A significant portion of the required energy should come from renewable sources.
- This includes renewable energy produced on-site or in close proximity to the site.

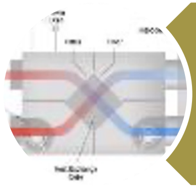


Source: REHVA

Example on nZEB definition in Latvia

Building energy consumption for heating ≤ 40 and 45 kWh/m2 per year.

Building's primary non-renewable energy consumption for heating, hot water supply, mechanical ventilation, cooling, and lighting (applicable to non-residential buildings) is less than or equal to 95 kWh/m2 per year.



The building has installed engineering systems and energy-consuming devices that comply with at least Class A

A certain microclimate is provided in the rooms (Requirements for room temperature, air exchange, overheating in summer, ...)

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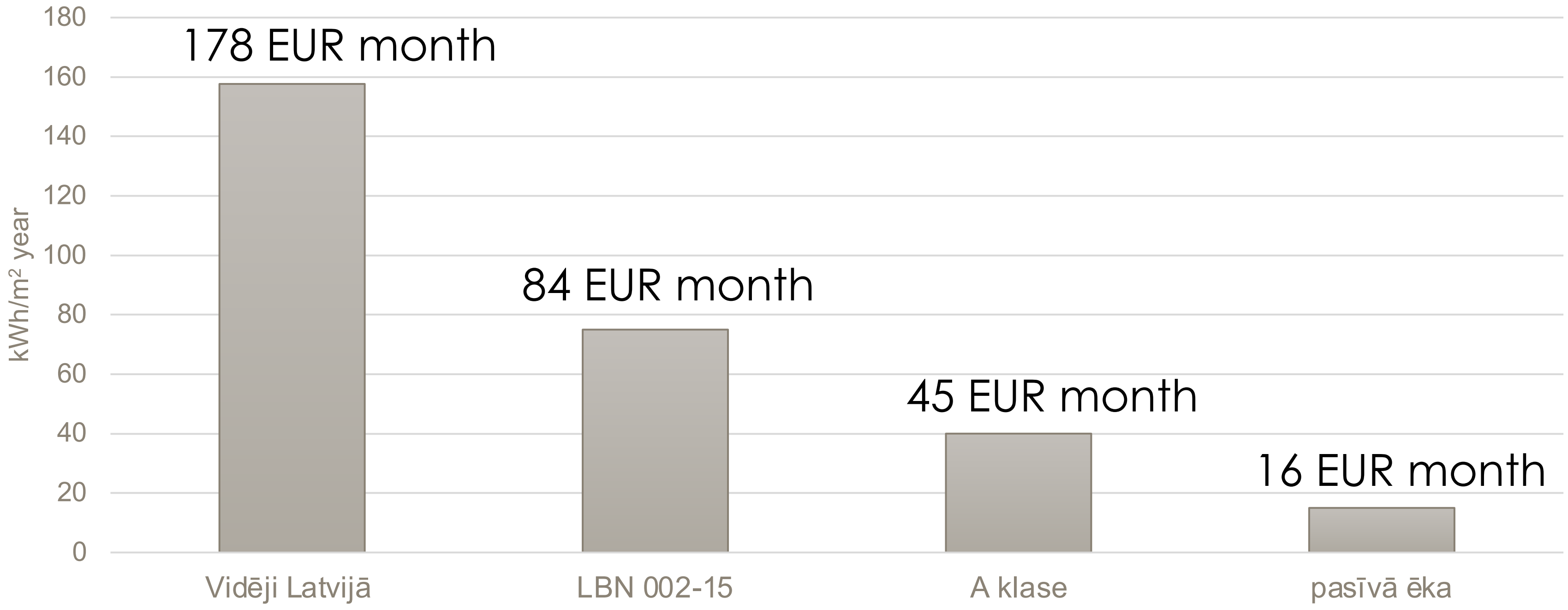
What it means for existing buildings - energy consumption and average heating costs for a 75 m² apartment.



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European Commission's recommendations of energy performance (EP) for NZEBs in different climate zones

NZEB level of energy performance	Mediterranean Zone 1: Catania (others: Athens, Larnaca, Luga, Seville, Palermo)	Oceanic Zone 4: Paris (Amsterdam, Berlin, Brussels, Copenhagen, London, Prague)	Continental Zone 3: Budapest (Bratislava, Ljubljana, Milan, Vienna)	Nordic Zone 5: Stockholm (Helsinki, Tallinn, Riga, Gdansk, Tovarene)
Offices, kWh/(m² a)				
net primary energy	20–30	40–55	40–55	55–70
primary energy	80–90	85–100	85–100	85–100
on-site RES primary energy	60	45	45	30
New single-family houses, kWh/(m² a)				
net primary energy	0–15	15–30	20–40	40–65
primary energy	50–65	50–65	50–70	65–90
on-site RES primary energy	50	35	30	25

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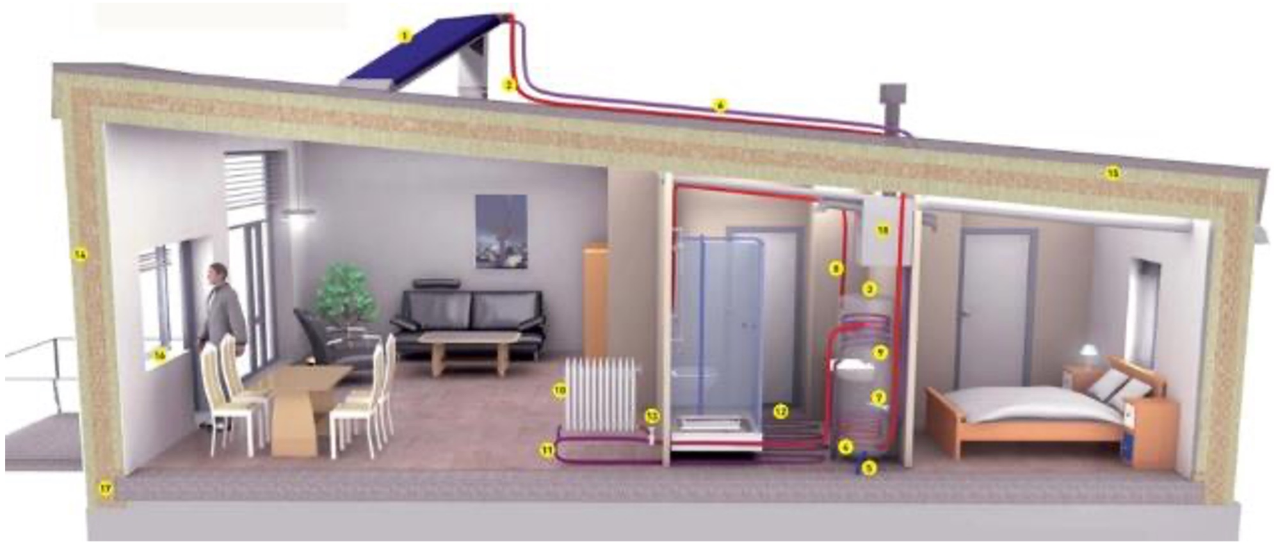
Nearly Zero Energy buildings

Transforms a building or building:

- before 1 January 2030, into a **nearly zero-energy building** (starting from 2021)
- as of 1 January 2030, into a **zero-emission buildings (**as of 1 January ***2028***, new buildings owned by public ***bodies***)



Bosco Verticale, Milan

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Up coming zero-emission building concept

Carbon Emission Standards

•Must not produce any onsite carbon emissions from fossil fuels.

Adaptive Energy Management

•Capable of responding to external signals to adapt energy usage, generation, or storage.

•Adaptations should be economically and technically feasible.

Compliance with National Standards

•Energy demand must comply with at least cost-optimal levels from the latest national report.

Energy Use Thresholds

•Maximum primary energy use threshold must be at least 10% lower than the national standard for nearly zero-energy buildings.

Renewable Energy Sourcing

•Prioritize energy from renewable sources generated onsite or nearby.

•Encourage the use of renewable energy community initiatives.

•Support the inclusion of efficient district heating and cooling systems

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In 1893, the expedition ship "Fram" was considered a nearly zero-energy consumption building.

Walls:
- Tarred felt
- Cork filling
- Spruce wood

Ceilings:
- Approximately 40 cm thick

Windows:
- Triple glazing

Ventilation and Comfort:
- Excellent ventilation ensures air quality
- Warm and cozy living space for comfort

The world's first 'zero energy' house from 1970s

During the 1973-74 oil crisis Denmark, which was massively impacted by the quadrupling of energy prices, invested in applied energy conservation in building research.

- Utilized prefabricated sandwich panels with mineral wool insulation to minimize field joints and maximize airtightness.
- Achieved impressive U-values: 0.14 for walls and 0.10 for floors/ceiling.
- Employed double-glazed windows with insulated shutters to enhance insulation further.
- Integrated a mechanical ventilation system with heat recovery, operating at 70% efficiency.
- Featured a unique solar water heating system, despite challenges with material durability.
- Real-world occupancy highlighted discrepancies in energy use expectations and actual outcomes, providing valuable insights for future zero energy buildings.

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1991: Passive House in Darmstadt-Kranichstein

Quelle: PHI

- **Heating and Cooling:**
  - Maximum of 15 kWh/m^2 per year as per Passivhaus Planning Package.
  - Peak heat load should not exceed 10 W/m^2, considering local climate data.
- **Primary Energy Consumption:**
  - Does not exceed 60 kWh/m^2 per year, covering heating, hot water, and electricity.
- **Airtightness Criterion:**
  - No more than 0.6 air changes per hour at 50 Pascals, confirmed by a pressure test.

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Passive House Certification Requirements:

- **Space Heating Demand:** The annual heating demand must not exceed 15 kWh/m² per year (or heating load of 10 W/m²).
- **Total Primary Energy Demand:** The annual primary energy demand for all uses (heating, cooling, hot water, lighting, and appliances) must not exceed 120 kWh/m² per year.
- **Airtightness:** The building must achieve an airtightness of 0.6 air changes per hour at 50 Pascals (ACH50) or less.
- **Thermal Comfort:** Indoor temperature requirements ensure that overheating does not occur for more than 10% of the year and that the temperature in all living areas remains between 20-25°C.
- **Renewable Energy:** A minimum portion of the building's energy demand must be covered by renewable energy sources, typically through on-site renewable energy generation.
- **Quality Assurance:** Passive house projects must undergo rigorous quality assurance measures, including design review, site inspections, and testing to verify compliance with certification requirements.

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PRINCIPLES OF NEARLY ZERO-ENERGY BUILDING DESIGN

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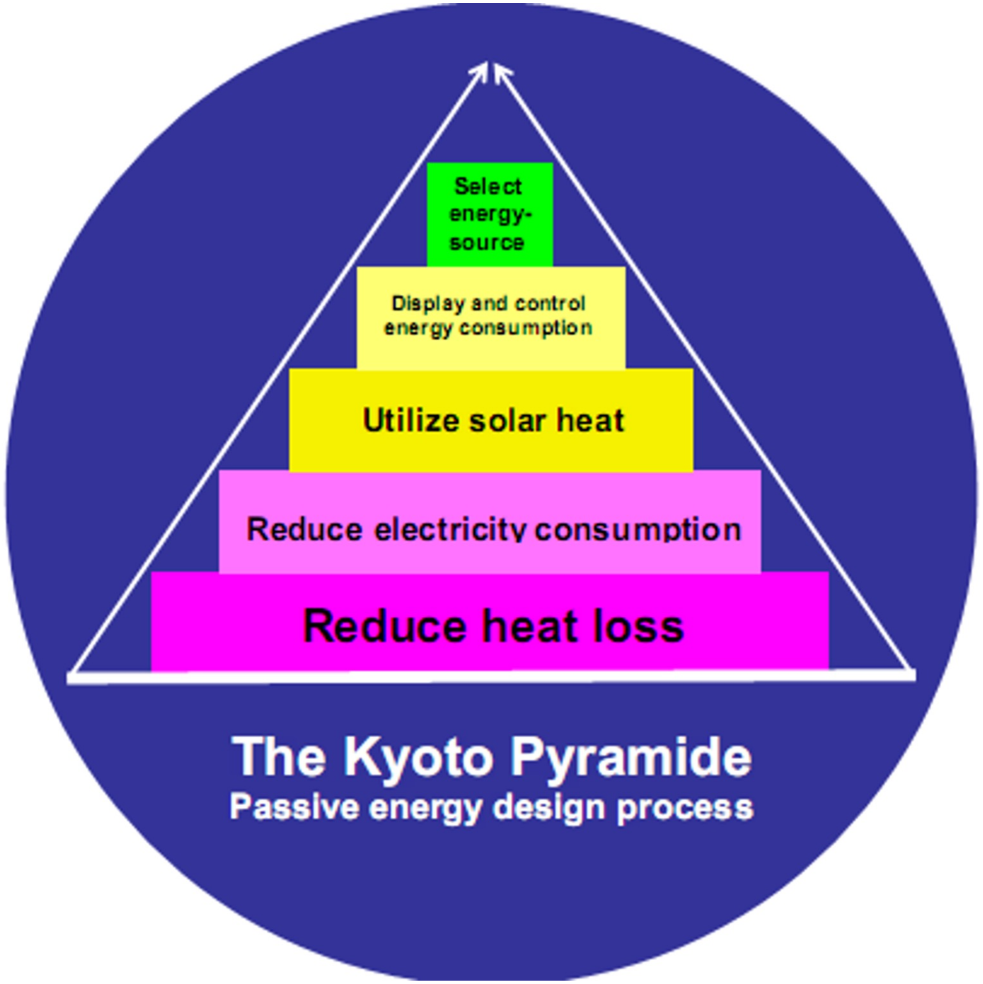
Conceptual approach (Kyoto Pyramid) - NZEB design strategies



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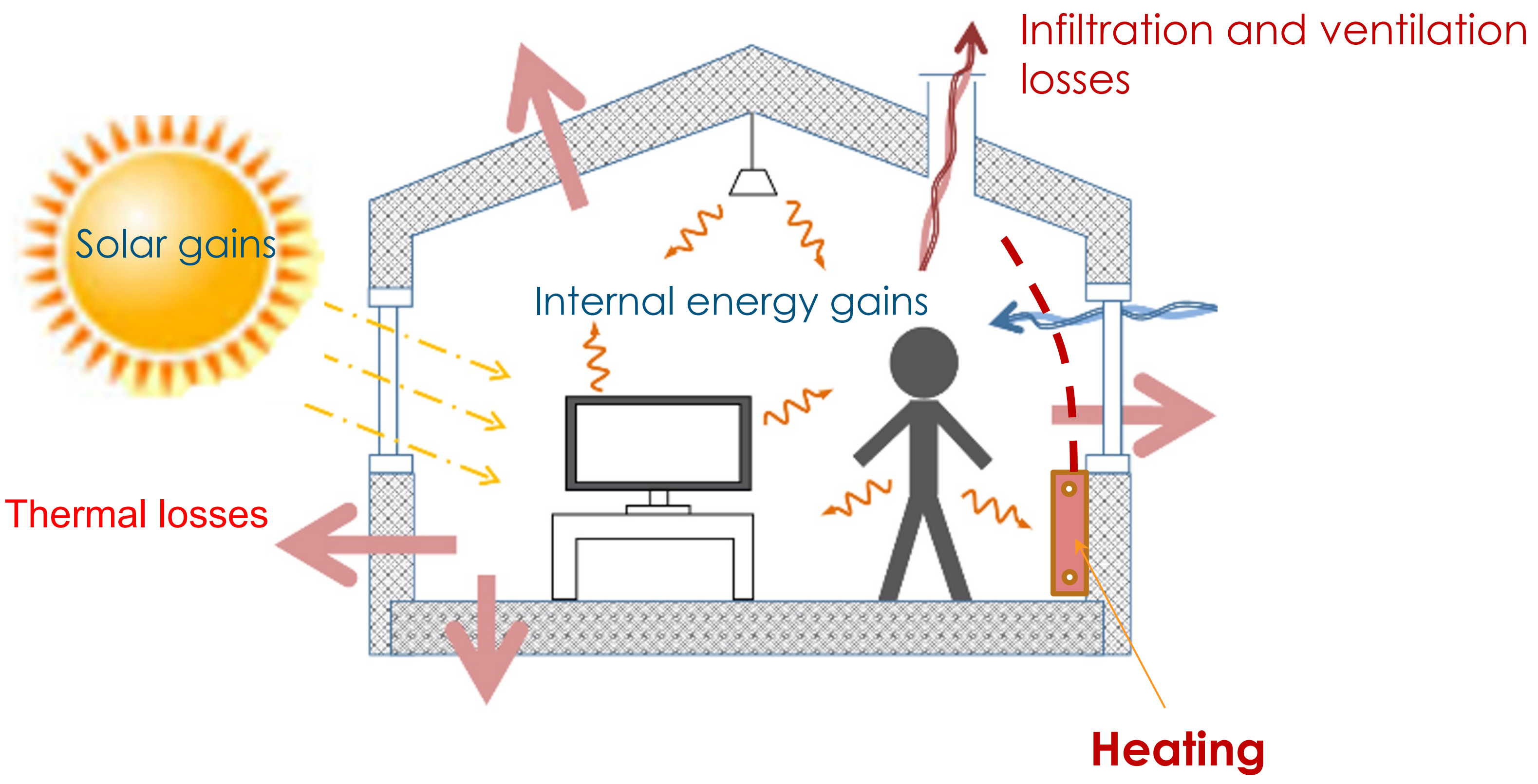
Building energy balance



Heating = Losses – energy gains

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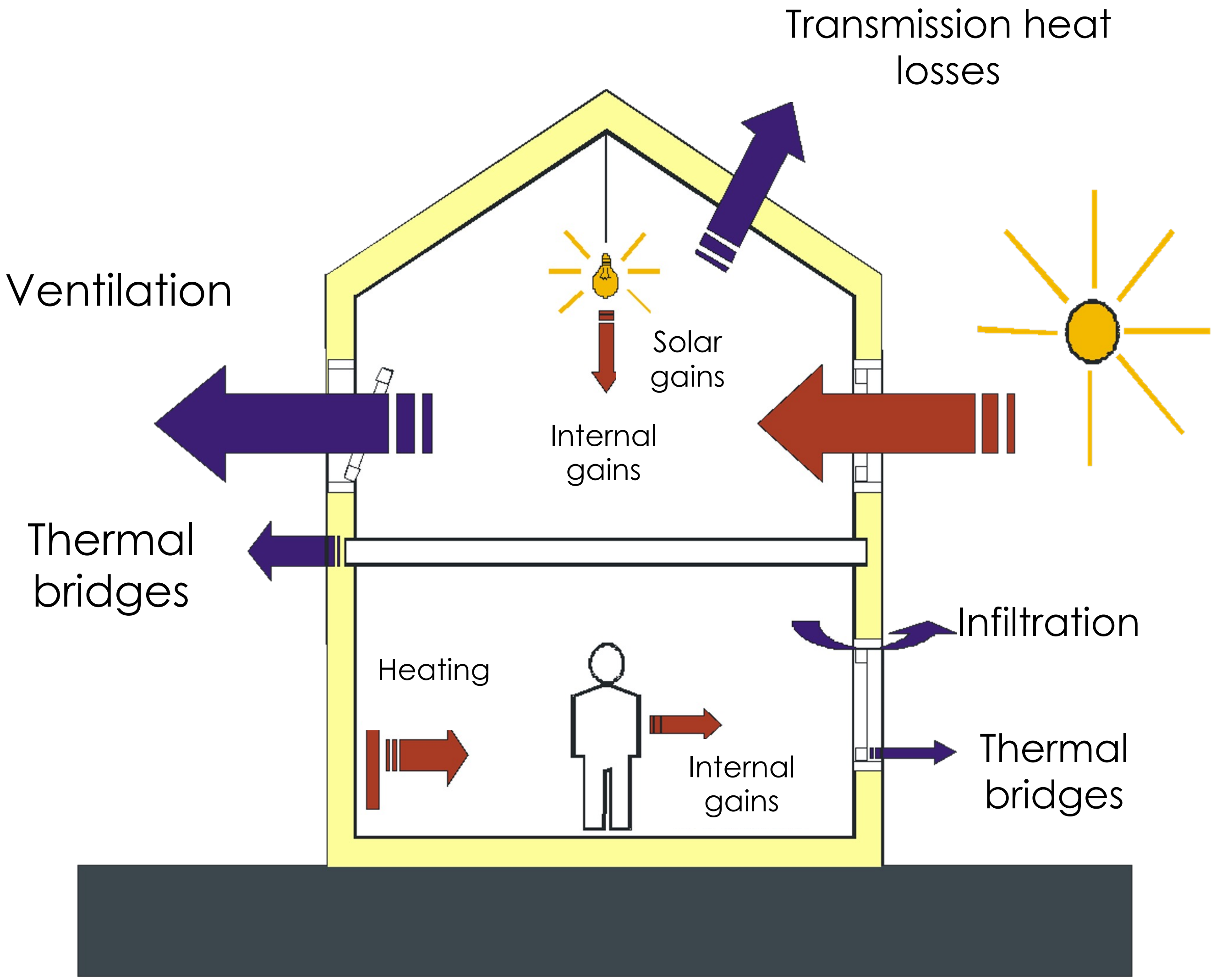
Building energy balance for conventional building



Source: Martin Ploss

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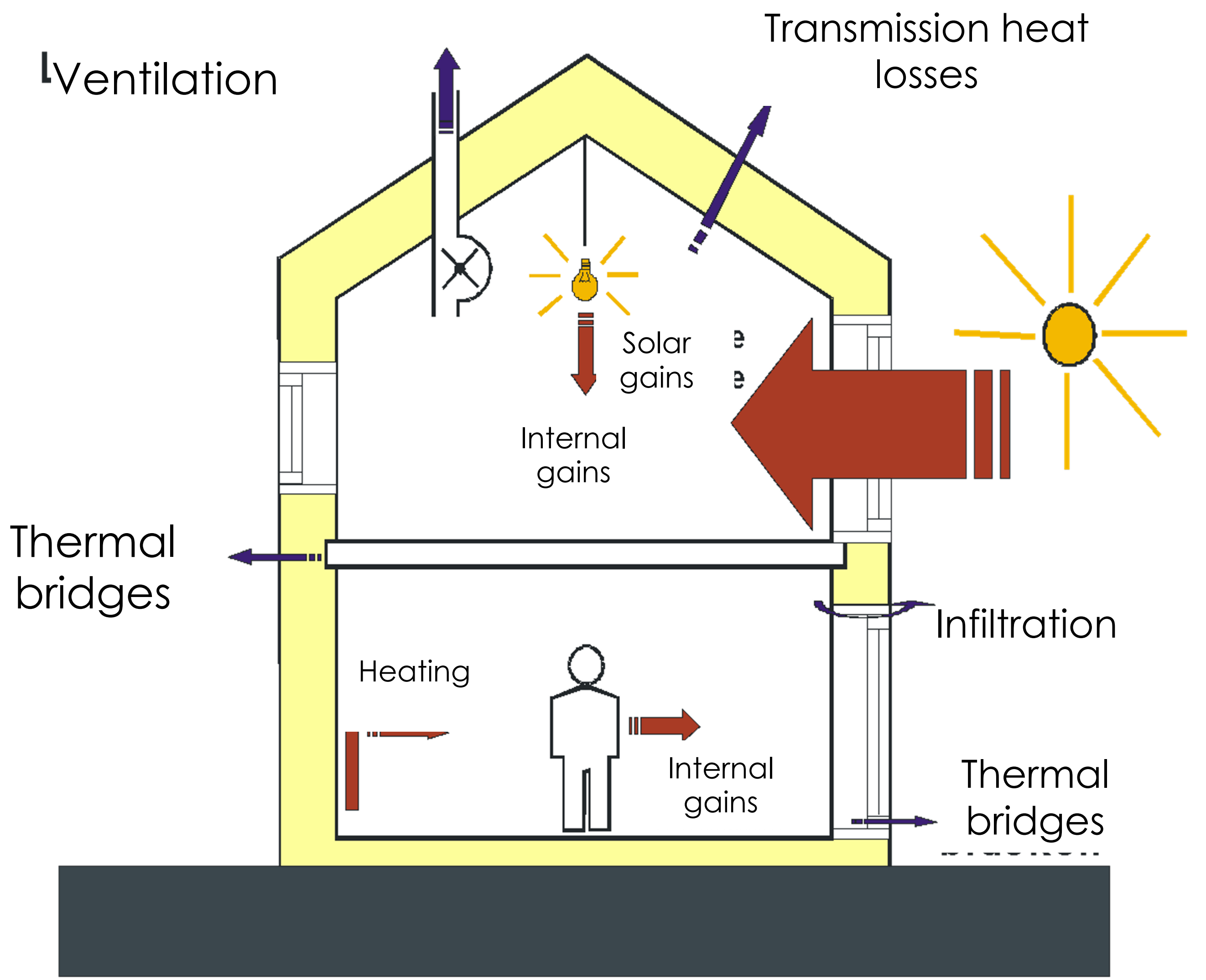
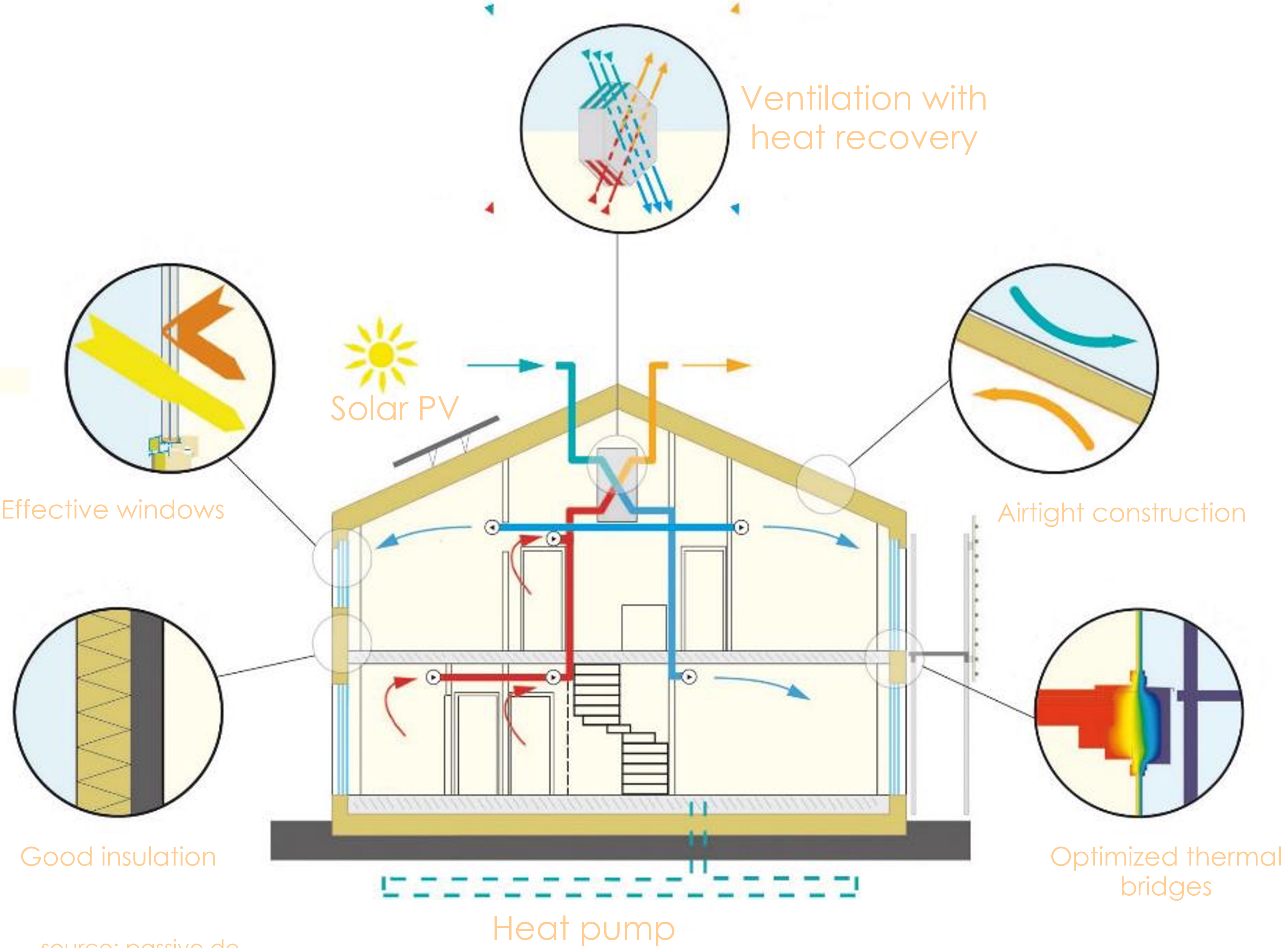
Building energy balance for nZEB building

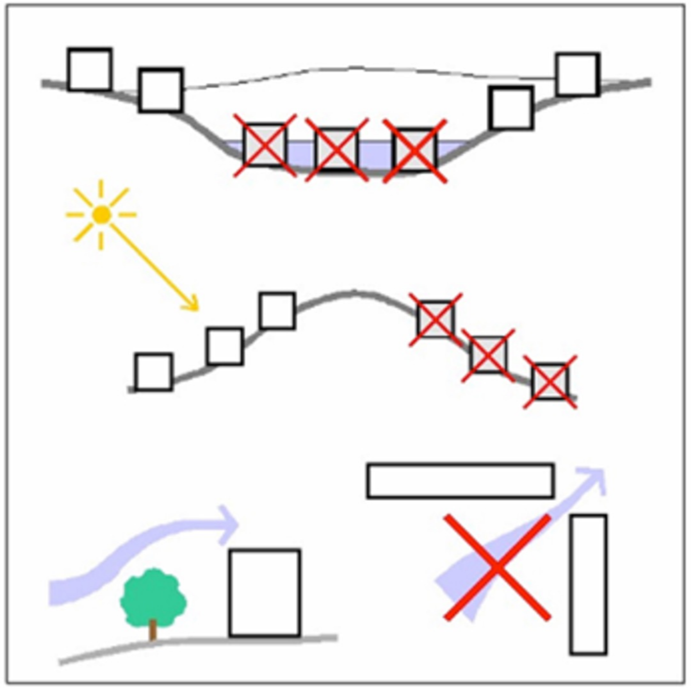


Source: Martin Ploss



source: passive.de

Building location



For preservation EE construction prerequisites:

- South orientation and optimization of solar energy utilization
- Issues with building shading and overheating in summer
- Evaluate the shading from surrounding buildings. Assess building compactness: For example, the possibilities of forming terraced houses.
- Evaluate the opportunities to use roofs and facades for solar energy utilization (optimal placement of solar panels)
- Assess the potential for creating wind tunnels

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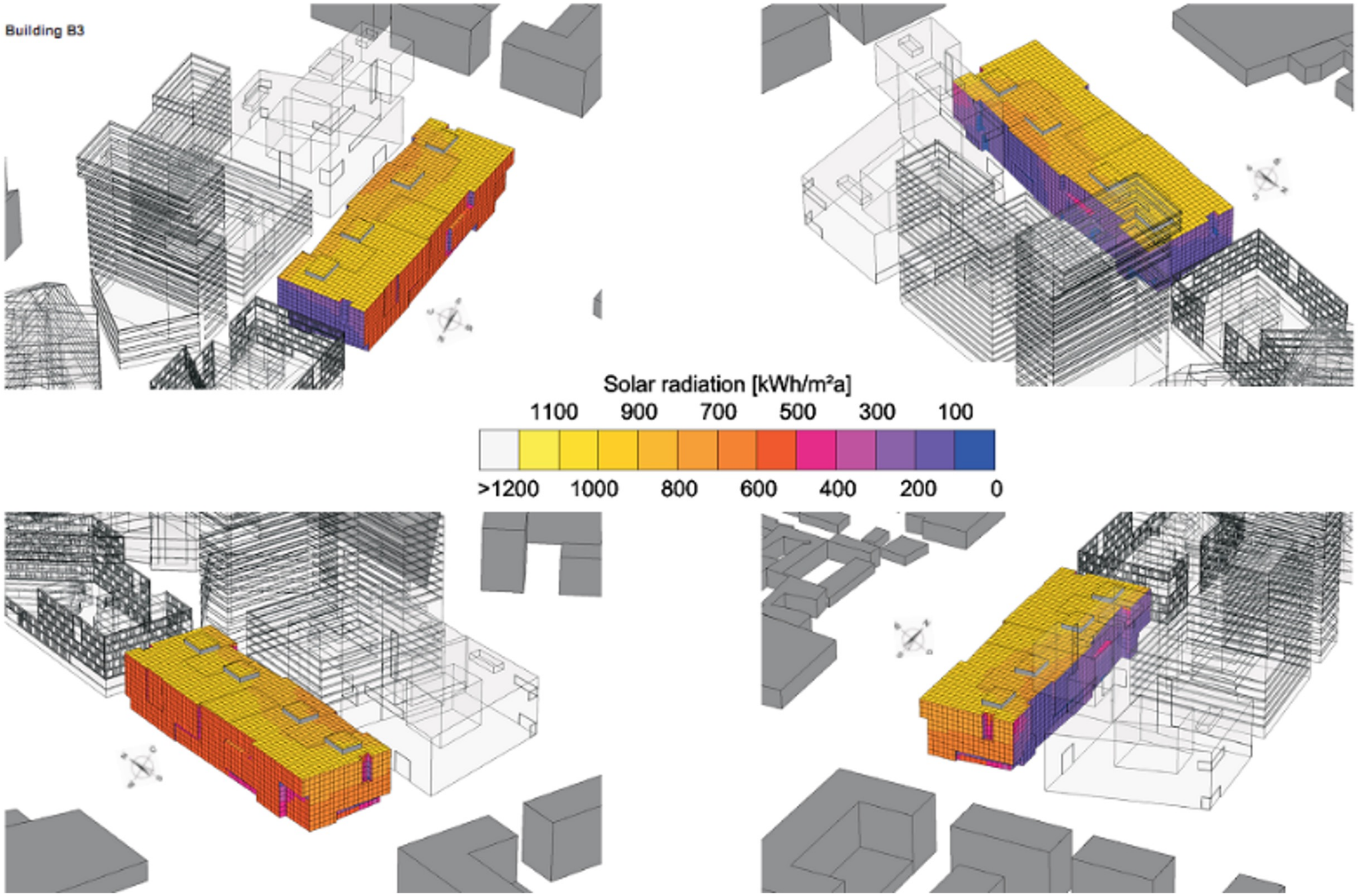
The mutual placement of the buildings and whether the buildings/structures shade each other must also be taken into account.



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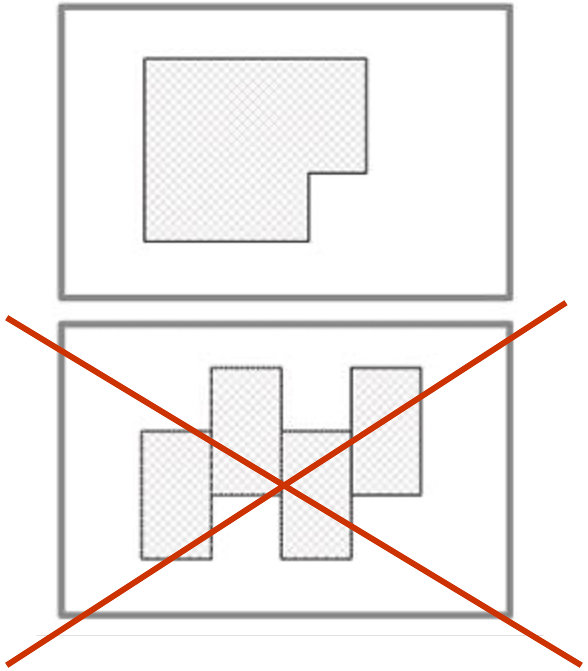
Building shape and functionality



Avots: Passnet

- The more compact the shape of the building, the smaller the heat losses through the enclosing structures. Fewer thermal bridges.
- Non-residential spaces (kitchen, WC, utility rooms) should be located on the north side of the building, as these rooms can have smaller windows.
- The building's envelope includes all types of engineering communications (electrical wires, water supplies, etc.). These nodes must be carefully resolved to ensure low air permeability.

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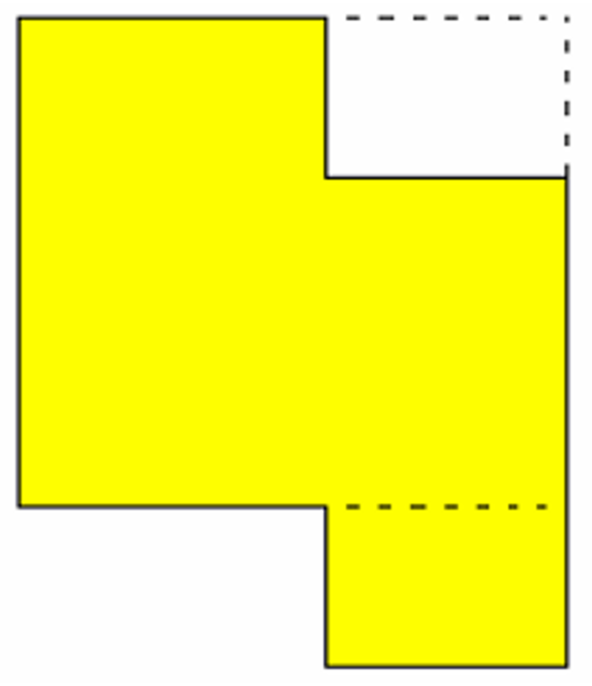
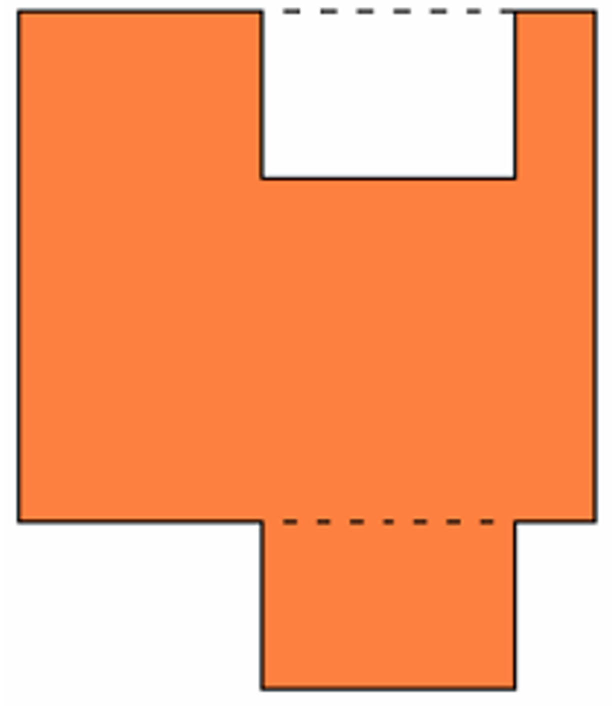
Compact building form



The building's perimeter has increased by 10%. It is necessary to increase the insulation layer by 2 cm



The building's perimeter has increased by 20%. It is necessary to increase the insulation layer by 4 cm

Soruce: NorthPass

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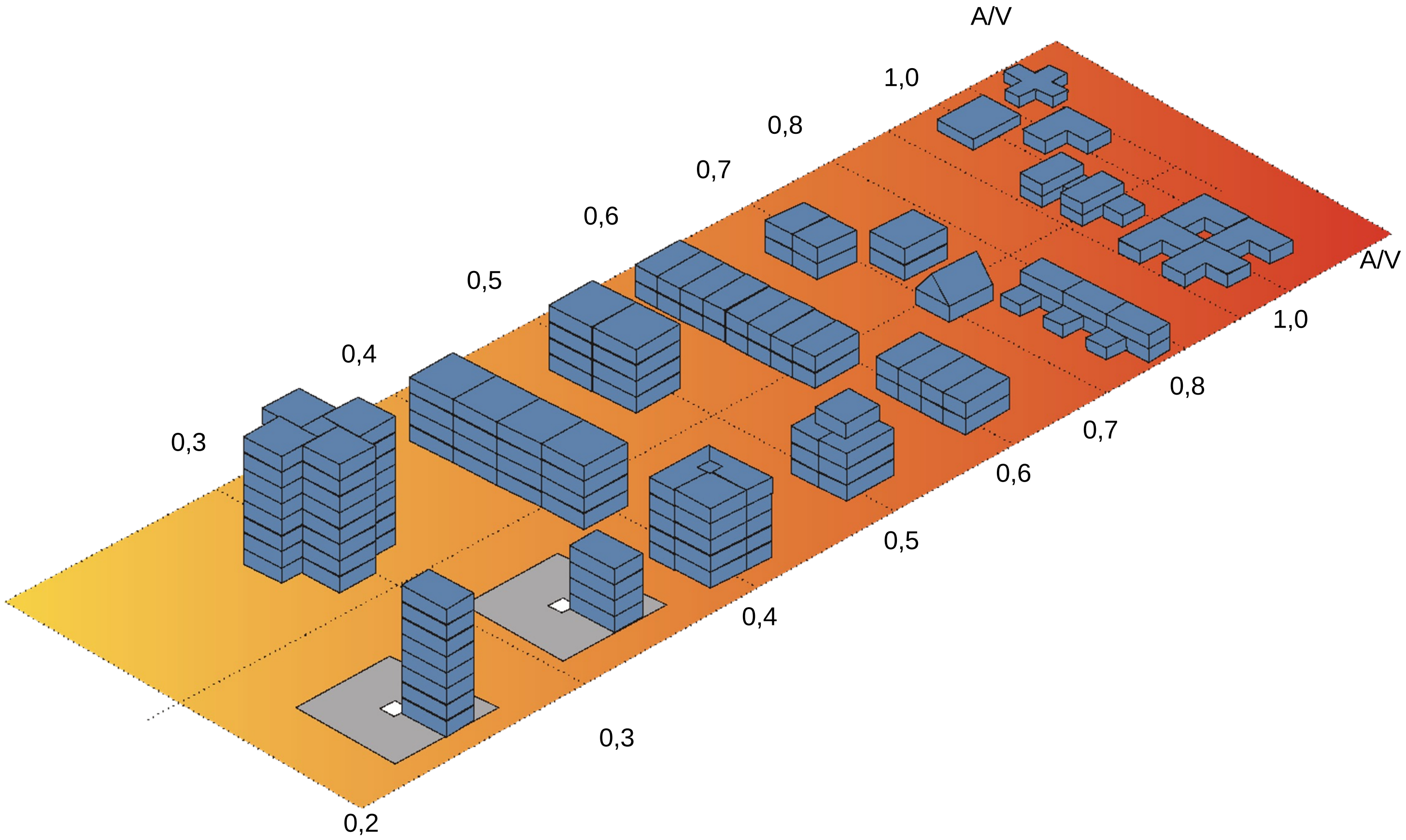
Compact building shape



Source: Passive House Institute, Darmstadt

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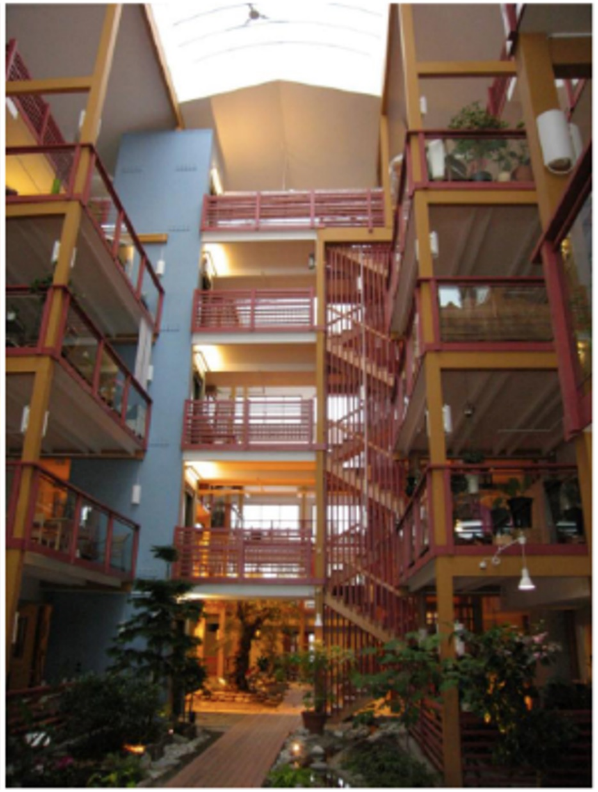
Examples of compact building shape



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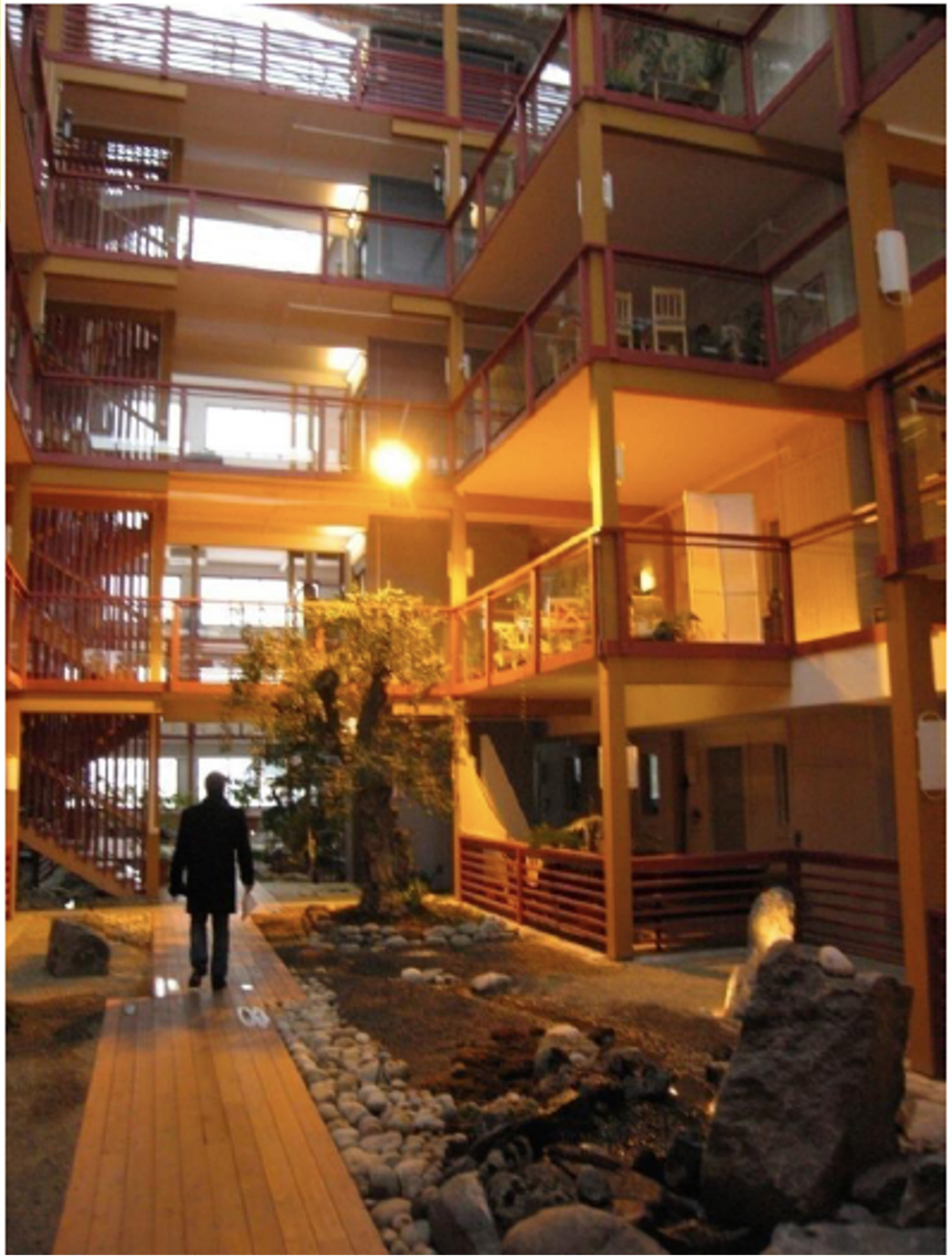

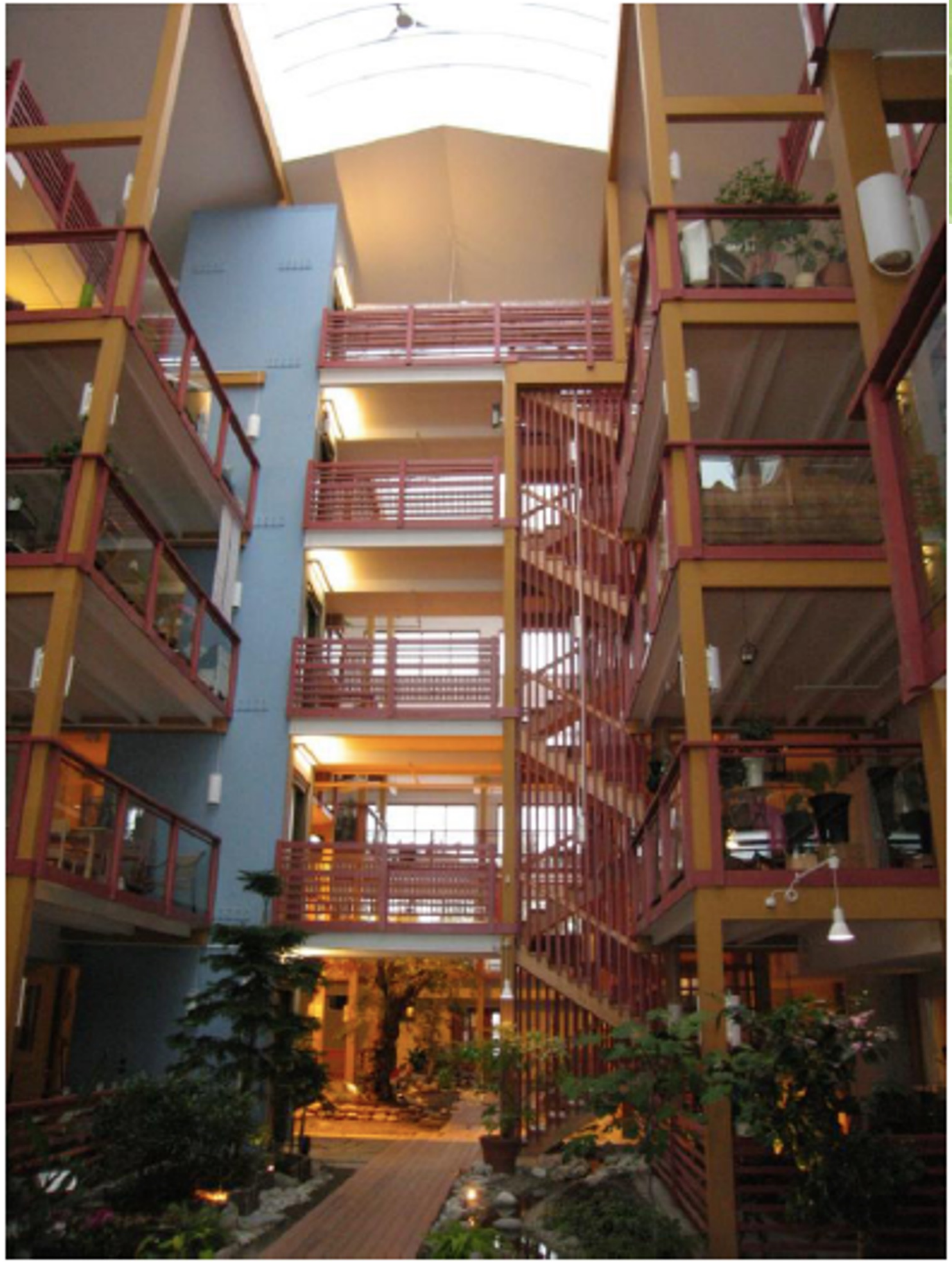

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Examples of compact building shape

SOLAR ENERGY IN PASSIVE HOUSE

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Utilization of solar energy and daylight

Positive Impact: Free Energy

•Passive Systems: Utilize solar heat gains

•Active Systems: Implement solar collectors, PV panels

Negative Impact: Potential Room Overheating and Glare

Solar energy utilization is crucial for achieving low-consumption buildings.

Solar energy through glazed surfaces: 10-6 kWh/m^2 per year depending on the building, location...

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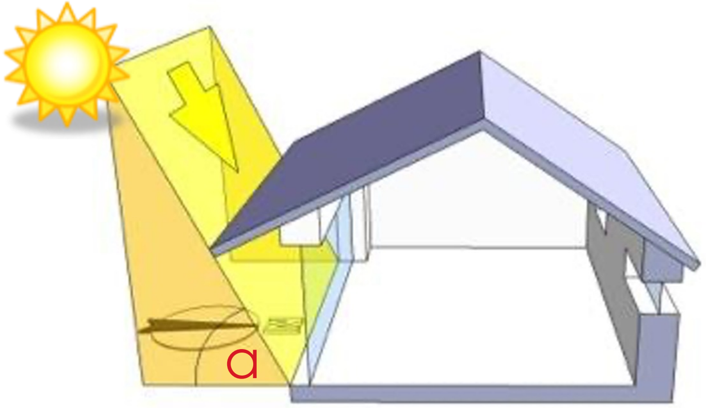
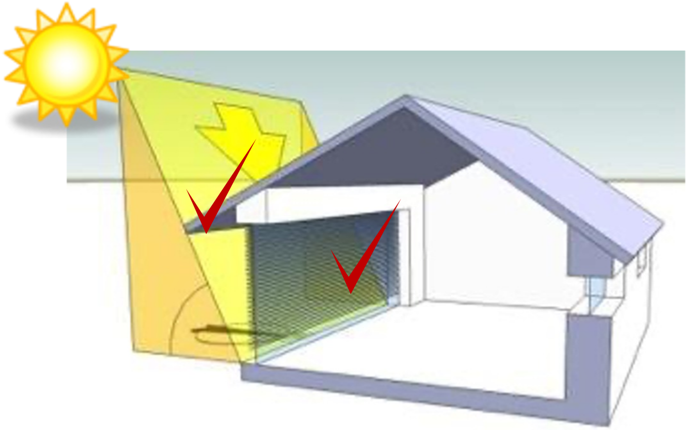
Shading Solutions for Summer Comfort





Source: iEPD

- To mitigate overheating in summer, various shading options can be employed such as blinds, overhangs, etc.
- Static Overhangs: These structures, like roofs and balconies, reduce direct solar radiation.
- Active Shading Systems: External blinds and shutters provide protection against both direct and reflected radiation.
- Vegetation: Greenery offers summer shade while allowing for solar energy absorption in winter.

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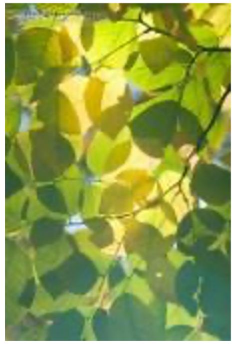
Embassy of Finland in Washington

Summer



Winter

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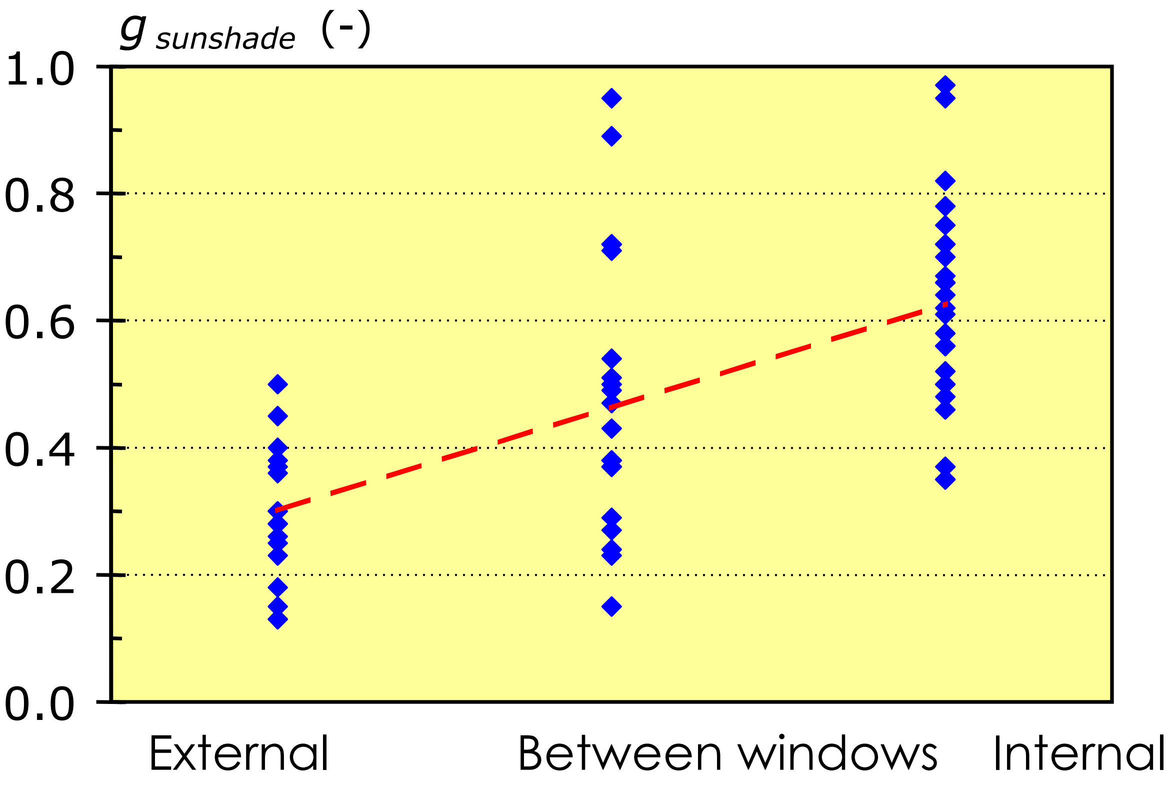
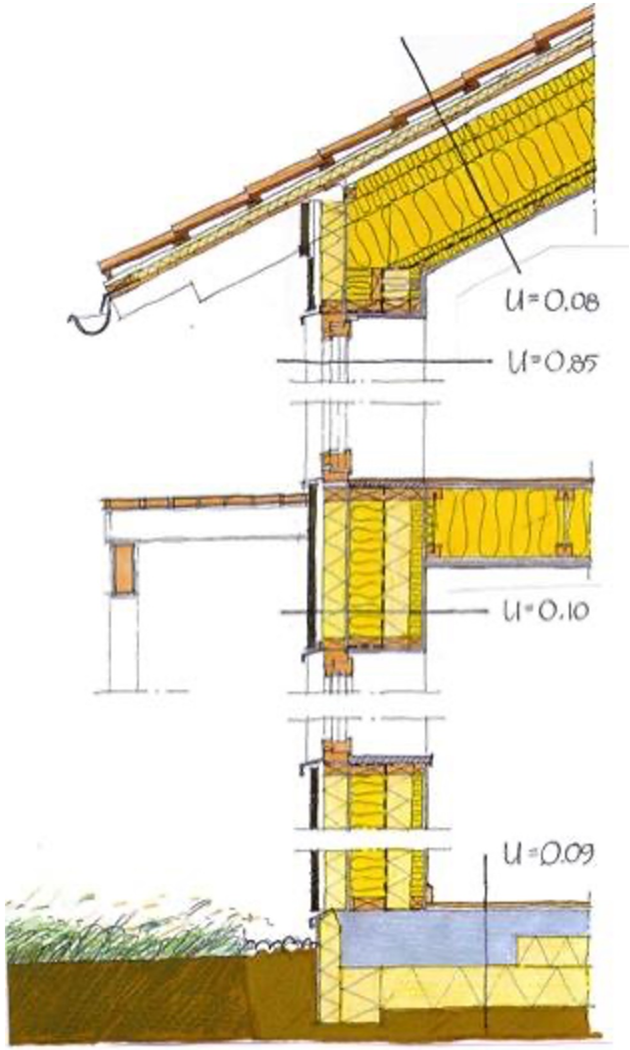
Shading solution in summer

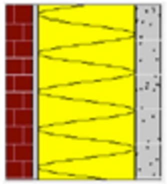
Shading koeficient



Good thermal insulation

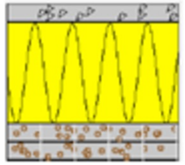


WALL



Brick	110 mm
Air gap	20 mm
Mineral wool	380 mm
Lightweight concrete	100 mm
U-value	0,08 W/(m²·K)

FLOOR



Concrete	100 mm
Mineral wool	550 mm
Expanded clay aggregate	200 mm
U-value	0,06 W/(m²·K)

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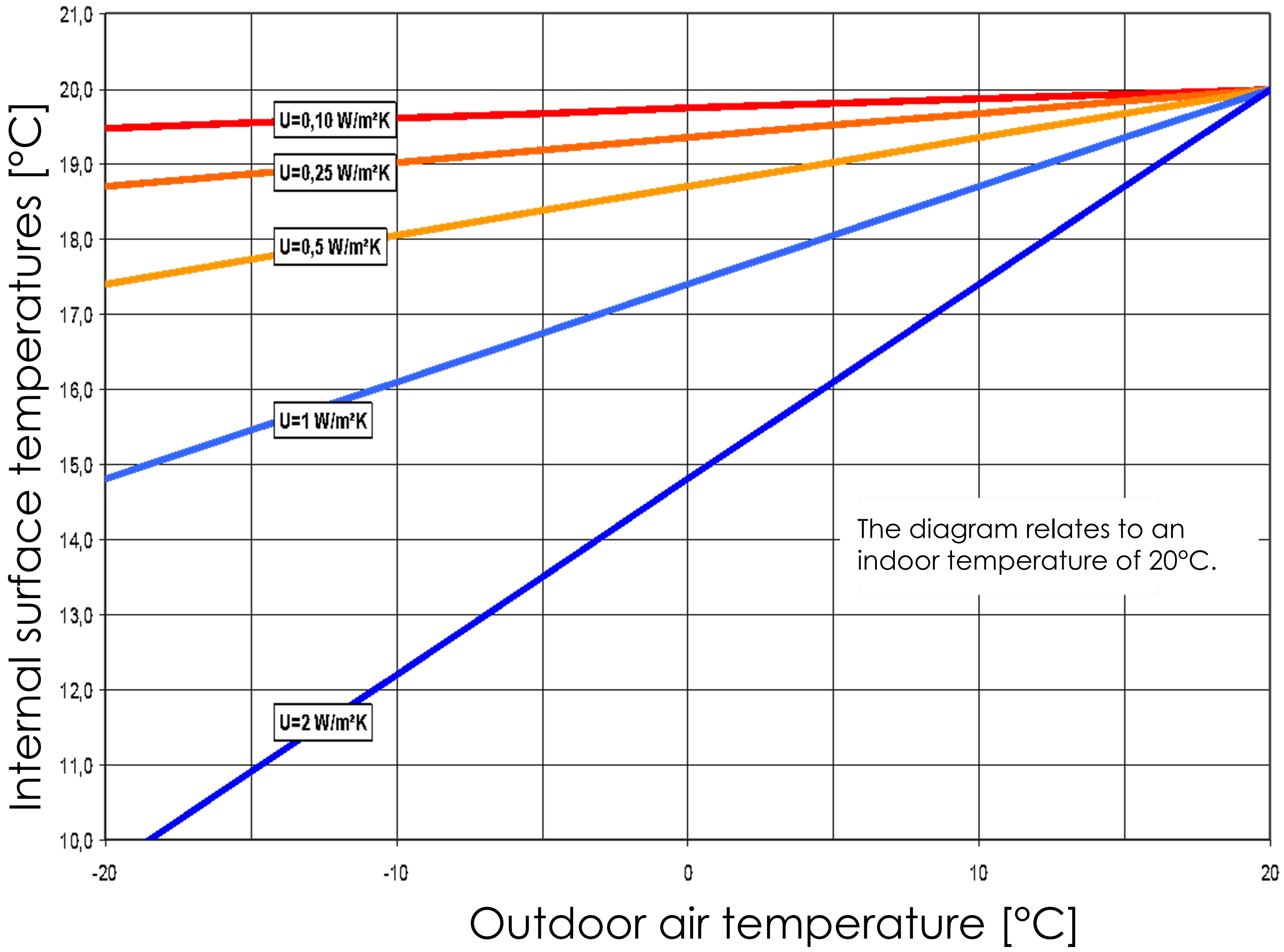
U-value and surface temperature



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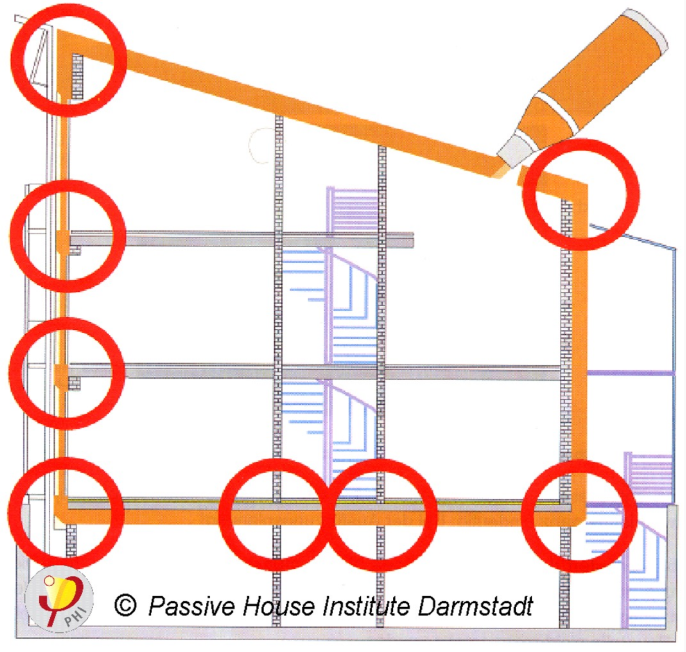
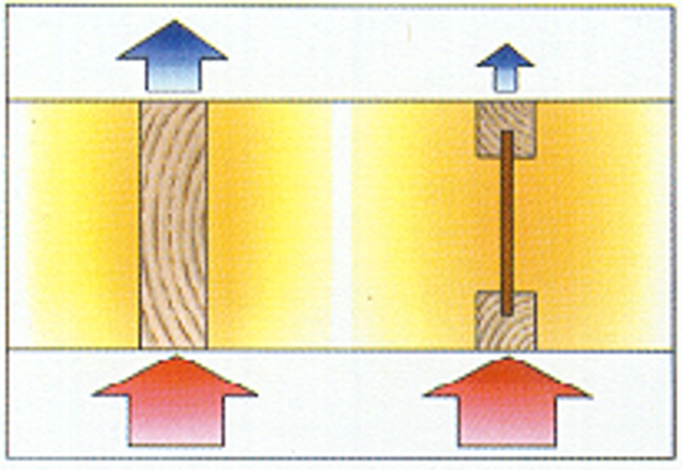
Avots: P. Holzer, Donau Universität Krems Autors: kra/EIV

Thermal-bridge-free designing

Thermal-bridge-free designing < 0,01 W/(mK)





Source: Passive House Institute Darmstadt

Maximally insulated thermoses

2 identical thermoses with a significant difference

the significant difference is that the thermos on the left cools down 30% faster.

Source: kra/EIV

Maximally insulated thermoses

2 identical thermoses with a significant difference

The significant difference is that the thermos on the left cools down 30% faster.

Source: kra/EIV

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Maximally insulated thermoses

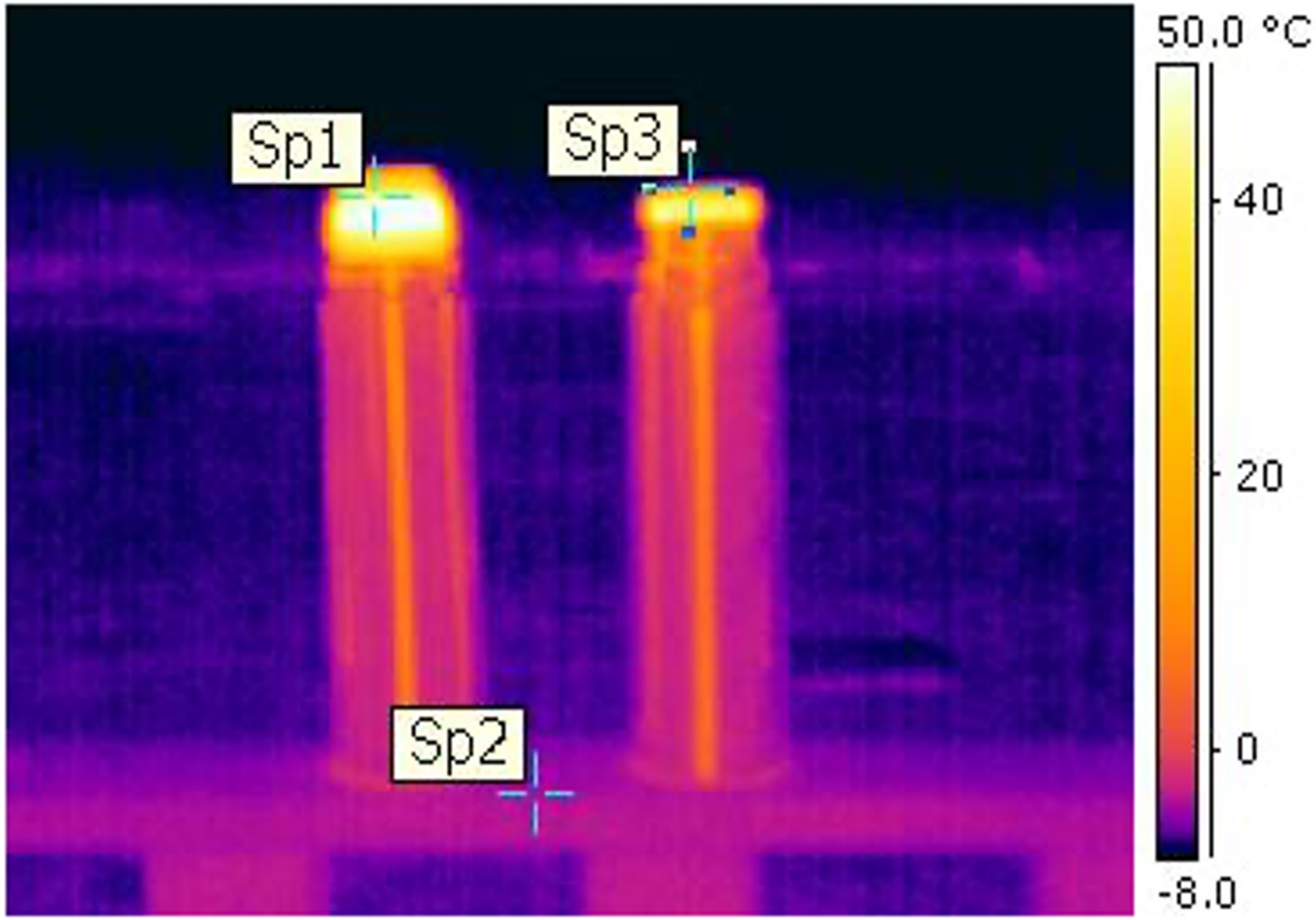
2 identical thermoses with a significant difference

The significant difference is:

This thermal bridge solution is better.

Source: kra/EIV

Maximally insulated thermoses



The significant difference is the thermos cork!

The secret to low heat loss lies in a well-detailed design of construction junctions!

Source: Helmut Krapmeier, Energieinstitut Vorarlberg; Thermografie: Ökoberatung Gebhard Bertsch

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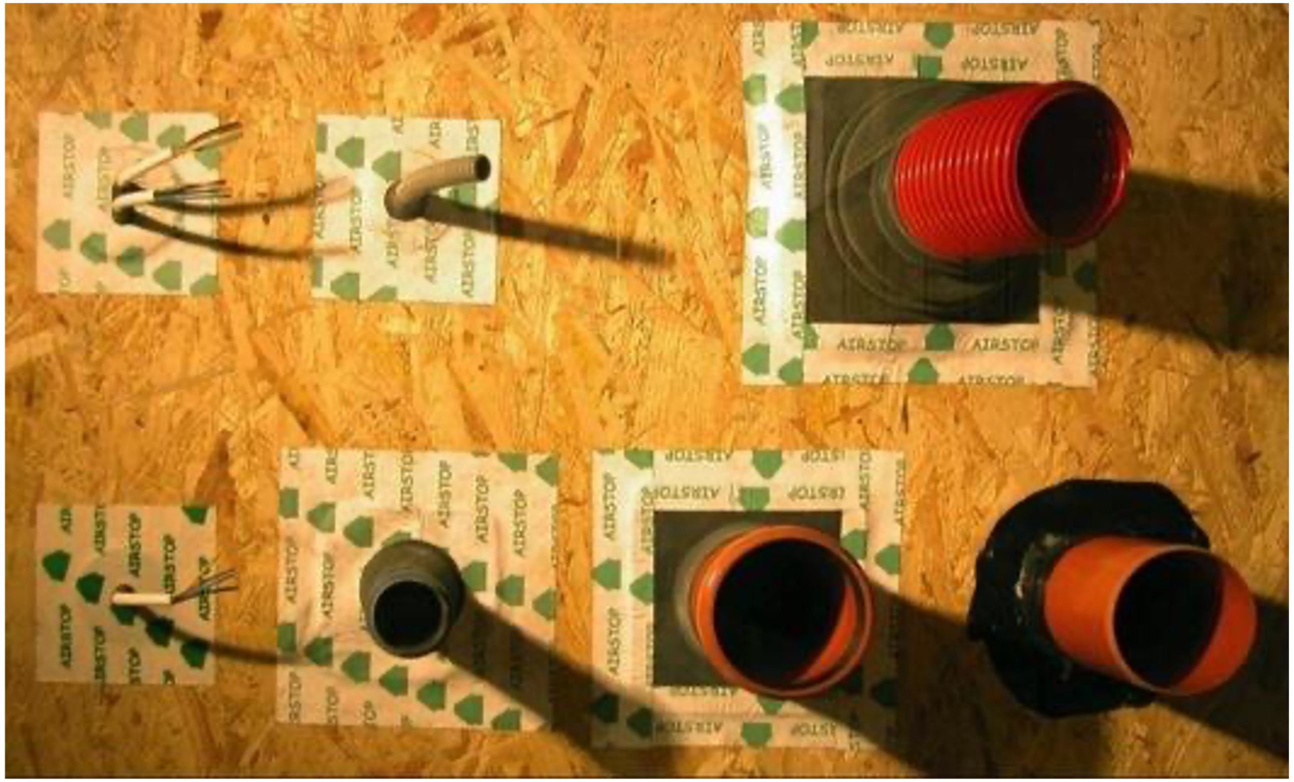
Airtight layer



Continuous cement lime plaster Solid concrete Special membranes
A masonry without plaster is not airtight.

Special self-adhesive tapes need to be used instead of foam.

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Comparison of heat load of building and passive building

Conventional building

Heat load exceeds 100 W/m²

Passive house

Heat load only 10 W/m²

Cold radiation

Surface
9°C

air

Cold air
draft

Radiators for temperature compensation

Optimal thermal
comfort

Surface
17°C

gaiss

Without additional radiator

Source: PHI

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Components of central ventilation equipment

- Air-to-air heat exchanger with heat recovery ≥ 75%
- DC motor
- Control/regulation: operation levels and air balance
- Thermal insulation and airtightness Condensate drain
- Filter: exhaust air + outdoor air Anti-frost protection Summer bypass

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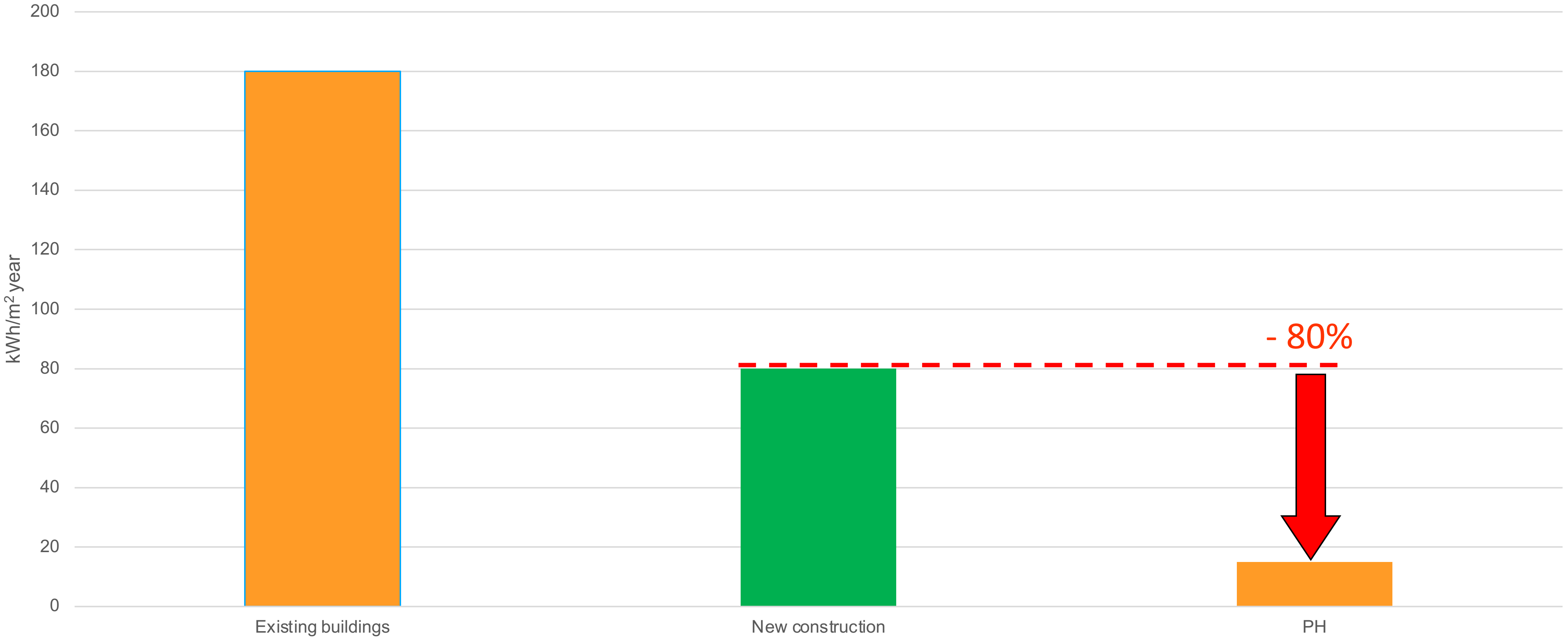
Examples

What is achieved



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Passive house

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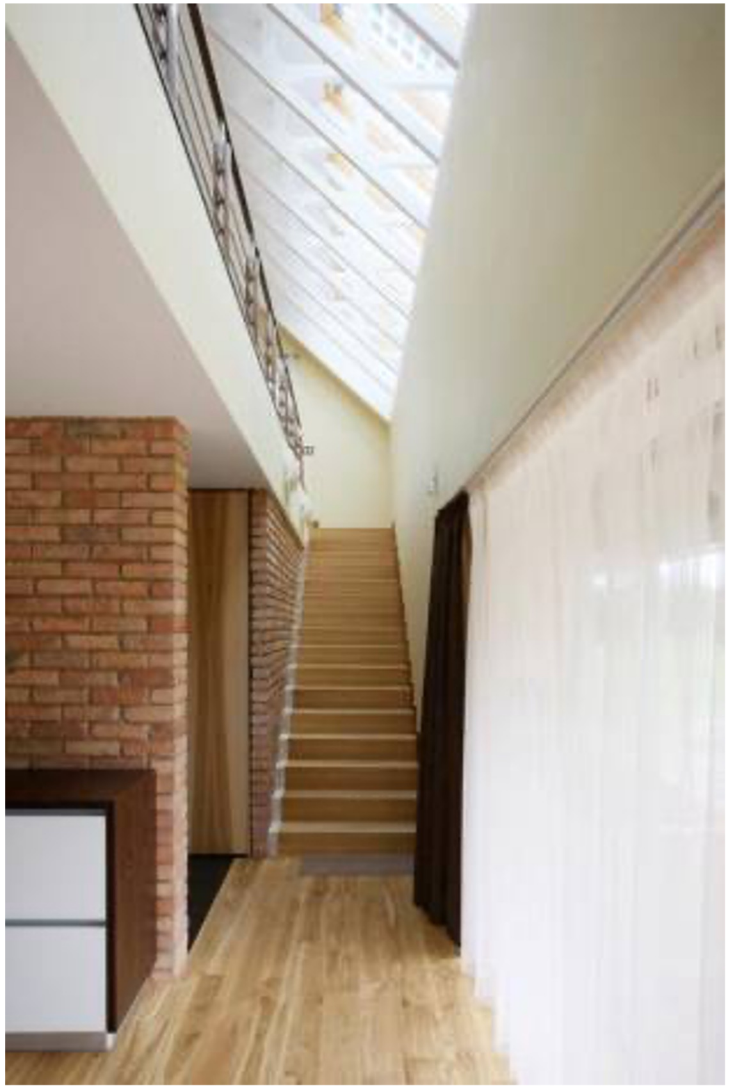
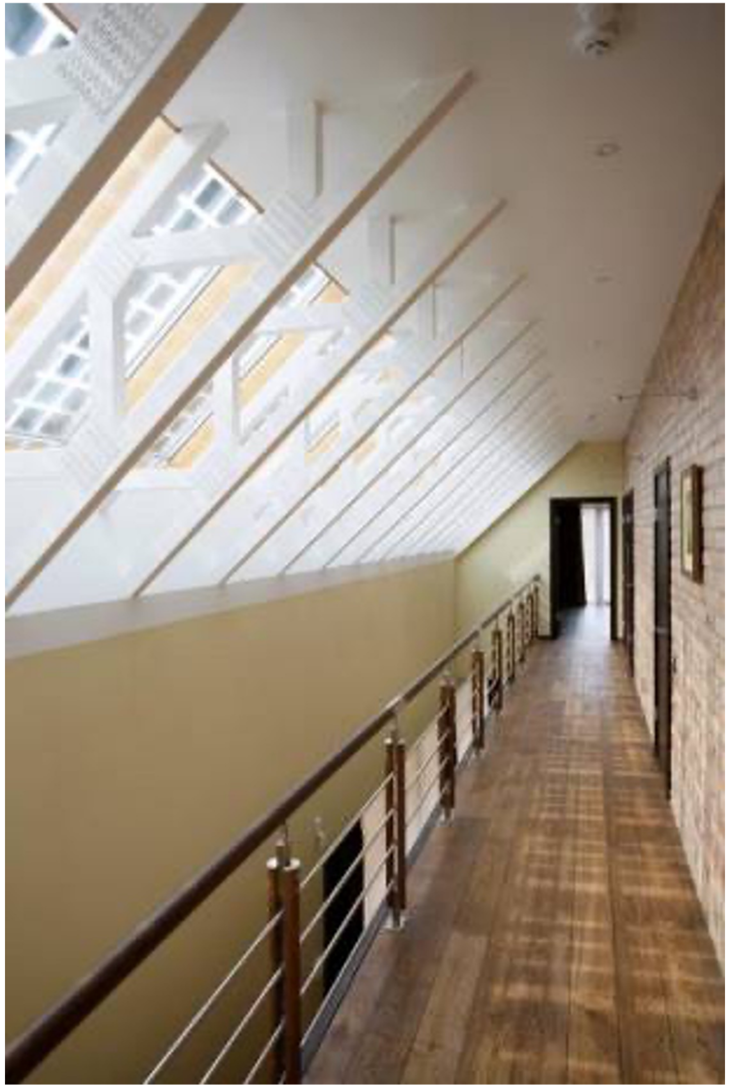
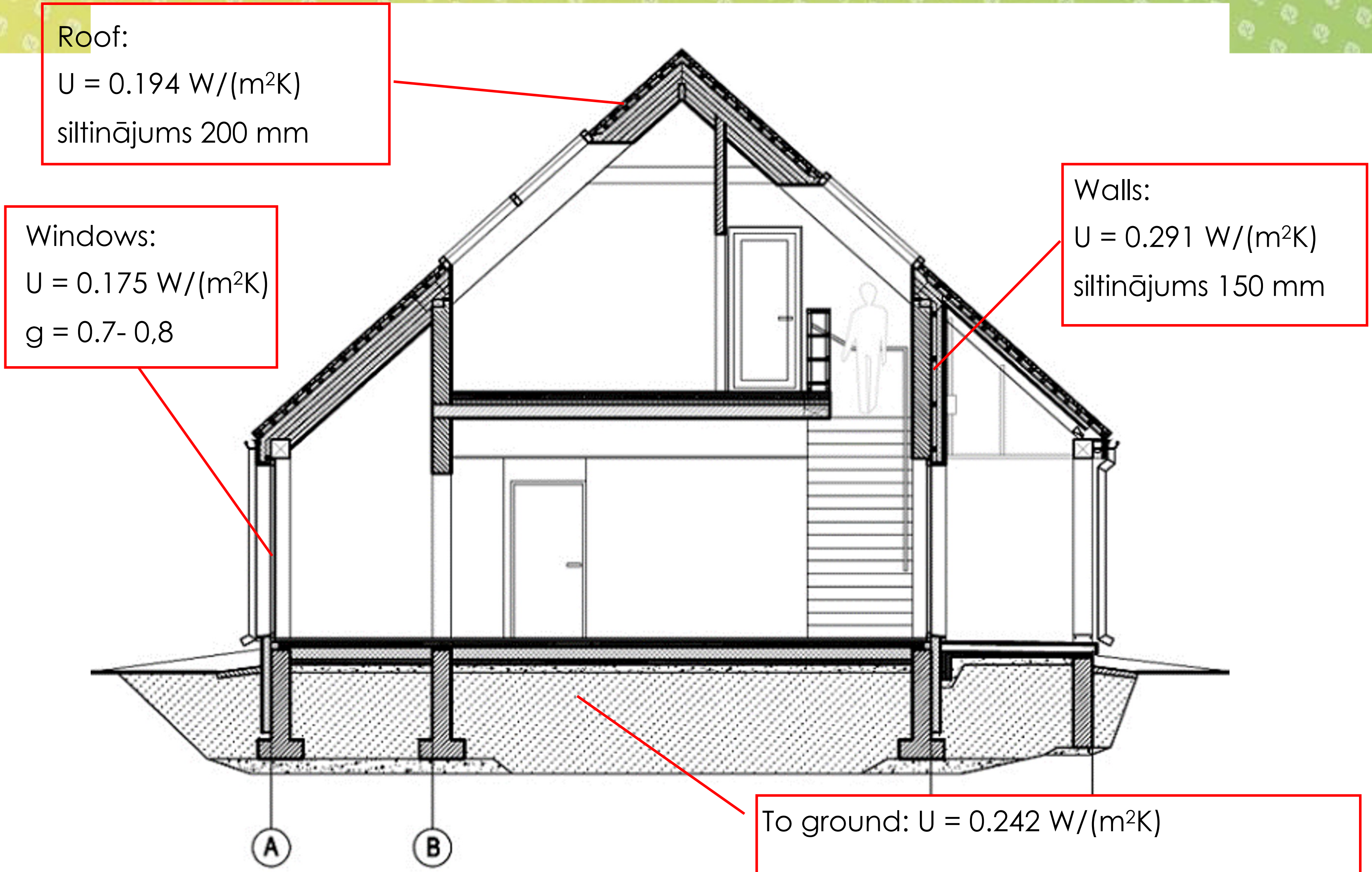
Passive house

Passive house





Before



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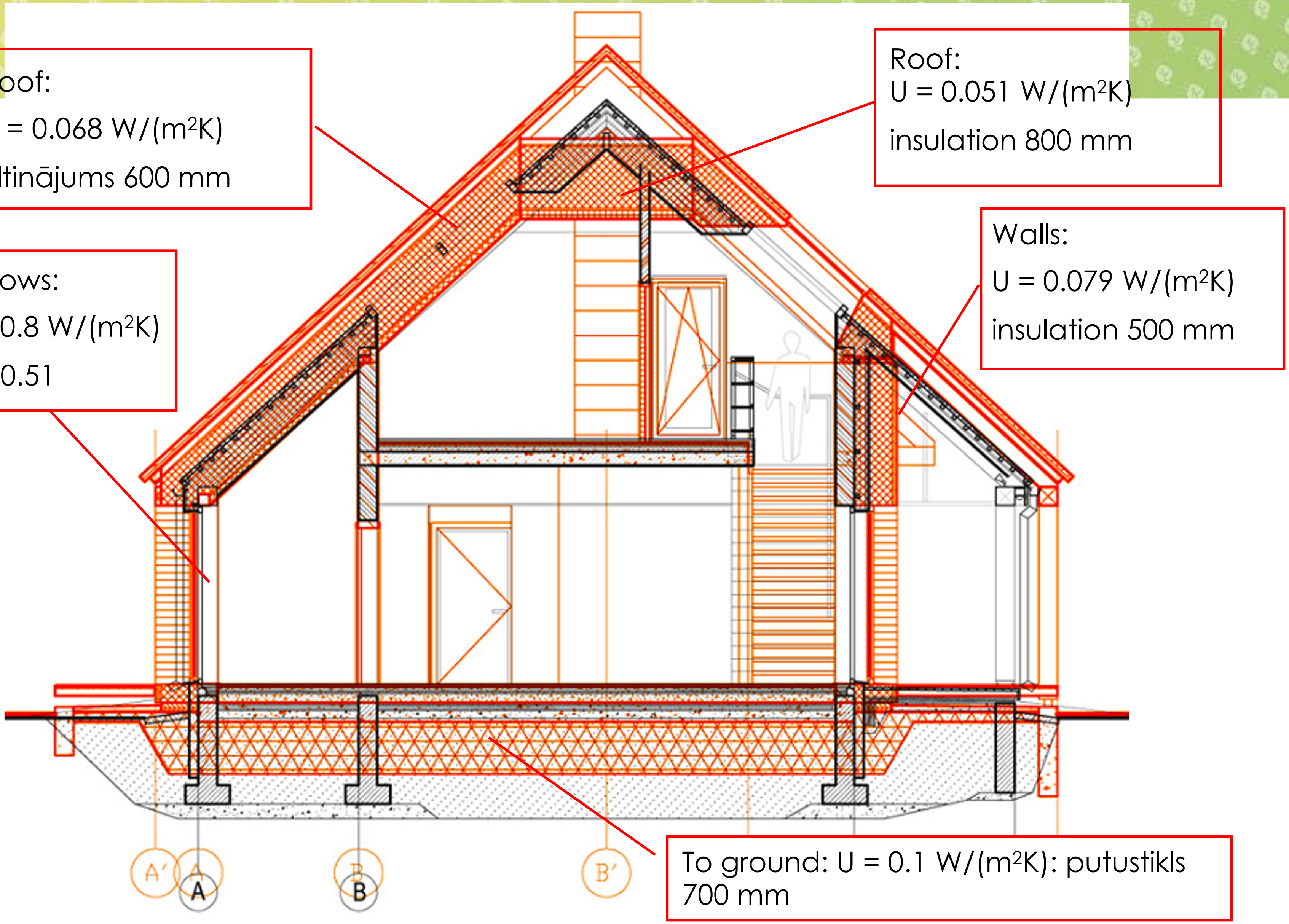
After



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PASSIVE HOUSE RENOVATIO N

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Dormitory

- The building was constructed in 1972.
- Heated area: 3346 m²
- Energy consumption: 159 kWh/m² per year
- Typical building

- Heating season: 207 days
- Average temperature during the heating season: -1.2°C
- Design temperature: -23.8°C

Before renovation

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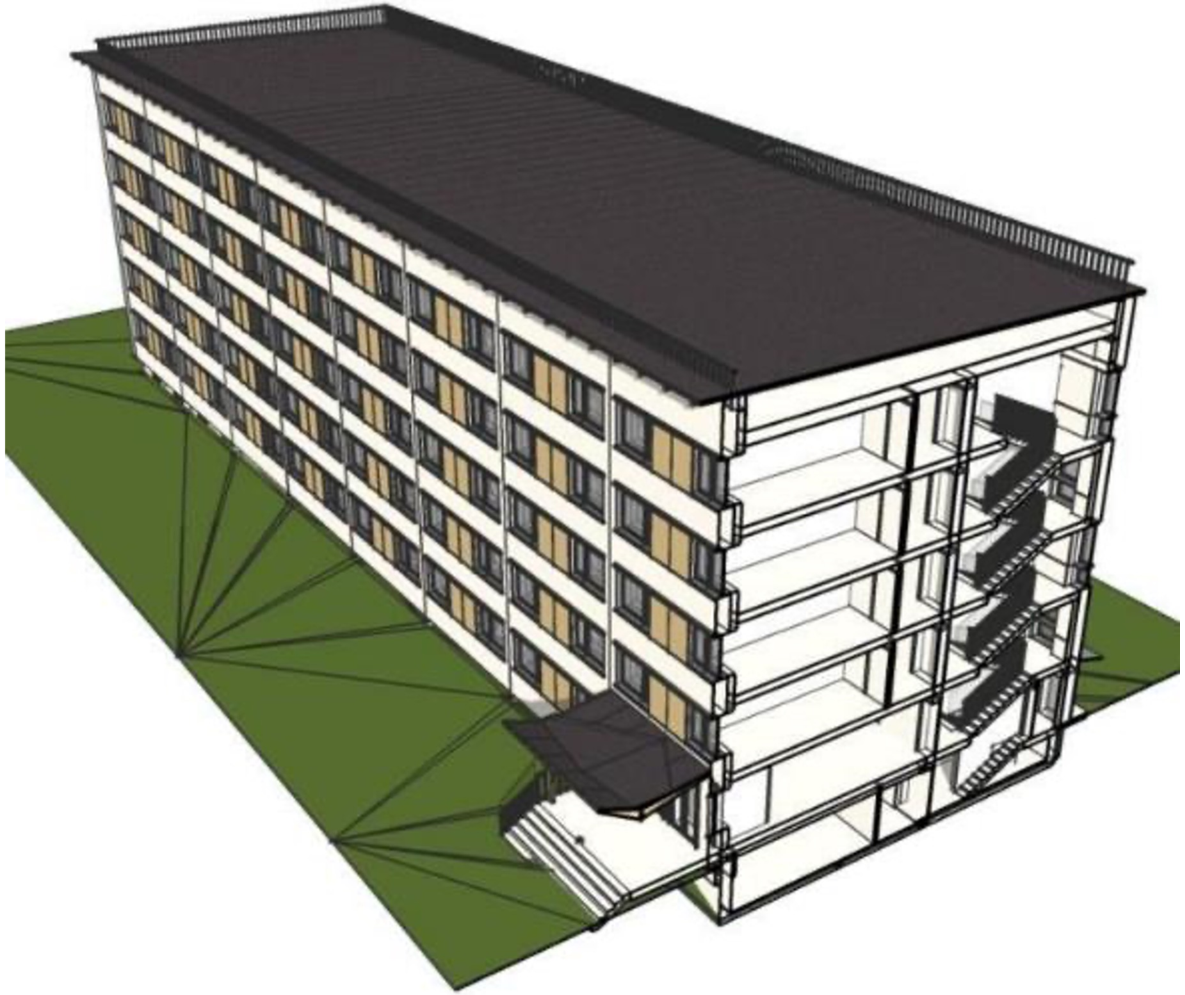
- Ventilation system with heat recovery
- Main ducts within the roof insulation layer, >70 cm
- Piping within the wall insulation structure, >40 cm

	Before, W/m²K	After, W/m²K
Walls	U=1.05	U=0.09
Roof	U=0.52	U=0.06
Windows	U=2,6	U=0.80



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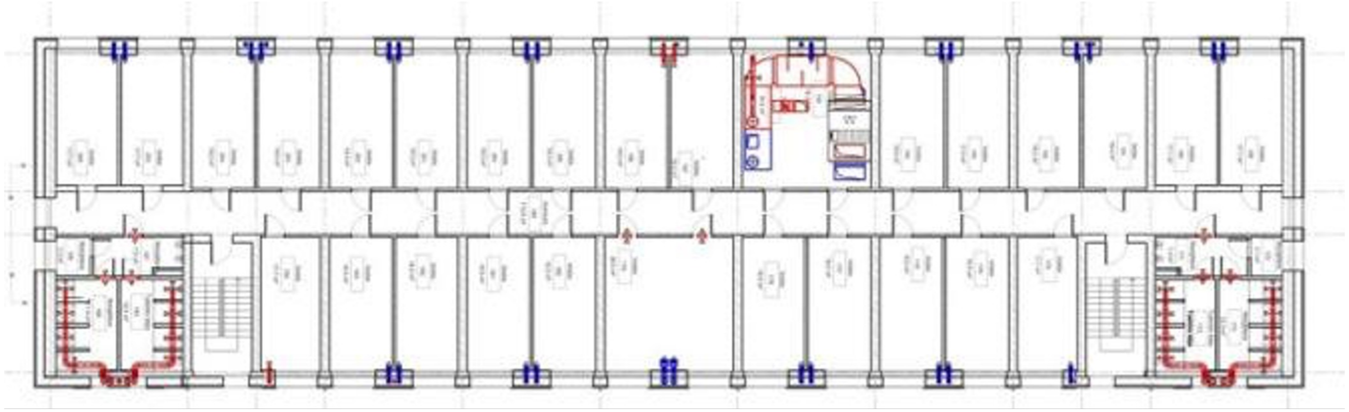
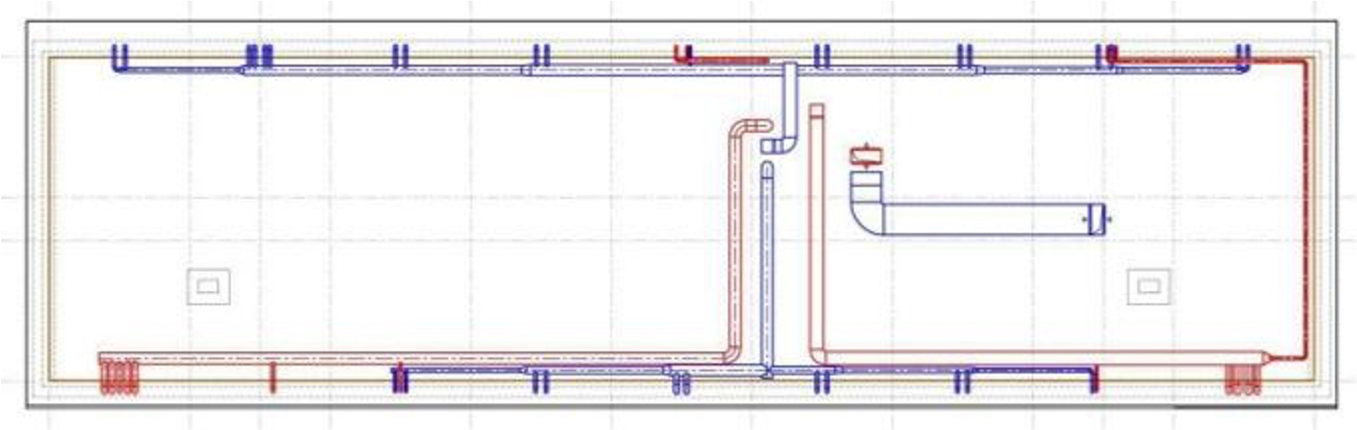
Concept of ventilation system creation





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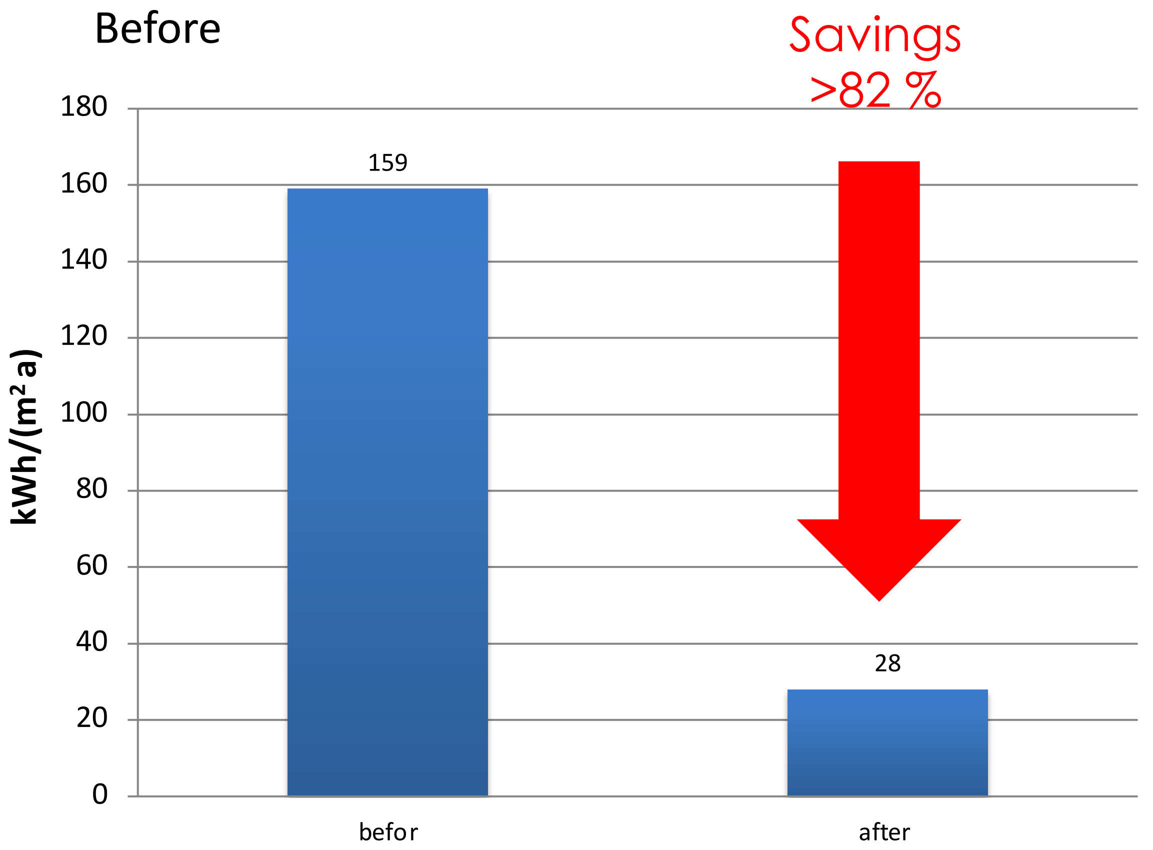
Before and after



Heating + How water