Technical condition, indoor climate and renovation demand of brick apartment buildings in Estonia

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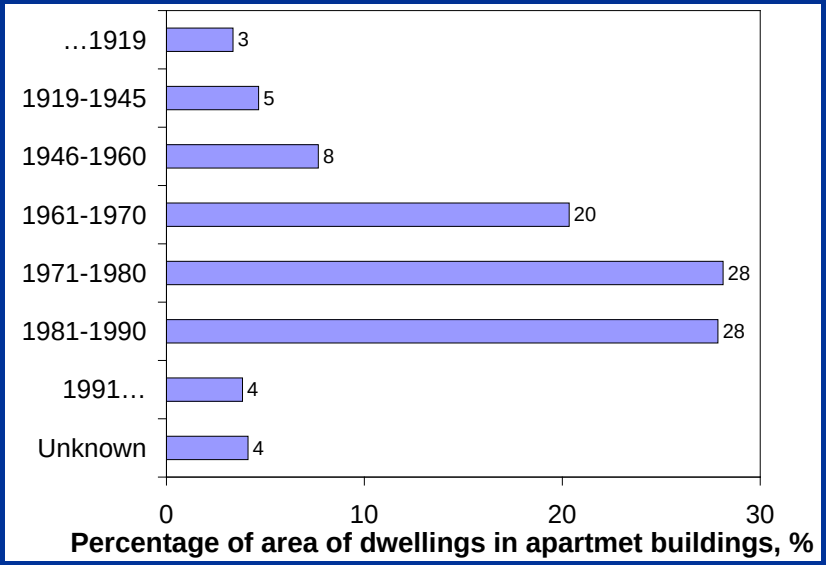
Situation of housing in Estonia

- 71% of population lives in apartment buildings, 20%: in detached- or in terraced house, 9%: in farmhouses;
- Brick is one of the main structural material;



- Today the end of the designed service life of these older buildings is close;
- Typically each occupant is owner of the apartment → building;
- Milieu valuable areas (urban environment).

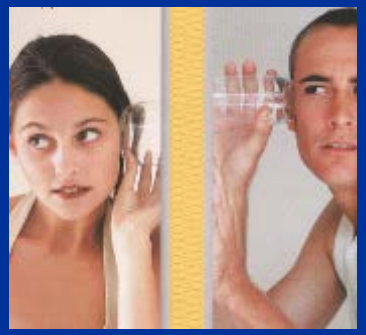
Service life of buildings / Performance criteria

- Service life
  - Quality and properties of components and building materials;
  - Design level;
  - Work execution level;
  - Indoor environment;
  - Outdoor environment;
  - In-use conditions;
  - Maintenance level;

- Performance criteria:

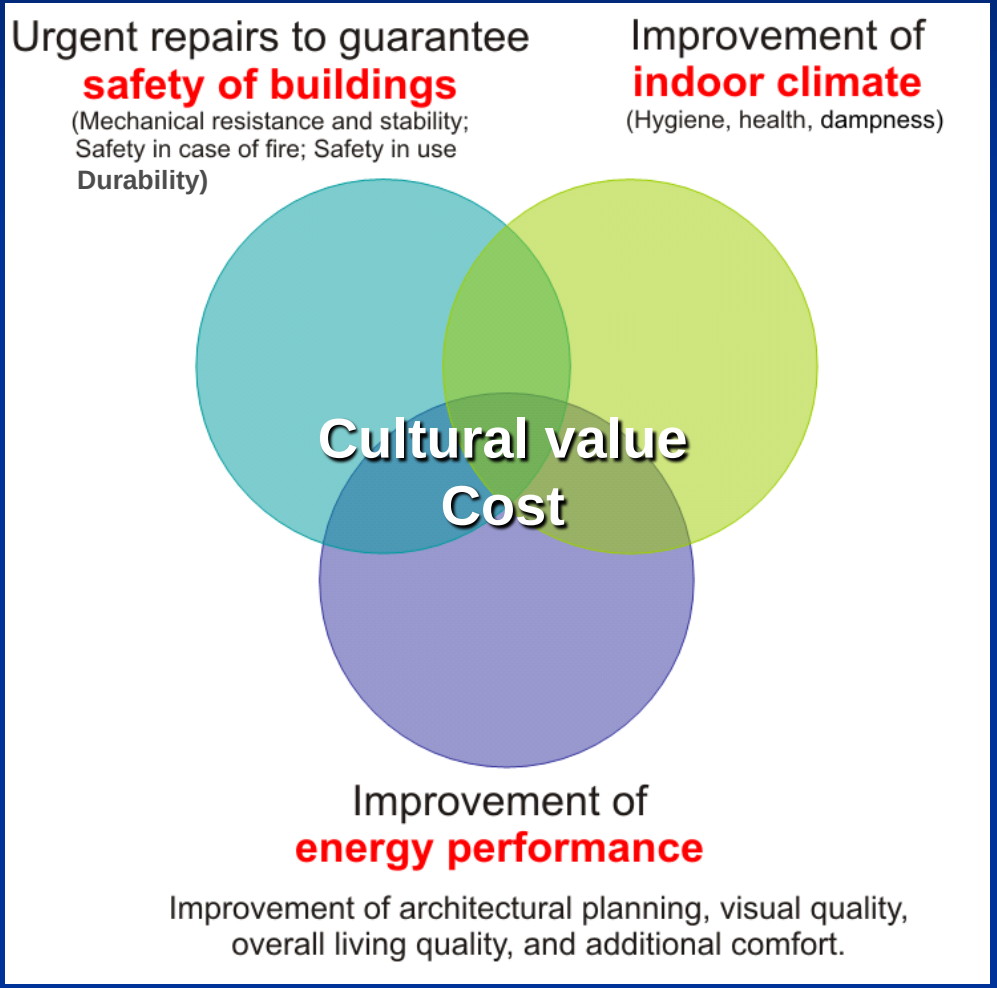
  7 essential requirements
  - Mechanical resistance and stability;
  - Safety in case of fire;
  - Hygiene, safe to health and environment;
  - Safety in use;
  - Protection against noise;
  - Energy performance
  - Sustainable use of natural resources




The demand for renovation

- Typical aspects:
  1. safety of building, durability;
  2. healthy indoor climate;
  3. energy performance + living & visual quality
- Renovation and reducing energy consumption of historical buildings need to be done without losing their cultural value and identity.



The areas of research

- Different areas of research
  - Values: historical, cultural, architectural (milieu valuable areas);
  - Structures: mechanical resistance and stability, durability, degradation of materials and components;
  - Building physics, energy performance, indoor climate;
  - Building services: heating, ventilation, water, sewerage, electricity, etc.;
  - Background information of the building (actual drawings of the building; earlier damages, previous investigations, interviews, risk assessment);
- Scale of the research
  - Case study (concerns one certain building or problem)
  - Large scale study (concerns certain type of buildings or problems)

The aim of investigation

- Investigation of the degradations
  - existents of the degradations
  - extent of the degradations
  - grade of the degradations
- Reasons of the degradations
  - detection of faults in design and construction
  - change of loading or alterations to a load-bearing member
  - change in thermal or moisture conditions
- Renovation solutions
  - Values;
  - Structures;
  - Building physics, energy performance, indoor climate;
  - Building services.

Renovation demand of brick apartment buildings in Estonia

- National research project: *"Technical condition and service life of Estonian brick apartment buildings"* 2009-2010
  - The main objectives:
    - Survey of technical condition of typical brick apartment buildings;
    - Investigate the indoor climate and energy performance of buildings;
    - Determine the main demands of renovations of brick apartment buildings.
  - Characterization of studied brick apartment buildings:
    - 30 buildings, constructed between 1940 and 1990, 4-9 storey;
    - From each building one to three apartments were selected to the indoor climate and building physics studies (50 apartments);
    - All the buildings and apartments studied were in private ownership.
  - The research was financed by Credit and Export Guarantee Fund KredEx and Tallinn University of Technology

Research

- **Investigation of building envelope**
  - survey of technical condition of the structures (walls, floors, roofs, balconies)

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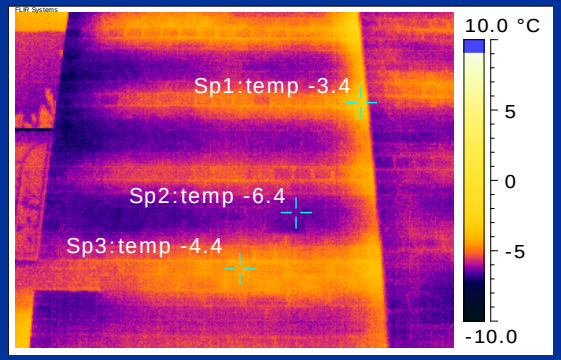
  - frost resistance of the facades
  - thermal transmittance and

  thermal bridges of building envelope
  - air tightness of building envelope

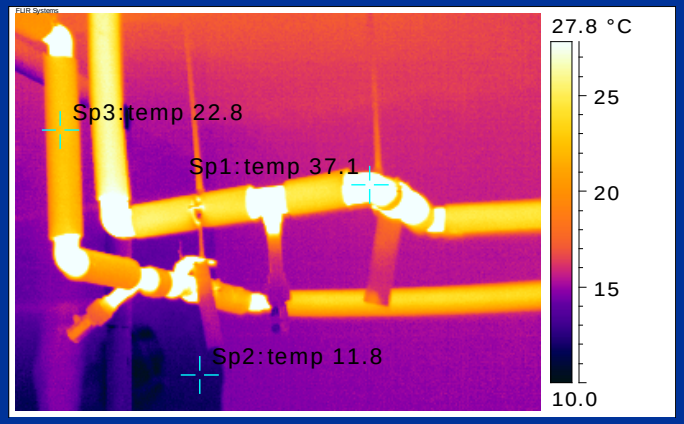


Research

- Investigation of building envelope;
- **Indoor climate, hygrothermal conditions**
  - indoor temperature and RH over one year period at o al
  - indoor CO_2, performance of ventilation
  - microbiological contamination on surfaces of buil
    indoor air

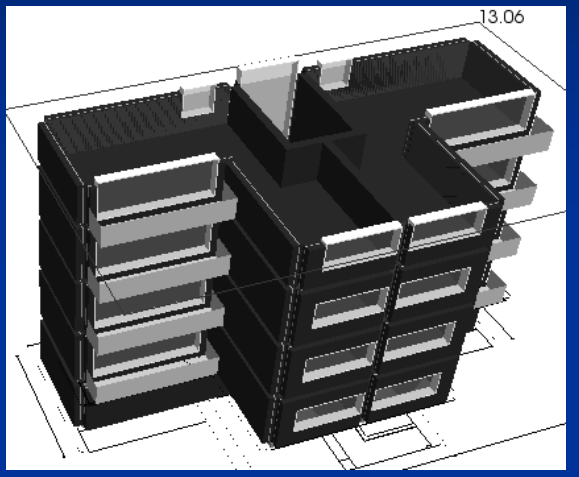
Research

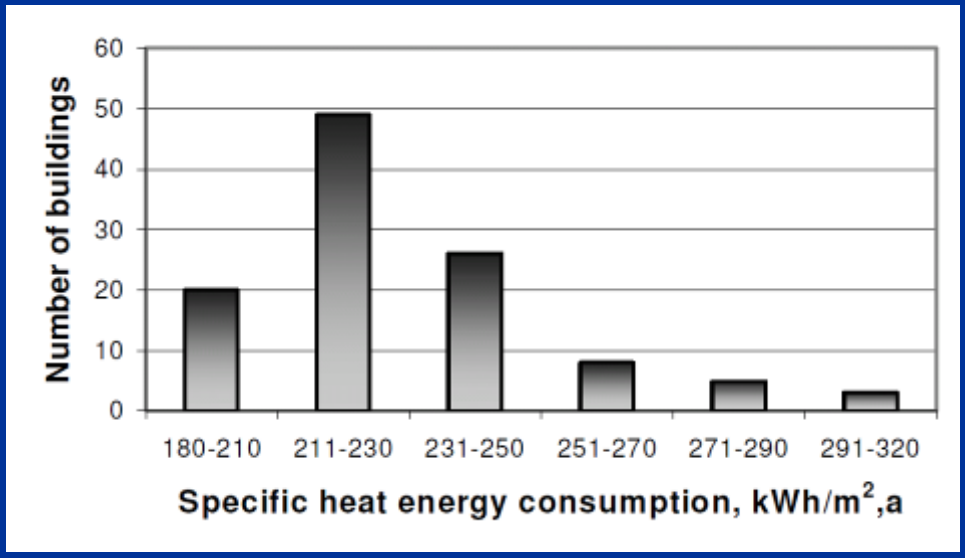
- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- **Conditions of building services**



Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of HVAC systems
- **Measurement and simulation of energy use**



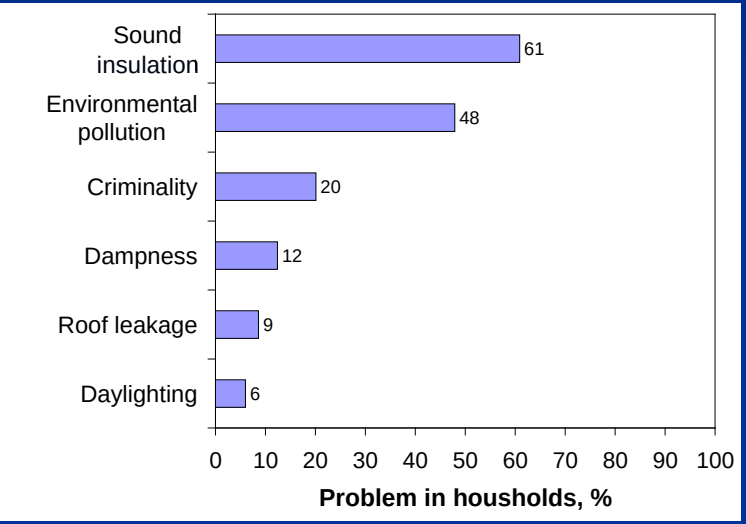


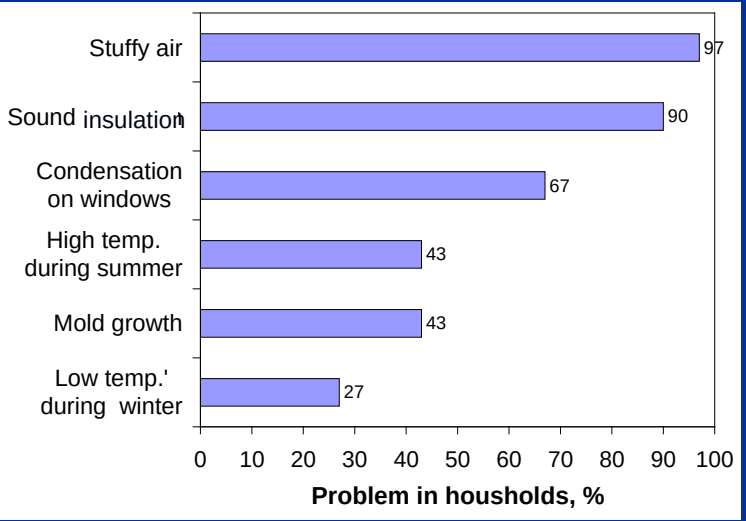
Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of HVAC systems
- Measurement and simulation of energy use
- **Questionnaire for occupants**

The main problems in general

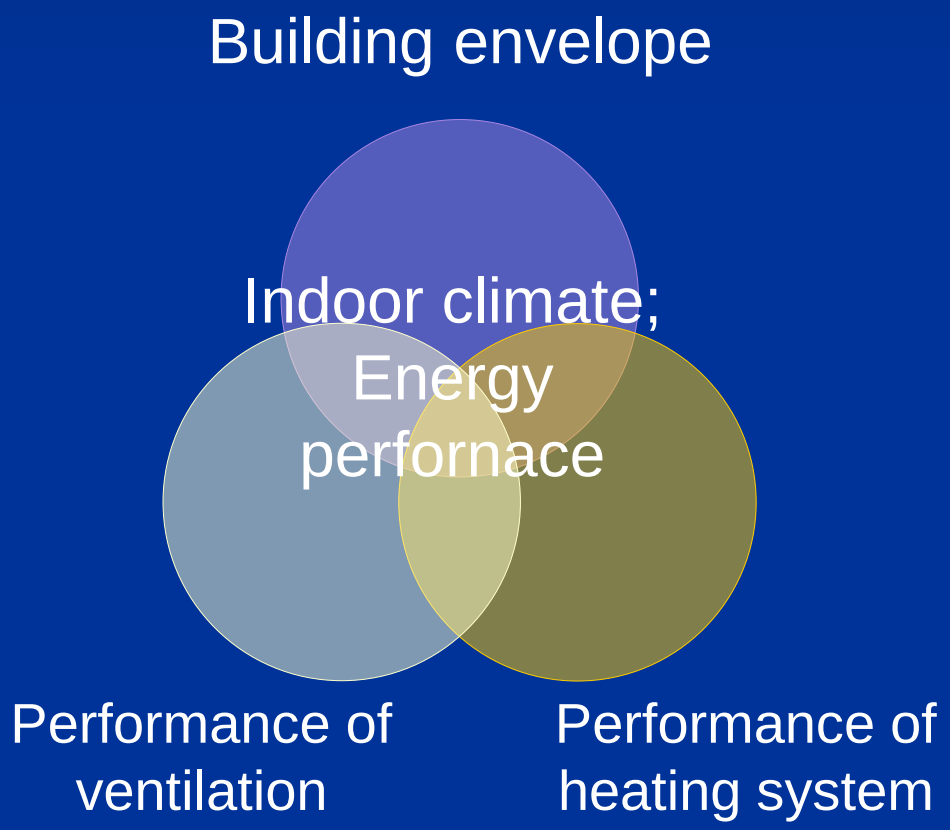
- Mechanical resistance and stability are not the main problems
- The main technical problems are in the field of:
  - indoor climate,
  - building physics,
  - HVAC systems,
  - energy efficiency.
- Old dwellings need improvement to meet today's requirements in a:
  - healthy indoor climate, thermal comfort,
  - energy performance,
  - functional / architectural,
  - structural / technical.





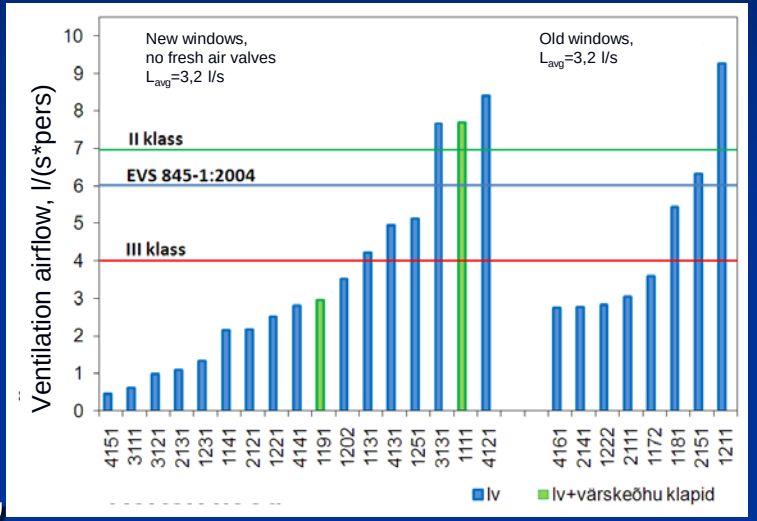
The main needs for renovation

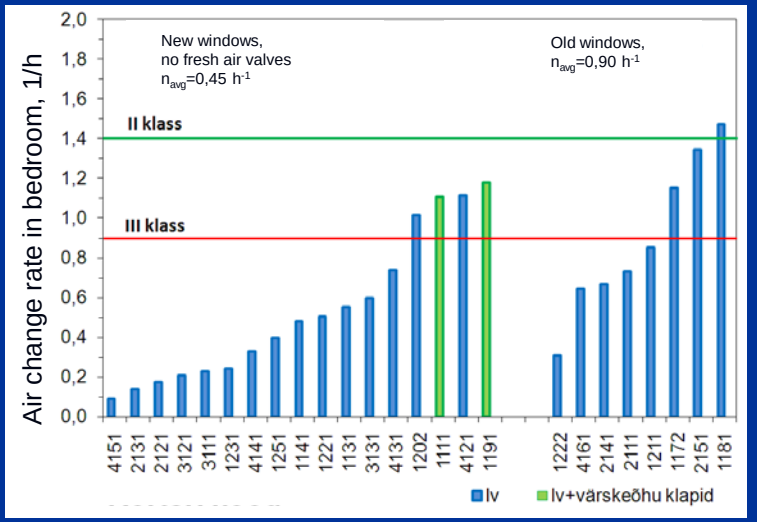
- Improvement of indoor climate and energy performance of buildings in cold climate:
  - performance of building envelope;
  - performance of ventilation;
  - performance of heating systems.



Ventilation

- Typical problems of existing systems:
  - natural ventilation (passive stack, window):
    - low air change,
    - low indoor air quality,
    - high moisture load,
  - no heat recovery: large energy consumption,
  - impossible to regulate air flows,
  - air inflow from stack (wind),
  - air tightness of old ventilation channels,
  - the replacement of windows without renovation of ventilation:
    - smaller leakage rate,
    - more airtight building envelope.





Ventilation

- Challenges for renovation:
  - mechanical exhaust ventilation with fresh air inlets:
    - thermal comfort during winter (fresh air inlets with radiators)
    - energy performance (exhaust air heat pump → domestic hot water and heating)
    - air tightness of old ventilation channels
    - not suitable for combined ventilation channels

Ventilation

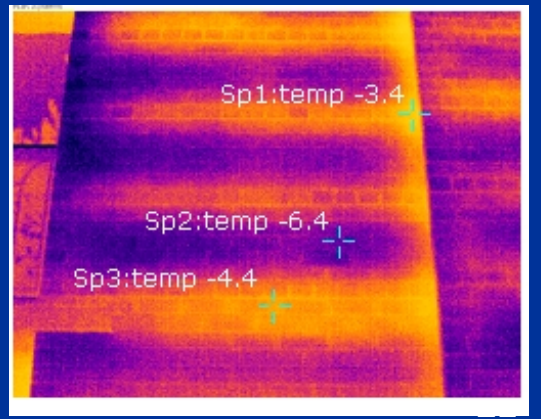
- Challenges for renovation:
  - mechanical exhaust ventilation
  - balanced ventilation with room units:
    - where to put room units: a little space,
    - problems with sound pressure levels,
    - where to put air channels: rooms height 2.5m,
    - air flow in apartment through existing doors

Ventilation

- Challenges for renovation:
  - mechanical exhaust ventilation
  - balanced ventilation with room units
  - acceptance of occupants:
    - how to motivate occupants for changes: “I do not want new tubes and noisy equipment in my apartment”
    - renovation works in apartments, change of internal doors?
    - cost-effective solutions are needed,
    - understanding about the importance of ventilation (customer, occupants): example-renovation without changes in ventilation: bad indoor climate

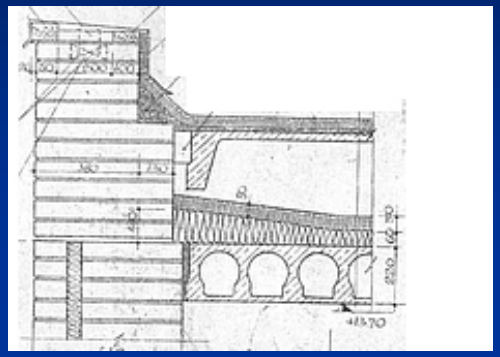
Thermal envelope

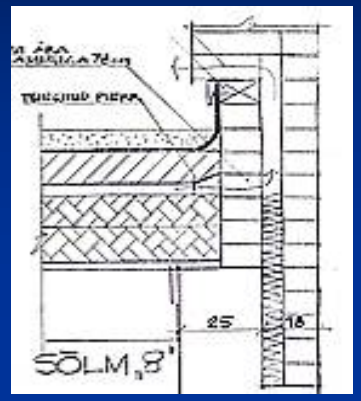
- Existing problems:
  - **high thermal transmittance**:
    - external walls 0.5–1.2 W/(m^2·K),
    - roof-ceilings 0.7–1.0 W/(m^2·K),
    - windows 2–3 W/(m^2·K).



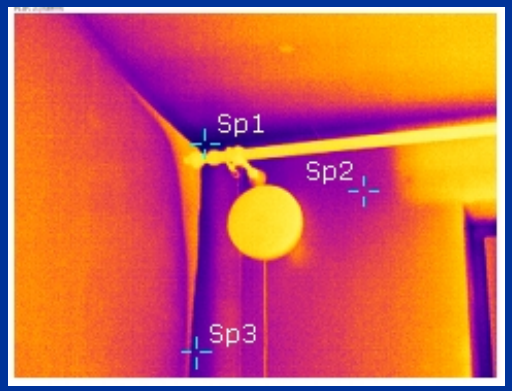
Thermal envelope

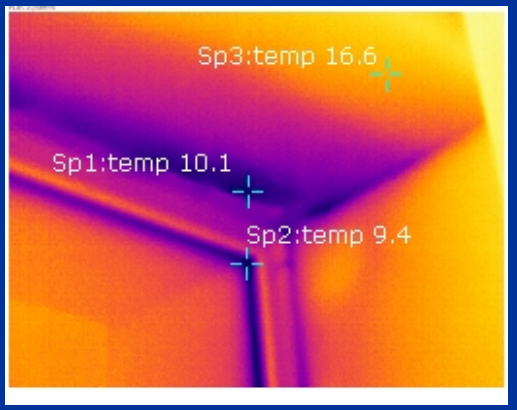
- Existing problems:
  - **high thermal transmittance**
  - **serious thermal bridges**:
    a large problem especially in
    old apartment buildings





mould growth and surface condensation
on the internal surfaces of thermal bridges
is unavoidable without:
- lowering thermal transmittance,
- lowering internal humidity loads.



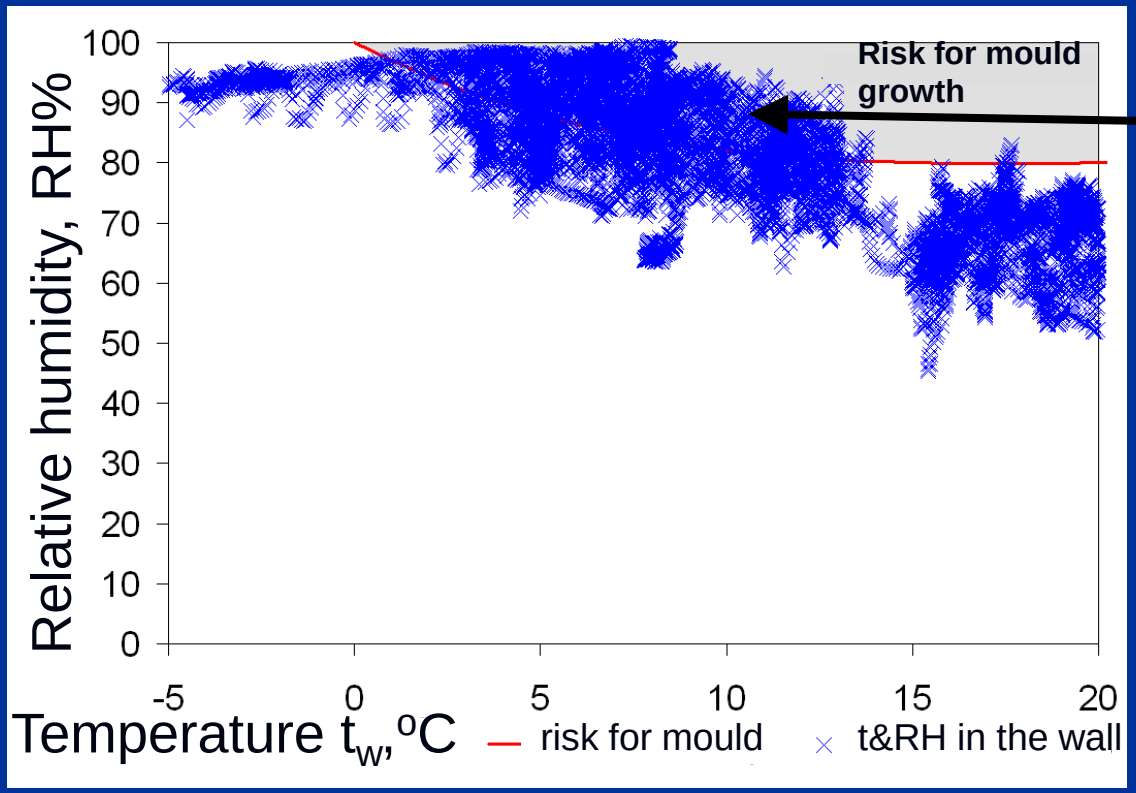


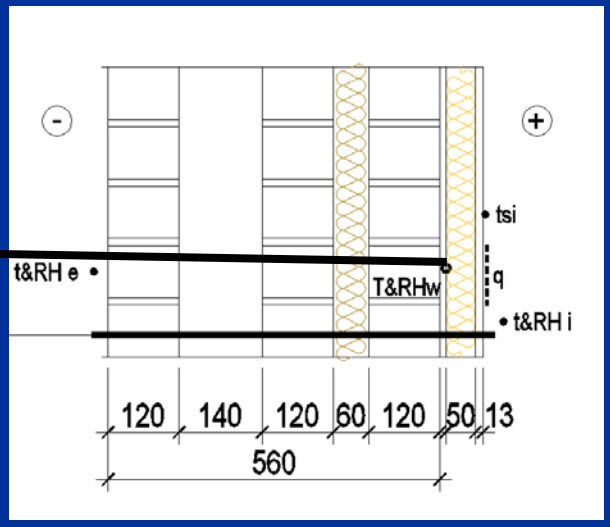
Thermal envelope

- Existing problems:
  - **high thermal transmittance**:
  - **serious thermal bridges**:
    also big problem in old apartment buildings already additionally insulated (windows)
  - **low frost resistance**:
    a need to protect facade,
  - **carbonization of mortar**,
  - it is economically reasonable to make the additional thermal insulation for walls and roofs (strong pressure).
  - cultural value should be preserved

Thermal envelope

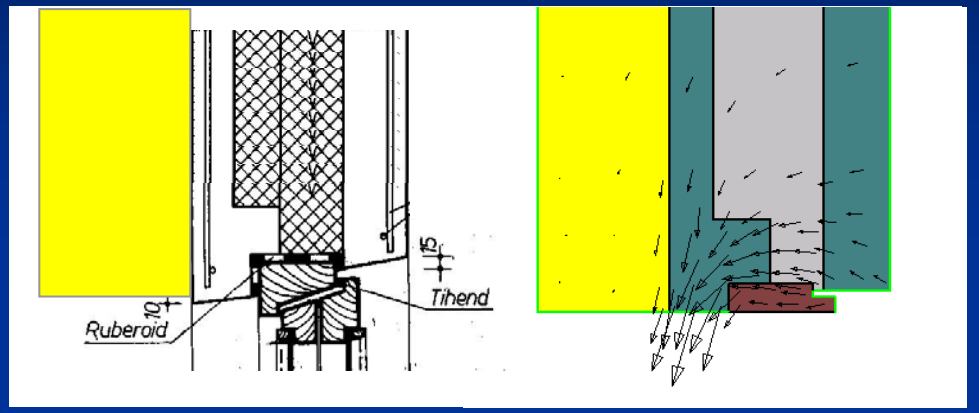
- Internal thermal insulation is risky solution in cold climate:
  mould growth and condensation in the wall on the old wall surface





Thermal envelope

- Typical problems with the additional insulation:
  - Windows: old or new, on its original place
    - thermal bridge in connection of wall and window
    - visually bad solution



Thermal envelope

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  - Low quality: air space between old wall and new insulation;

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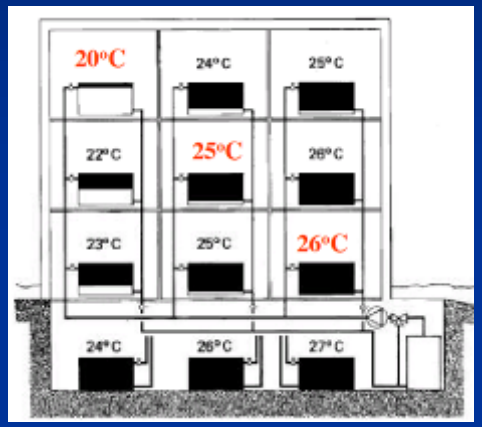
  - Loggias: thermal bridges, mould
  - Drying out of structural moisture

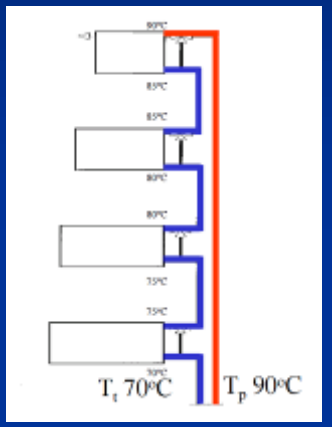
Thermal envelope

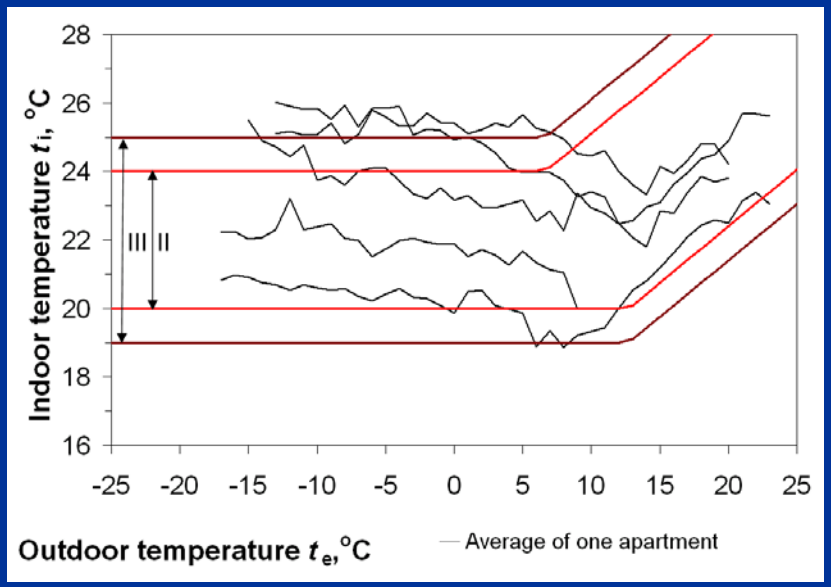
- Typical problems with the additional insulation:
  - Windows: old or new, on its original
  - Low quality: air space between old wall and new insulation;
  - Loggias: thermal bridges, mould
  - Drying out of structural moisture
  - **Complex renovation** (ventilation + building envelope + heating systems) is not common: mould after insulation (ventilation was not renovated)

Heating systems

- Typical solution:
  - one-pipe heat distribution system;
  - no room thermostats on radiators;
- Typical problems:
  - incorrect control curve of the temperature of the supply water of the heating system,
  - incorrect water flow rate of the risers of the heating system,
  - lack of direct room temperature control,
  - difficulties to balance the one-pipe heat distribution system,
  - lack of maintenance and improper modifications of the heating and ventilation systems.







Conclusion

- There exists a demand to renovate brick apartment buildings:
  - to lenghten the service life of building;
  - to provide healthy indoor climate;
  - to lower the energy consumption of buildings (pressure from occupants and from EU (20/20/20));
  - to ensure mechanical resistance and stability.
- During renovation of historical buildings we face different problems compared to new buildings;
- During renovation of historical buildings the identity should be preserved;
- There is a need for different renovation solutions where all presented aspects are taken into account;
- Example renovations with good practice, including monitoring and actual performance reports, are needed.