

The Effect of Thermal Insulation and User Behaviour on Energy Consumption and Comfort of Residential Houses

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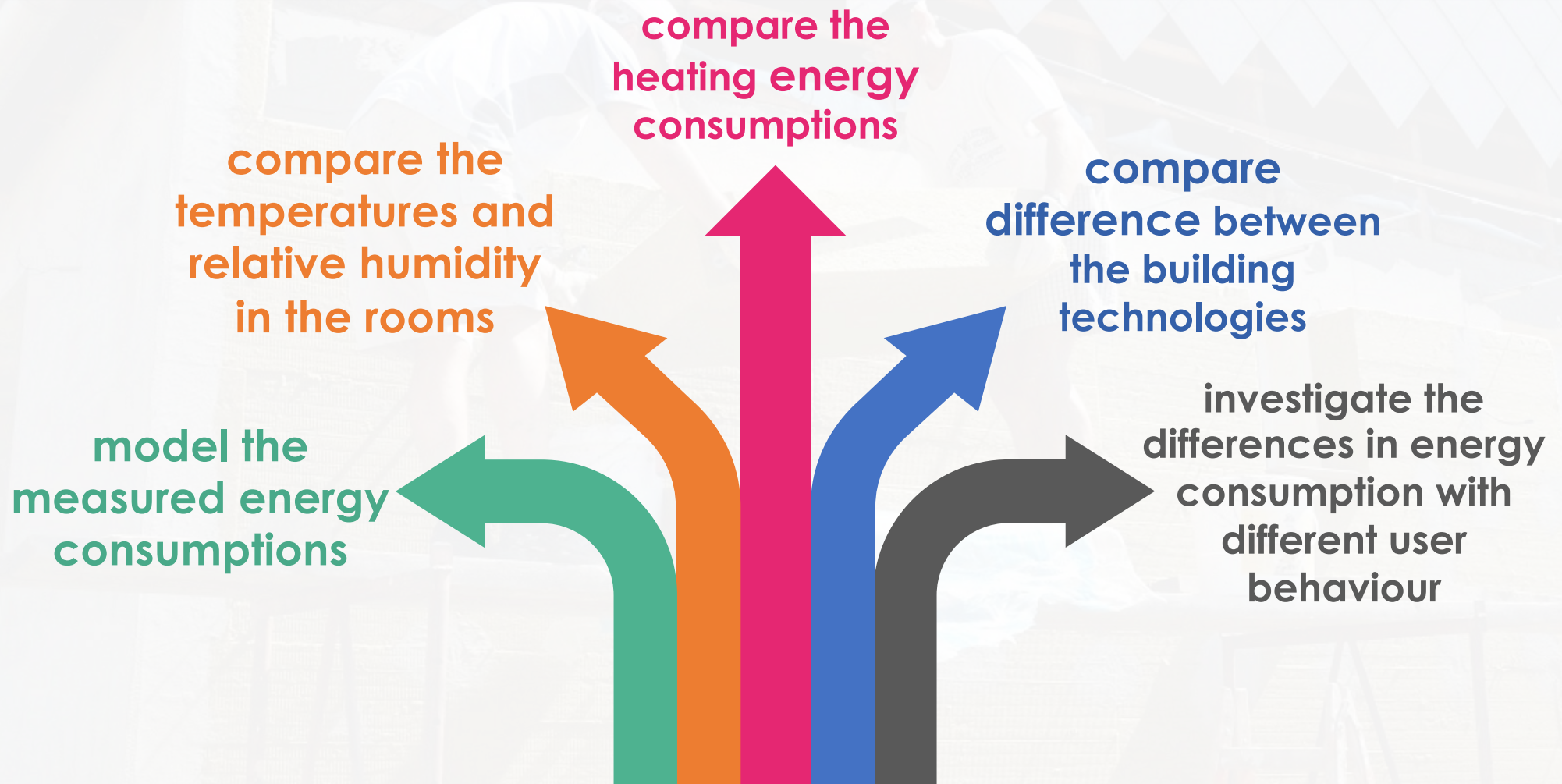
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Background

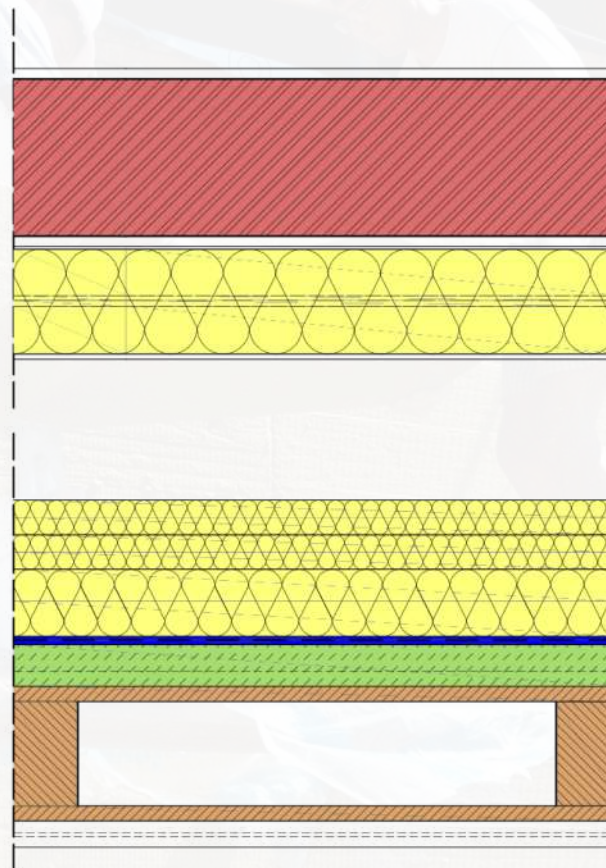


- 2 family homes were selected, which are almost identical in size, construction, heating type (gas boiler) and orientation
- the façade and attic of the first house were insulated
- monitoring measurements were conducted in the rooms (temperature and relative humidity) and building structure

Main Goals of the Study

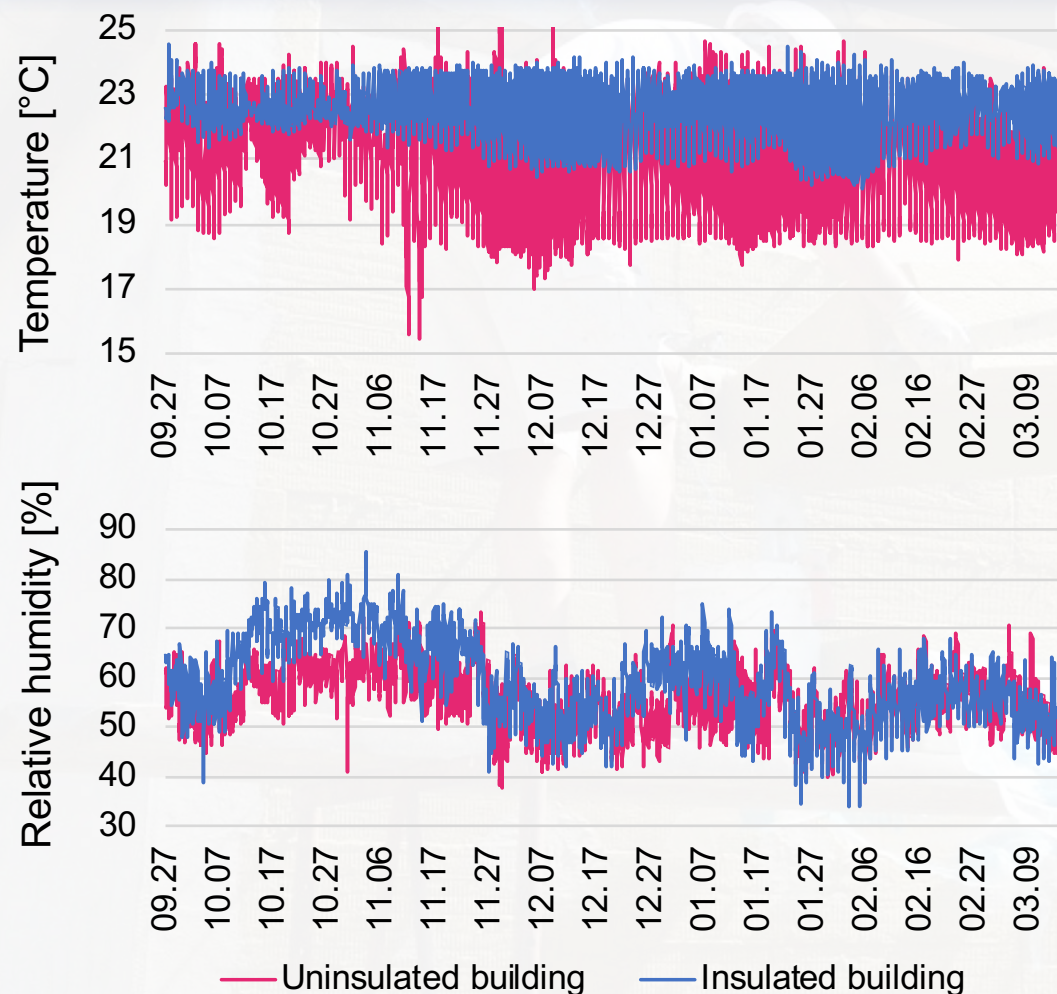


Building Construction Design – Installation Process



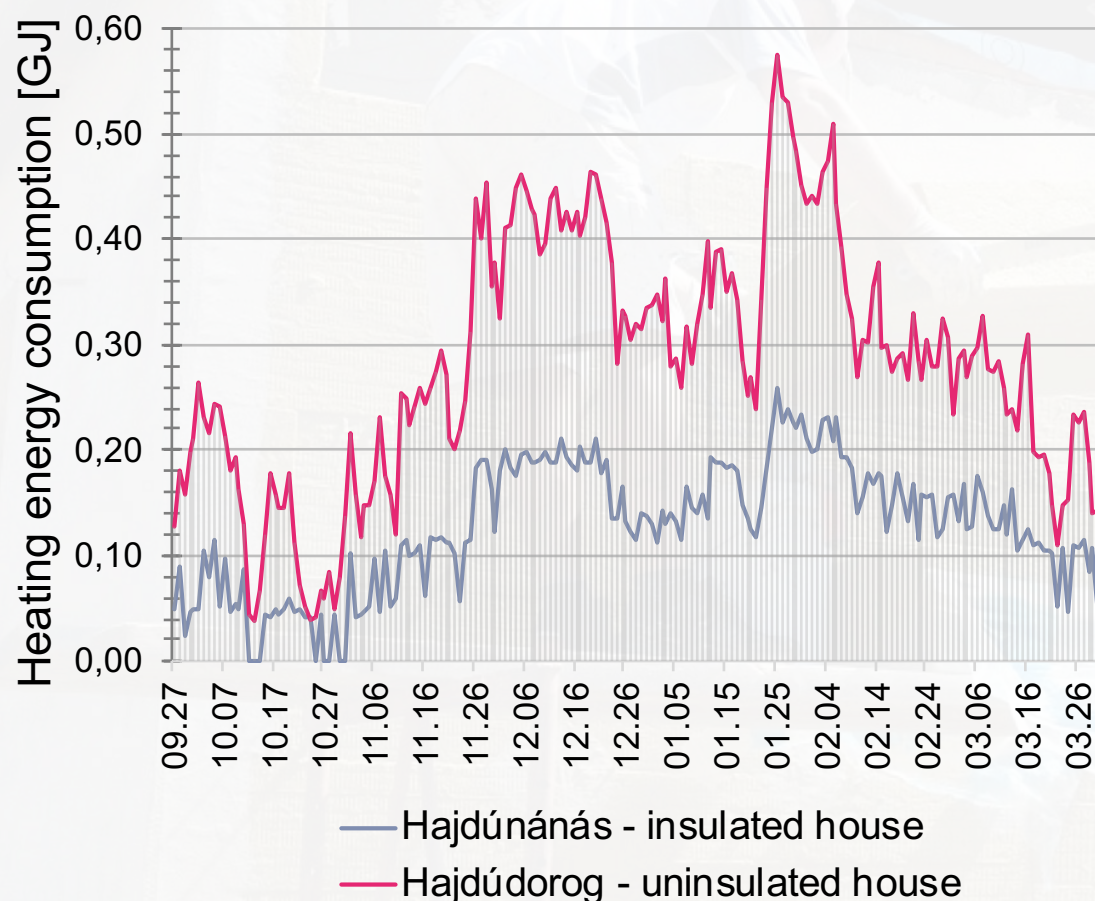
- 1,5 cm - internal plaster
- 30 cm - Poroton 30 masonry
- 1,5 cm - external plaster
- 1 layer adhesive mortar
- 20 cm - mineral wool insulation
- 1 cm - mesh reinforced plaster
- 1 layer vapour permeable underlay
- 25 cm - glass wool insulation
- 1 layer vapour barrier membrane
- 5 cm - clay
- 2,5 cm - wooden boarding
- 18 cm - joist/air layer
- 2,5 cm - wooden boarding
- 3 cm - internal plaster

Results – Internal Air Temperature and RH



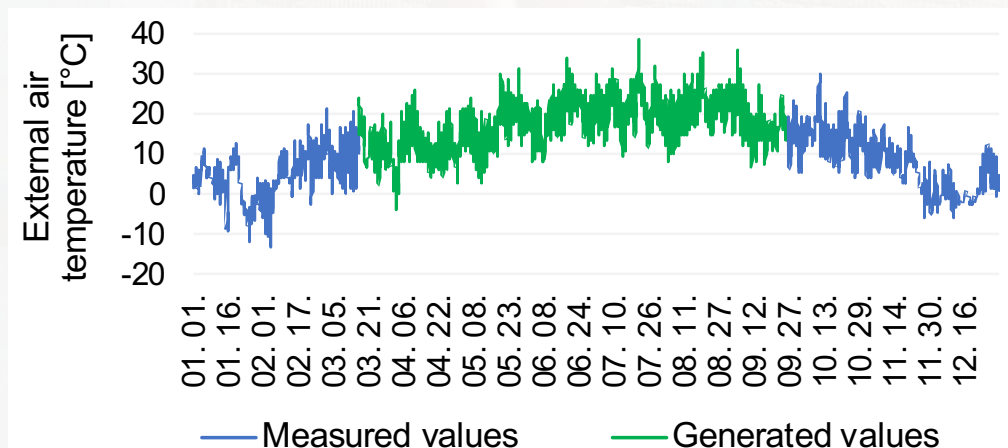
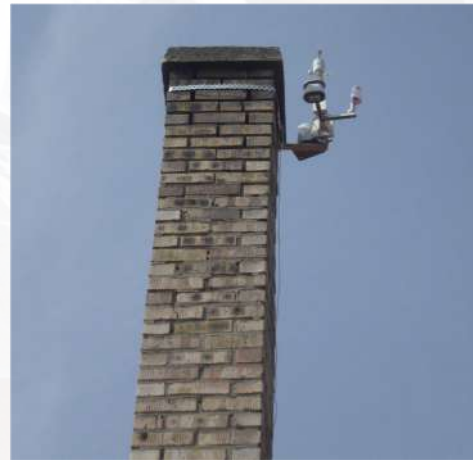
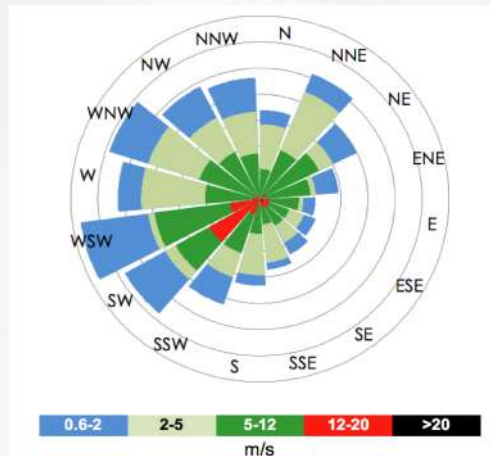
- the temperature and relative humidity (RH) in the rooms were measured at every 15 minutes
- the average temperature and relative humidity of the living room was 22.4 °C and 60% in the insulated, and 21.2 °C and 55% in the uninsulated building
- the daytime temperature fluctuation was much greater in the uninsulated house
- the residents have to ventilate more often in the insulated building

Results - Energy Used for Heating



- the insulated house used more than 55% less energy for heating during the examined period
- overall energy consumption in the insulated house was 23.73 GJ while the uninsulated house used 52.60 GJ energy
- energy consumption reached its peak in both cases at the end of January
- energy usage is smoother in the insulated building

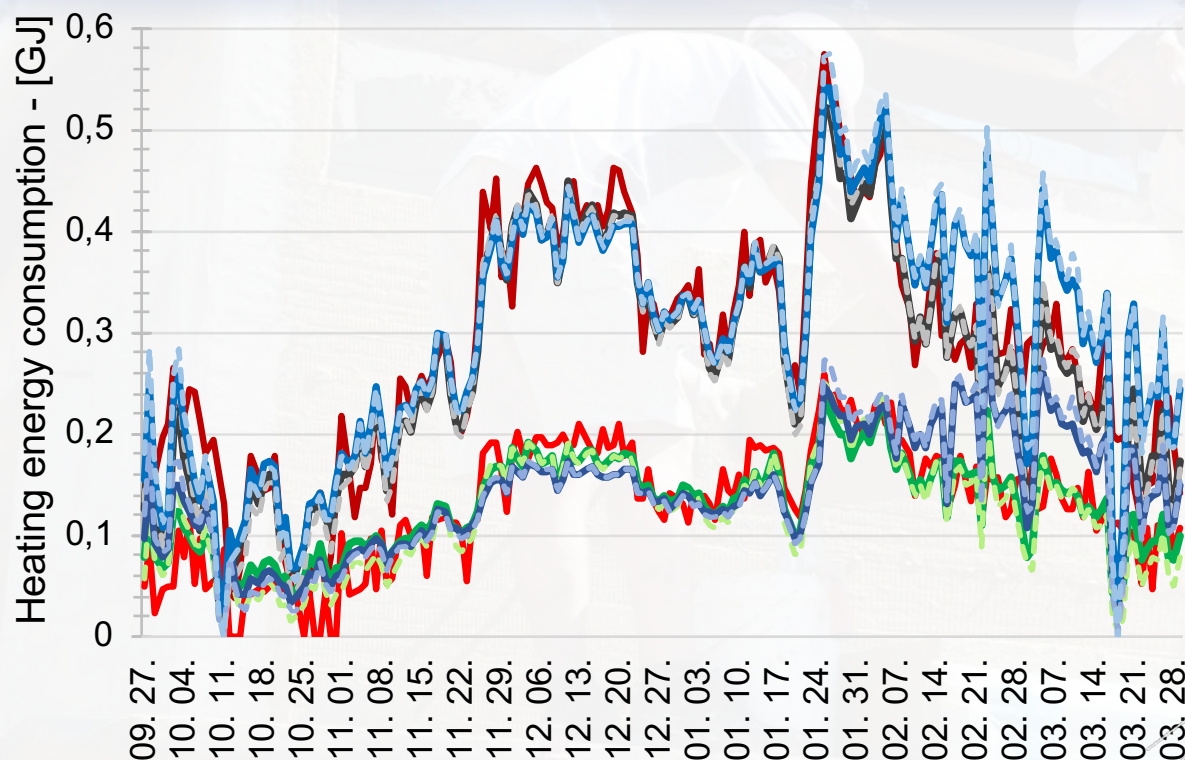
Boundary Conditions for Simulation



- a weather station at the buildings' unused chimney
- temperature, RH, wind speed and direction, atmospheric pressure, precipitation and UV values
- dynamic simulations with WUFI Plus software
- model the measured heating energy consumption
- user-dependent variables: ventilation, internal gains



Simulation Results – Single and Multizone Approach



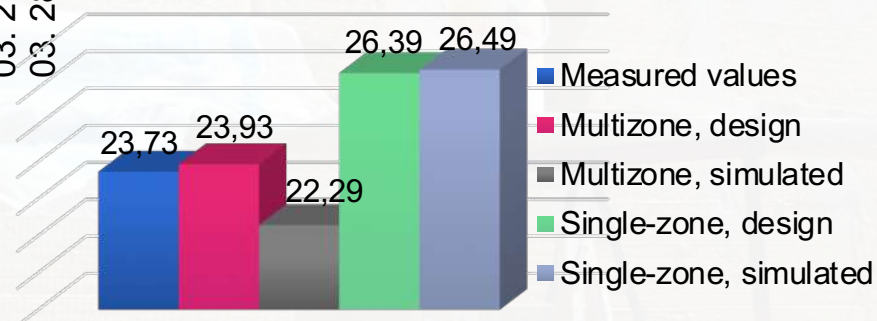
Insulated building

- Measured
- Multizone, design
- - Multizone, simulated
- Singlezone, design
- - Singlezone, simulated

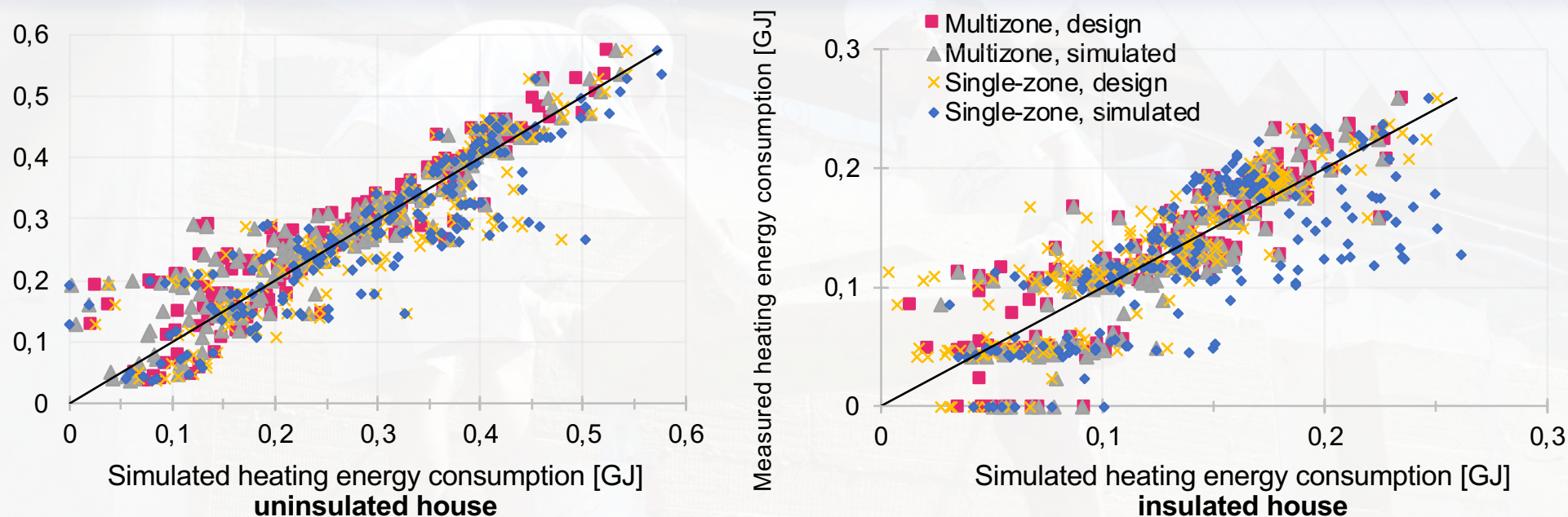
Uninsulated building

- Measured
- Multizone, design
- - Multizone, simulated
- Singlezone, design
- - Singlezone, simulated

- adjusting the ventilation and internal gains, the heating energy consumption of the building can be modelled fairly well
- best approximation was achieved by the multizone approach with set inner design conditions



Simulation Results – Simulation vs. Measurement



- each marker represents a daily averaged result of the simulated values compared to the measured values
- singlezone models have greater scattering and much more points are farther from the ideal line compared to multizone models
- singlezone results tend to overestimate the heating energy consumption

User Behavior Analysis

		1	2	3	4	5	6	7	8	9	10	11	12
Solar protection	Reduce overheating												
	Radiation limit												
	Winter/Summer Schedule												
Ventilation	Hungarian reg.												
	Winter/Summer Schedule												
Internal gains	Hungarian reg.												
	Built-in profile												

- Solar protection**

- preventing overheating, which try to avoid internal temperatures over 26 °C, schedule controlled by profile, and close by limit radiation value (500 W/m²) setting

- Ventilation**

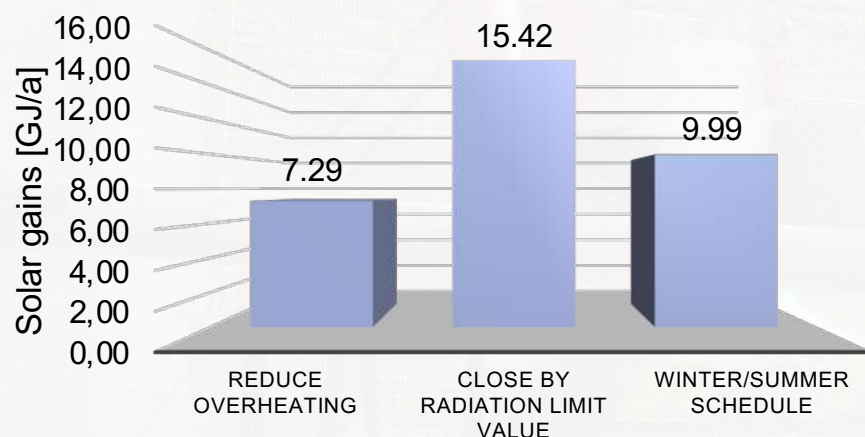
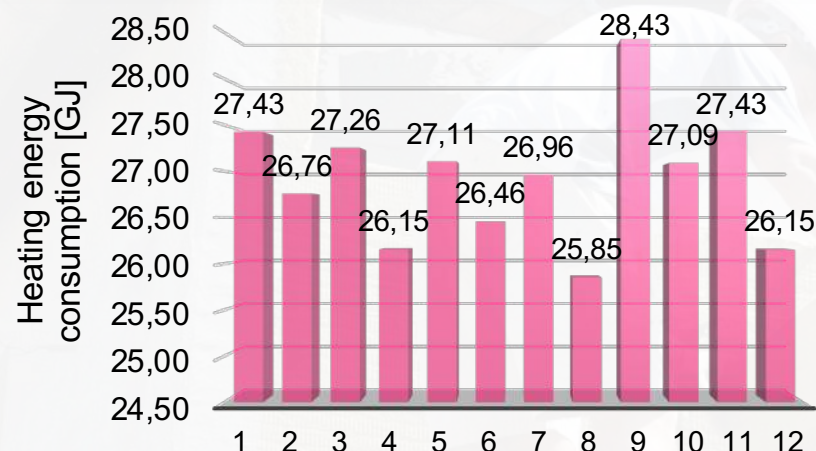
- according to the Hungarian regulation (0.5 1/h) and a profile setting (summer and winter ventilation routines)

- Internal gains**

- Hungarian regulation's value (5 W/m²) and the built-in profiles of WUFI software

12 combinations

Results – User Behaviour Analysis



- the maximum difference between the smallest and the largest overall heating energy consumption was around 10%
- in case of the uninsulated building, the same tendency can be observed, but the maximum difference between heating energy consumptions are reduced to only 6%
- regarding the solar gains, there were 3 major groups
- we can use the result to find out which ventilation and shading options are recommended to minimize the heating energy costs and maximize solar gains

Conclusions

- the thermally insulated house used more than 55% less energy for heating
- however it cannot be ignored, that thermal insulating a house could result in a more sealed and tighter internal space, and therefore the relative humidity in the rooms can increase significantly
- with the knowledge of the basic input data, an appropriate model can be created which adequately models the heating energy consumptions (in case of optimally selected ventilation and internal gains)
- the design of the zones greatly influences the result; the most accurate values can be achieved by multizone simulation
- the used variables in the user behaviour show significant differences in the results, however thermal insulating of the building caused much more effect



Thank you for the attention!

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