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Analysis of thermal comfort conditions and actual energy efficiency for different heating systems in test buildings

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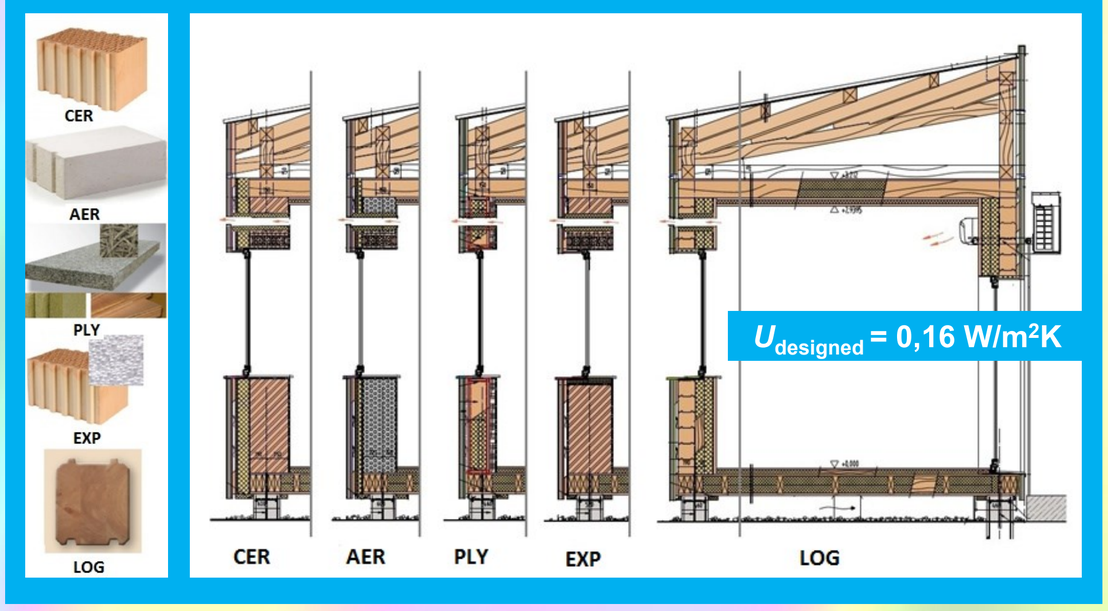
TEST BUILDINGS:

CER – perforated ceramic blocks (440 mm) with stone wool outside
AER – aerated concrete blocks (375 mm) with stone wool outside
PLY – plywood panels with stone wool filling (200 mm) and fibrolite (70 mm)
EXP – perforated ceramic blocks (500 mm) filled with insulating granules
LOG – laminated beams (200 mm) with stone wool and wood paneling inside



HEATING SYSTEMS:

EL – standard electric heater placed near the window (installed in building CER);
A-A – air-air heat pump (installed in buildings AER and LOG);
A-W.F – air-water heat pump with water storage tank and low-temperature large-sized convectors placed on the floor near outer wall (installed in building PLY);
A-W.C – air-water heat pump with water storage tank and heating capillary mats placed on the ceiling (installed in building EXP).

THERMAL COMFORT PARAMETERS

Optimal thermal comfort is established when the heat released by the human body is in equilibrium with its heat production. It depends on **activity**, **clothing** and environmental factors (**air temperature**, **radiant temperature**, **air speed/turbulence** and **air humidity**). There is a range of combinations of these factors where the comfort level is good. It can be determined by Fanger's equation (ISO 7730).

Categories of thermal environment according ISO 7730

Category	Thermal state of the body		Local discomfort			
	PPD, %	PMV	Draught rate, %	PD (%) caused by		
				vertical air ΔT	warm/ cool floor	radiant asymmetry
A	< 6	-0,2 < PMV < 0,2	< 10	< 3	< 10	< 5
B	< 10	-0,5 < PMV < 0,5	< 20	< 5	< 10	< 5
C	< 15	-0,7 < PMV < 0,7	< 30	< 10	< 15	< 10

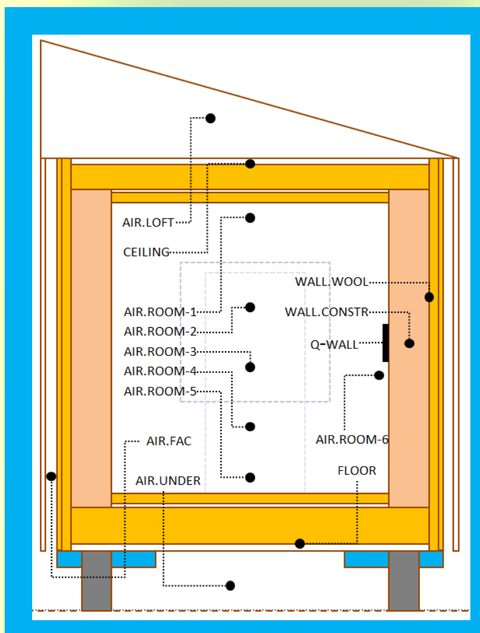
Other parameters

met=1,2

clo=1

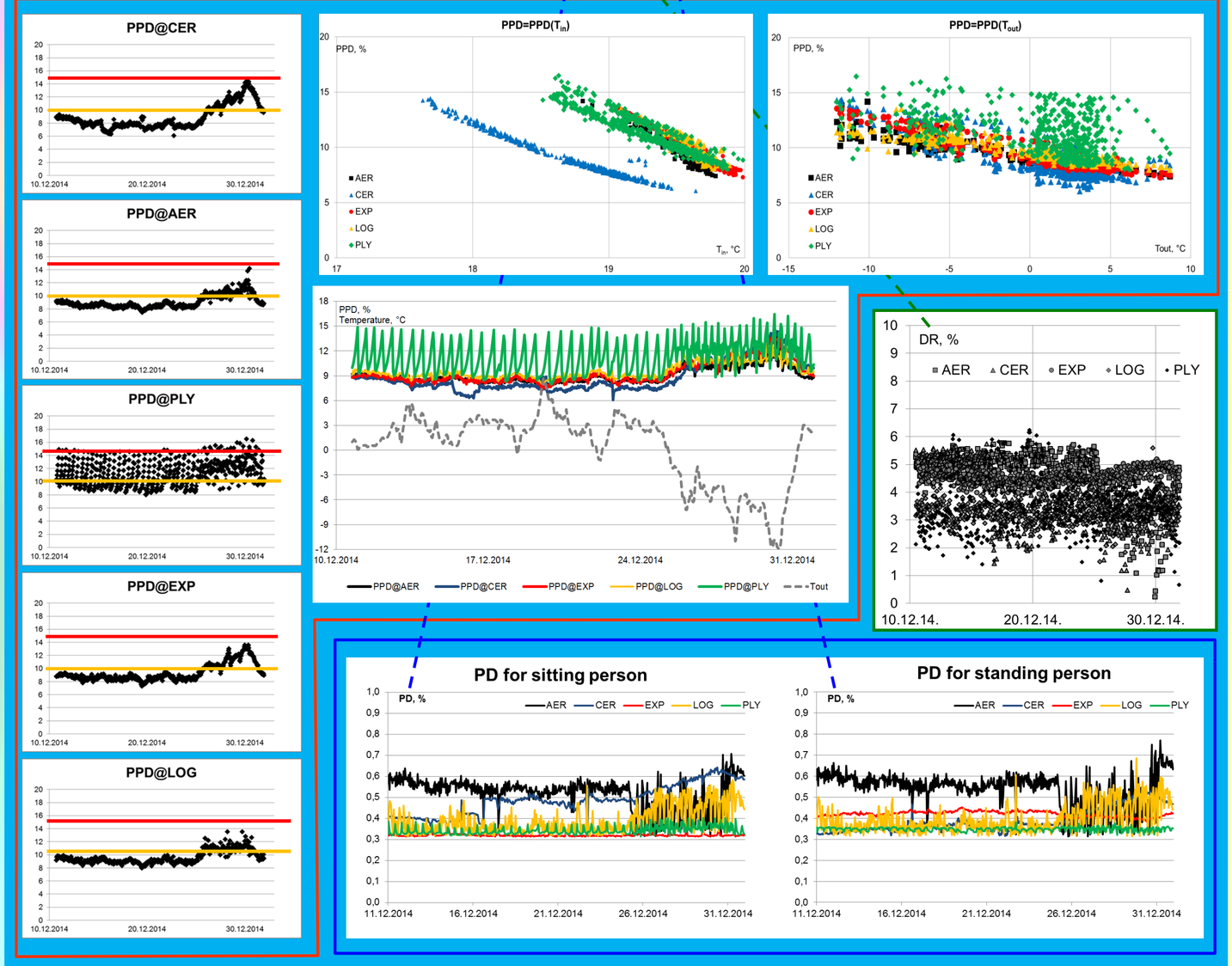
Turbulence intensity 40%

Heights for ΔT calculations: 0.1/1.1/1.7 m

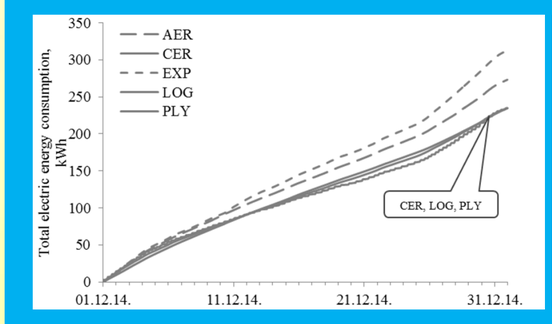


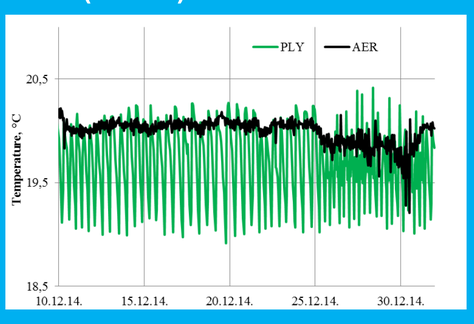
Location of main temperature sensors in a test building

Microclimate measuring device *DeltaOHM HD 32.1*



ACTUAL ENERGY EFFICIENCY RATIO (AEER) CALCULATIONS





Test building	AER	CER	EXP	LOG	PLY	Time period	Average T_{out}
Heating system	A-A	EL	A-W.C	A-A	A-W.F		
AEER	**1.4**	**1.0**	**1.1**	**1.4**	**2.5**	Nov-2014	+3 °C
	1.7	**1.0**	**0.9**	**1.7**	**2.3**	Dec-2014	-0.4 °C
	1.7	**1.0**	**0.9**	**1.7**	**2.5**	Jan-2015	-0.2 °C

AEER<1 for A-W.C can be explained as large proportion of heat losses from heat pump systems outer block.

AEER=2.5 for A-W.F system can be explained mainly by the water temperature settings, which are set in an unusually wide range (Fig).

All the heat pumps used in the experiment are over-dimensioned for such small test houses, but the results are still reliable for **comparable qualitative analysis**. Calculated AEER values are several times lower than standardized COP and SCOP values and show a real electric energy usage. Results can be used for all heating system only and does not represents the type of heating system generally.

Totally different heating systems with standard settings **provide the same level of thermal comfort** (category B), which is high dependent on environmental parameters (e.g. inside or outside temperature).

Lower category of thermal environment is observed in the room when heating system is adjusted to allowing wide range of heat carrier's temperature (category C), on the other hand this approach may be used to increase the efficiency of heating system due to less frequent operation. Thus, the **balance between thermal comfort and energy efficiency** (i.e. running cost) can be adjusted in a necessary direction.

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