Compliance to summer thermal comfort requirements: control of overheating in new Estonian apartment buildings

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Summer thermal comfort

EPBD Annex I requirement:
“1. The energy performance of a building shall be determined ... and shall reflect the ... cooling energy needs (energy needed to avoid overheating) to maintain the envisaged temperature conditions ...”

Estonian legislation:
• Addressed by a requirement not allowing to exceed +27°C more than 150Kh in residential buildings and +25°C more than 100Kh in non-residential buildings from June 1 till Aug 31
• Compliance verification to be done with specific temperature simulation based procedure - needs to be simulated in critical rooms with standard use data and test reference year, cannot be measured
• The study included:
  • Simulations in total in 158 dwellings from 25 new apartment buildings
  • Measurements in 22 dwellings
The requirement of temperature excess $\leq 150$ Kh (degree-hours)

- In residential buildings window airing is taken into account.
- Compliance is proved by performing a simulation calculation based on standard room types.
- Passive cooling solutions should be preferred over active cooling systems.
- The summertime indoor temperature is checked in types of room in which the heat gain is the highest.
- In residential buildings, the summertime indoor temperature calculation is performed with respect to at least one living room and one bedroom.
The requirement of temperature excess $\leq 150$ Kh (degree-hours)

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<th>Date</th>
<th>Time</th>
<th>Temp, °C</th>
<th>Excess, Kh</th>
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$\sum 158.0 \leq 150$ Kh

Temperature excess over $+27$ °C
Methods

- 25 apartment buildings
  - Randomly selected newly built modern apartment buildings
  - 18 dwellings measured
  - 158 dwellings simulated

- Description of the studied buildings
  - Most of the buildings were designed with precast or monolithic concrete structures with more than four floors above ground
  - The thermal transmittances of the buildings envelope were between 0.15 and 0.25 W/(m²•K) for external walls, 0.09 ÷ 0.17 for roofs and 0.60 ÷ 1.65 W/(m²•K) for windows.
  - The SHGC-s of the windows for different buildings varied from 0.40 to 0.71
Measurements

- Temperature measurements in dwellings

- Logger saving interval: 1h, hourly mean
Simulations

• Indoor climate and energy simulation tool IDA-ICE
• Simulation of selected dwellings with possible risk of overheating
Simulations – TRY

• Outdoor climate

Regardless of the building’s location, verification of compliance with the summertime indoor temperature requirement are performed on the basis of the data of the Estonian Test Reference Year (TRY).

• The TRY represents the typical outdoor climate of three decades (1970–2000), containing hourly-average data of outdoor temperature, relative humidity, wind speeds and solar radiation.
Simulations – standard use

- Occupied hours and heat gain

<table>
<thead>
<tr>
<th>Building’s purpose of use</th>
<th>Lighting W/m²</th>
<th>Appliances W/m²</th>
<th>Occupants W/m²</th>
<th>Occupants m²/person</th>
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<tbody>
<tr>
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Window opening

Window opening schedule

Openable window airing area ~10%

Non-openable

Actual room

Room model
# Window modelling

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<th>KOBUS</th>
<th>AVA MYYDUD</th>
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<td>A6</td>
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<td>![Diagram](AVA MYYDUD A6.png)</td>
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</table>

**Detailed window construction**

**Layers**
- Inside (ambient or adjacent zone):
  - Pane: PLANILUX 4mm SGG (WIN7)
- Pane: PLANILUX 4mm SGG (WIN7)

**Glazing properties at reference conditions**
- Solar heat gain coefficient: 0.65
- Solar transmittance: 0.412
- Visible transmittance: 0.719
- Glazing U-value: 0.694 (W/m².K)

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Measurements –
Openable area of windows and WWR*g

- Openable windows area (OA) below 5% result in higher temperature excess values.
- In south and west oriented dwellings, WWR*g-values over 0.2 result in higher temperature excess values.

![Graph 1: OA vs. Indoor temperature excess over +27°C (Kh)](image1)
P < 0.01
R² = 0.5893

![Graph 2: WWR · g-value vs. Indoor temperature excess over +27°C (Kh)](image2)
P = 0.07
R² = 0.4065
Shading balconies

- Overhangs with $A/H>0.7$ in south orientation
- Side-fins with $B/C>0.7$ in west orientation
- North and east oriented rooms did not experience values over the threshold

![Shading diagram]

Temperature excess over $+27^\circ C$ (Kh)

- All simulations (N=158)
- West No shading (N=19)
- South No shading (N=16)
- South $A/H<0.7$ (N=14)
- West $B/C<0.7$ (N=23)
- West $B/C>0.7$ (N=9)
- North (N=11)
- South $A/H>0.7$ (N=28)
- East (N=38)

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QUALICheck
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In total 158 dwellings from 25 buildings were simulated.

Overall building results:

17 out of 25 (68%) did not comply with the regulation
Conclusions (1/2)

- Measurement results confirm that high temperatures over +27°C did exist also in reality in majority of buildings for a remarkable portion of the measuring period, indicating **high risk of overheating in new apartment buildings**
- Many occupants had complaints, but this data was not systematically collected
- **Shading balconies had the largest effect** on overheating risk reduction
- ‘Critical room’ was defined by combination of the following factors: south and/or west oriented windows, lack of external shading elements or insufficient dimensions of shading, with **WWR · g-values > 0.2** and total windows’ airing area < 5%.
Conclusions (2/2)

• Out of the 25 new apartment buildings studied, 17 buildings (68%) did not comply with the summer thermal comfort requirements

• This relatively new building code requirement was not fully established in practice, as only in 8 buildings the required calculations were included in the building permit documentation

• Measured and simulated results cannot be directly compared because of differences in weather data and occupancy behavior (e.g. opening windows, internal gains) – simulations are to be used for the compliance assessment

• The methodology proved to be sound and robust
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