Summertime overheating prevention requirements and results in Estonia

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Overheating has become a problem even in a cold climate in new airtight and highly insulated buildings with large glazing areas. To avoid such problems, Estonia has launched temperature simulation based procedure and requirements.

One of the aims of the Energy Performance of Buildings Directive (Directive 2010/31/EU) [1] is to reduce cooling energy consumption of buildings and at the same time to improve indoor climate, and prevent overheating. More specifically, EPBD Annex I requires: *"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 ..."* In Estonia this has addressed in the regulation 'Minimum requirements for energy performance' [2], which besides energy performance also regulates summer thermal comfort since 2008. Estonian regulation sets a limit for maximum indoor temperature excess, expressed in degree-hours (°Ch) over a given base temperature, which is calculated from simulated room temperature values as:

$$DH_{\vartheta_b} = \sum_{i=1}^{j} (\vartheta_i - \vartheta_b)$$

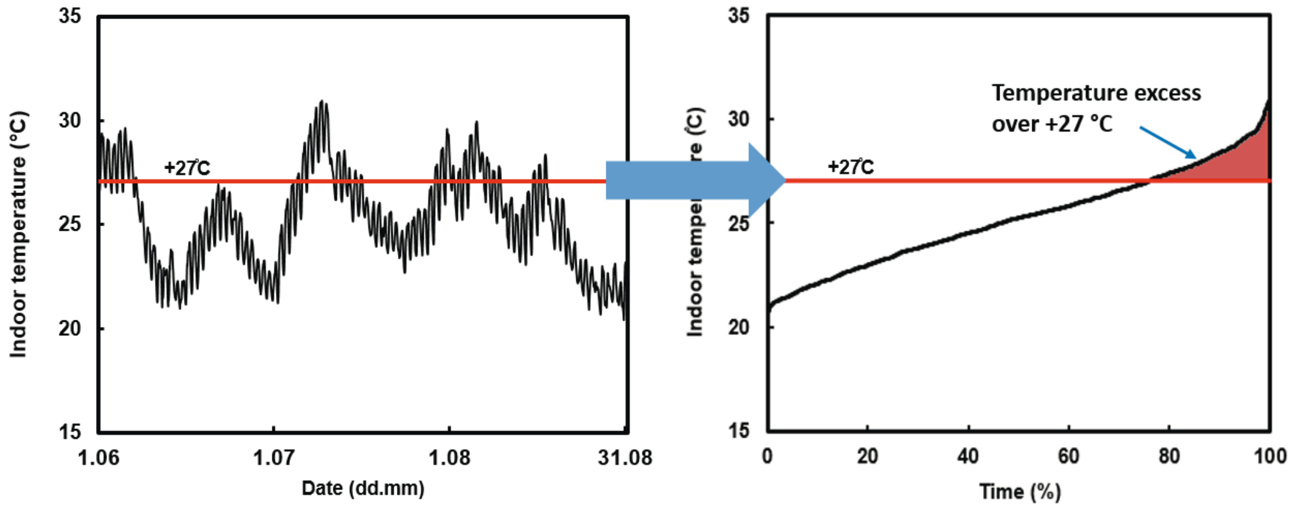
Where DH_{ϑ_b} is temperature excess over base temperature ϑ_b, ϑ_i is hourly mean room temperature and j is the total number of hours in the given period. The "+" sign means that only positive values are summed (**Figure 1**).

For residential buildings, the base temperature, is t_b = +27°C and the excess limit is 150°Ch, for non-residential buildings the values are +25°C and 100°Ch respectively. The calculation period is set in the summertime from July 1st till August 31st, including only occupied hours of the building – outside those hours the indoor temperature may be higher (in non-residential buildings, as residential buildings are considered to be used 24 h and 7 d). In buildings with cooling system, specific temperature simulation reporting is not required as cooling energy is in any case accounted in dynamic energy simulation. Only exception is for detached houses where temperature simulation is not required if specified requirements for window size, shading and openable windows are fulfilled, and specific form with this data is provided.

Compliance verification process

In the building design process, dynamic indoor temperature simulations are required to produce summer thermal comfort compliance verification certificate as a part of the EPC.

The simulation methodology and standardized input data for the compliance assessment procedure is described in detail in the regulation No. 63, 'Methodology for calculating the energy performance of buildings' [3]. The simulation models use a single zone method, meaning that only selected rooms are modelled individually with no connections to other rooms (**Figure 2**). In case of residential buildings, at least two 'critical' rooms are required to simulate, one bedroom and one living room, which have the biggest potential to score high temperatures, e.g. south or west orientation, higher floor location, relatively large glazed surfaces. The selection of these rooms is up to the energy efficiency specialist, designer or HVAC engineer responsible for the calculations (**Figure 2**).



Date	Time	Temp, °C	Excess, °Ch	
...	...	...	...	
5. July	10:00	26.4	0.0	
5. July	11:00	26.8	0.0	
5. July	12:00	27.3	0.3	
5. July	13:00	27.4	0.4	
5. July	14:00	27.6	0.6	
5. July	15:00	27.8	0.8	4.2°Ch
5. July	16:00	28.6	1.6	
5. July	17:00	27.5	0.5	
5. July	18:00	27.0	0.0	
5. July	19:00	26.8	0.0	
...	...	...	...	Requirement
		Σ	685.0	≤ 150°Ch

Figure 1. Calculation principle of temperature excess. Hourly mean indoor temperature values are simulated and excess values over the base temperature are summed up for total degree-hours. If the sum is lower than the requirement, the building is considered compliant, otherwise one needs to apply measures to reduce the temperature excess.

Figure 2. Rooms most likely to counter overheating are modeled and simulated. At least two 'critical' rooms – one bedroom and one living room must be analyzed in case of residential buildings.

For the internal heat gains detailed standard use profiles of hourly loads for equipment, occupancy and lighting, depending on the building type are used. Also, depending on the building type, ventilation and infiltration air flows are considered as standard values.

All solar protection solutions, such as solar protection glass or coatings, internal and external window blinds, grates, awnings etc. as provided in the design solution, as well as the surrounding objects that cast shadows on glass surfaces and parts of the building itself, are also included in the building model (**Figure 2**, **Figure 3**).

One of the most important difference between modelling residential and non-residential buildings is the use of window airing. Ventilative cooling through the opening of windows is not taken into account in non-residential buildings. In residential buildings, the opening of windows to the airing position (the use of airing position instead of fully opened window is especially stressed in the regulation) and the air change driven by the difference between outdoor and indoor temperature are taken into account (wind driven air change is not allowed to be simulated). The windows are to be closed when the temperature falls to the heating set-point (**Figure 4**).

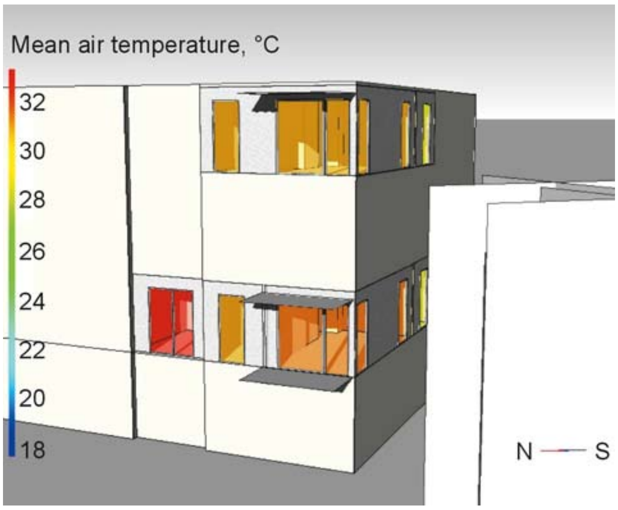


Figure 3. Visualizing simulation results.

The calculations are performed regardless of the building's location on the basis of the data of Estonian Test Reference Year [4], initially built for energy calculations, containing parts of climate data from 30 real years.

The results of the temperature simulations with regard to all calculated rooms are presented as duration curves together with verification results as a mandatory part of the EPC of the building.

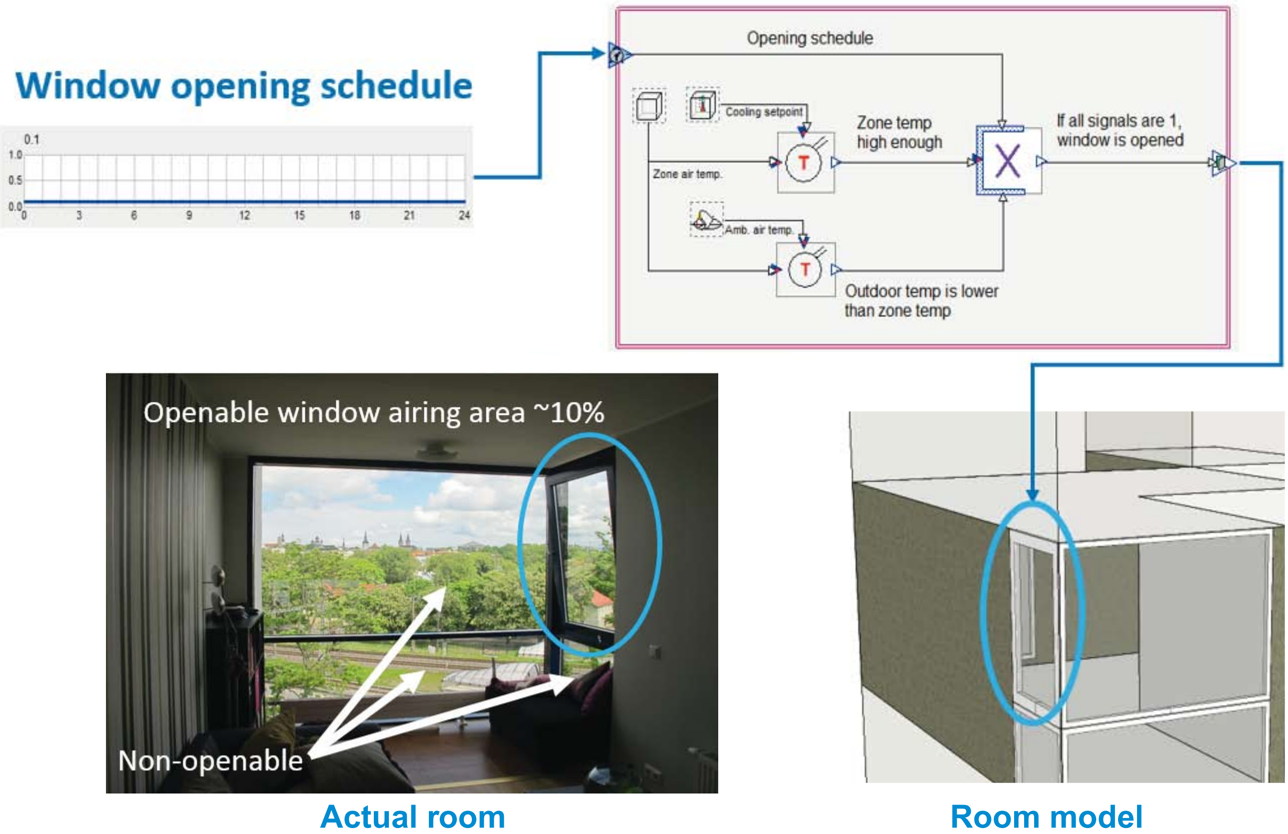


Figure 4. Modeling opening and closing of windows. Window is opened 10%, when room temperature is higher than outdoor temperature and cooling set-point is exceeded, otherwise the window is closed.

National study

During the summer 2014 we conducted a study on summer thermal comfort in new apartment buildings as a part of European QualiCheck project. Using field measurements and simulations we analysed the compliance of buildings, implementation of the relatively new regulation and overheating problems in reality.

For modelling and simulations we used indoor climate and energy simulation software IDA Indoor Climate and Energy (IDA-ICE) [5]. Input data for the buildings in question, including building site surroundings, architecture, floor plans, and specifications for walls, roofs and windows were acquired from the design documentation of the buildings, the Estonian Registry of Buildings database [6], and the Estonian Land Board web map [7]. In total, we simulated room temperature for 158 dwellings from 25 different apartment buildings and took indoor temperature measurements in 18 dwellings of 16 buildings, during the period of July 1 to August 31 2014.

Of the total dwellings that were simulated, 52 reached temperature excess values higher than 150°Ch. The temperature duration curves for all the simulated dwellings are shown in **Figure 5**. As was the case with simulations, also the measurement results showed strong signs of overheating (**Figure 6**). Although most cases that showed overheating risk with simulations, were also over the limit with measurements, the temperature measurement results cannot be used to assess dwelling compliance. This is stated in the methodology that is simulation based at standard use conditions and is also our conclusion based on the comparative analyses. Many factors influence the results and can be different in real operation. These include weather data differences, occupancy density and presence profile, other internal heat gains and window openings.

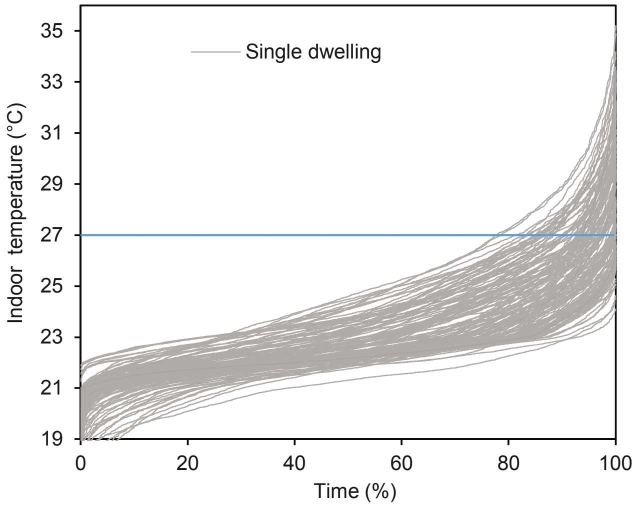


Figure 5. Simulated cumulative indoor air temperature of the studied dwellings.

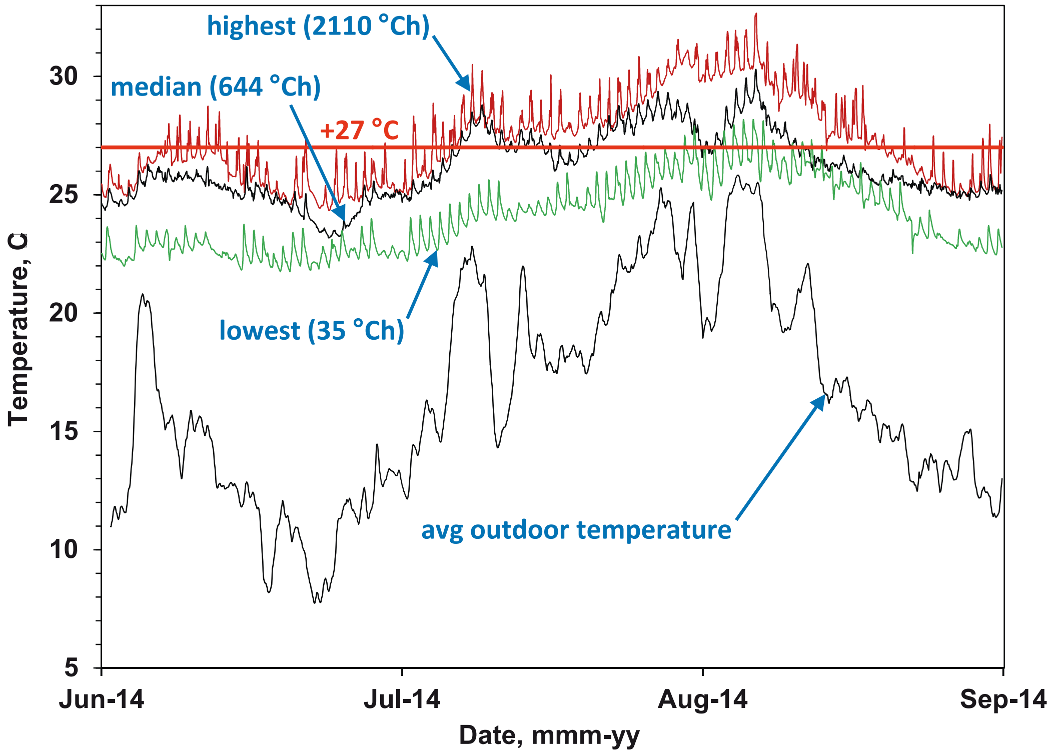


Figure 6. Example of measurement results: dwellings with highest, lowest and median temperature excess. Measured hourly mean indoor temperatures during period of 1. June – 31. August 2014.

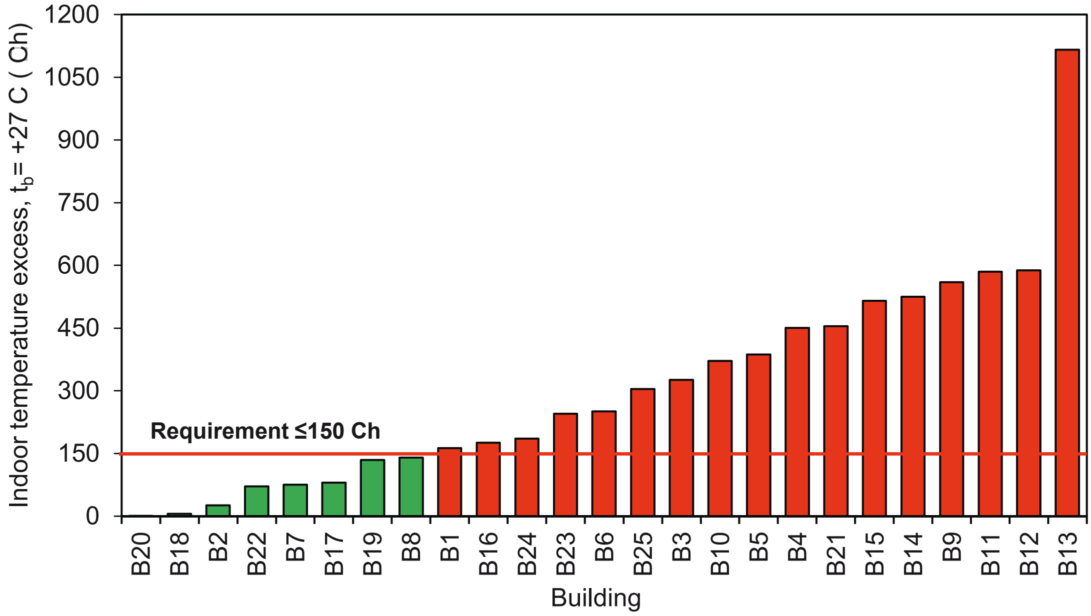


Figure 7. Overall building simulation results: out of the 25 simulated buildings, 17 (68%) did not comply with the requirement.

The overall simulations results showed that 17 out of 25 (68%) of the apartment buildings in this study did not comply with the summer thermal comfort requirements (**Figure** 7).

Conclusion

It may be concluded that this relatively new building code requirement was not fully established in practice; this conclusion is supported also by the fact that only in 8 buildings the required calculations and forms were included in the building permit documentation. Although the methodology for compliance assessment was proven to be sound and robust, the outcomes of the study suggested some minor improvements, such as guidance for selecting 'critical' rooms and combination of measures for avoiding the risk of overheating. Results show that the requirement in apartment buildings is achievable without cooling, if passive measures are properly applied. The regulation has evidently improved the summer thermal comfort in buildings which have conducted temperature simulation and have followed the requirements in the design. It is recommended for authorities to pay more attention for EPC (random) checks and to check also within this process the availability and plausibility of overheating temperature simulation reports. ■

References

[1] Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings (recast). Official Journal of the European Union; 2010.

[2] Estonian Regulation No 68: Minimum requirements for energy performance. Ministry of Economic Affairs and Communications; 2014.

[3] Estonian Regulation No 63: Methodology for calculating the energy performance of buildings. Ministry of Economic Affairs and Communications; 2012.

[4] Kalamees T, Kurnitski J. Estonian test reference year for energy calculations. Proceedings of the Estonian Academy of Sciences Engineering. 2006;12:40-58.

[5] EQUA. IDA Indoor Climate and Energy 4.6.1. Equa Simulations AB; 2014.

[6] Estonian Registry of Buildings database. Available: www.ehr.ee. [Accessed: 3. Dec 2014].

[7] Estonian Land Board Map Server. Available: http://geoportaal.maaamet.ee/eng/. [Accessed: 11. Nov 2014].