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Daylight situation of a renovated apartment in different urban settings

Renovation of existing residential buildings is acknowledged as an important and effective measure to increase efficiency of the building stock and thus decreasing energy use and related GHG emissions. However, substituting the old windows with new, better insulating windows has an influence on daylight availability. Daylight and solar radiation have a well-known influence on human health, by regulating the circadian rhythm, mood and behavior, as well as synthesizing vitamin D. In such a perspective, windows are the building's most complex physical interface, as they are required to both allow satisfactory daylight penetration and view to the outdoors, but also limit the thermal exchange between the indoor space and the outdoor environment. This aspect is particularly critical where the winter conditions require well insulated buildings and high daylight penetration. The relationship between the thermal insulation, the visible transmittance, and the solar energy transmittance of glazing, with either clear or low emissivity glass panes, can be described with an asymptotic curve [4-6]. In practice, improving the thermal insulation of a glazing system will automatically lower its visible transmittance, which in turn has a negative influence on daylight availability and increases the use of electricity for indoor lighting [7-9].

The scope of this paper is to investigate the consequences on daylight when substituting existing windows (center-glass U-value 2.8 W/m2K) for new better performing windows (center-glass U-value 0.6 W/m2K) commonly used in the upgrading of residential buildings.
This work is based on the case study of an apartment room, which is located in three different urban settings (high, medium, low density). Three types of window solutions were analysed; type 1 is the old window situation, type 2 is the new window situation, type 3 is the new window situation with additional window on another wall of the room. All types are simulated in Radiance/Daysim [10]. The illuminance values are calculated on a grid located at 0.80 m above the floor level of the apartment. Daylight factors (DF) are calculated as well as Daylight Autonomy (DA), useful daylight autonomy (UDA), daylight saturation percentage (DSP), annual sunlight exposure (ASE), as well as cumulative daylight (lux hours). The type of tasks performed by the building users are modelled with three illuminance levels, 100 lux, 300 lux, and 500 lux) [11]. The combination of the parameters yields the scenarios presented a Table in the paper, and for which the above-mentioned indicators are calculated.

Daylighting analysis carried out in three residential apartment types before and after retrofitting windows show that such measures lead to a significant reduction in daylight autonomy when the tasks performed require 300 lux or more. Furthermore, the addition of extra insulation on the facade, and the resulting increase in wall thickness, also notably influences DA values negatively. Overall, it was found that these common retrofitting efforts most critically affect buildings in dense urban settings.
One solution, which includes an additional window installation, increases the daylight indicators. This has implications for designers of renovation cases in urban areas and should be taken into consideration.

Keyword 1

daylight autonomy

Keyword 2

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Keyword 3

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Keyword 4

Keyword 5

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