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Actual energy performance of student housing: case study, benchmarking and performance gap analysis

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Abstract

While recent studies have shown an important gap between design and real energy use of multifamily buildings, this study analyses the energy performance gap for student housing. A very high energy performance (VHEP) student residency was analysed in detail, followed by a comparison of energy and water consumption with student residencies and other dwellings in Geneva. The analysis shows that for this VHEP residency the limit values according to the actual thermal regulations and MINERGIE label are exceeded: actual heat demand is 98 MJ/m^2.a for heating (without double-flow ventilation) and 116 MJ/m^2.a for hot water while the MINERGIE-index is 137 MJ/m^2 (38 kWh/m^2.a). Nevertheless, its thermal energy consumption (IDC=224 MJ/m^2.a) is similar to other VHEP buildings, and half of Geneva's average values. The study points to factors which highly influence real performance of VHEP buildings and concludes that there is a huge optimisation potential during use phase of a building.

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Keywords: energy performance gap, student housing, heat demand, electricity consumption, water use, residential sector, actual performance

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1. Introduction

The stepwise tightening of building energy requirements and labelling is leading to the design of buildings with high energy performance. However, previous research has shown that the actual energy use of buildings exceeds in many cases the estimated value in the design phase (also known as *energy performance gap* [1]). While some recent studies have dealt with performance gap in retrofitted multi-family buildings, this study focuses student housing. Despite the specific users and the different operating procedures, this subsector is not a separate category in SIA recommendations (SIA: Swiss society of engineers and architects). There is surprisingly little information available about the actual energy performance of such student residencies. Among the literature about this topic, studies about German student residencies by Engelmann [2] have shown that the thermal energy consumption of VHEP student residencies is about half of the average residencies. Planned space heating demand was exceeded by 30% to 145%, but there was also one example where the actual heat demand was 30% lower than expected. In this latter case, low heat demand was due to low ventilation rates, resulting in inferior air quality. In VHEP buildings, hot water contributes 50% to 60% of the thermal energy consumption. Engelmann and Voss [3,4] also showed that the per capita water consumption does not differ between student homes and the German average (122 l/cap.d). Due to high density, hot water energy consumption per surface was higher in student residencies than in multifamily buildings. They noted seasonal and daily variations (holidays and week-ends). While German studies found the lowest consumption in new homes with water saving appliances, Alborz & Berardi [5] showed for some LEED certified US residence halls that technology alone does not reduce consumption; despite water saving appliances, water consumption was not lower than in traditional residences, but 60% higher than planned. For electricity consumption, Engelmann found a lower per capita electricity consumption than the German average, and among residencies, a higher value in small apartments (studios) [3].

Against this background, the current study analyses actual performance of a very high energy performance (VHEP) student residency as well as energy and water consumption of a set of 35 residencies in Geneva.

This study aims to evaluate for the case of Geneva if student housing reaches its MINERGIE-P objectives (Swiss label for VHEP buildings) and corresponds to the SIA limits and standard values, and if not, which parameters explain the energy performance gap. Furthermore, this study analyses whether there is a difference in energy consumption between student residencies and Geneva's multifamily buildings, in order to derive recommendations for the design, construction and use phase of student accommodation.

2. Methodology

First, we performed a detailed analysis of a very high energy performance student house. This case study is applied to a building called "Pavillons" owned by the Ciguë (a self-managed housing cooperative for people in training). This building offers housing to 40 students who live in 8 apartments. "Pavillons" was built in 2009 in accordance with the MINERGIE-P-ECO standard. A wood-pellet furnace and a solar thermal installation provide heat for domestic hot water (DHW) and space heating (SH). A "double flow" ventilation system recovers heat from the extracted air in order to preheat fresh air before blowing it into the building.

The aim of the detailed analysis is to assess its actual energy consumption, i.e. to check whether the VHEP-objective is reached and to identify the main causes behind the energy performance gap.

The analysis is based on-meter readings over a two-year period (July 2010 to June 2012) and information derived from energy bills, as electricity consumption and pellet deliveries. In-situ measurements were made to complete data and identify causes of heat losses: thermal images, heat flow measurements, data collections concerning the electric power of appliances and the recordings of the solar control system.

Secondly, the obtained results were compared to a set of 35 student residencies located in the canton of Geneva (both new and existing buildings).

In terms of thermal consumption for space heating and hot water, a cantonal index (indice de dépense de chaleur, IDC) is available as open-source data. Electricity and water consumption, obtained through agreement of the different residencies, were aggregated to the building level and a three years mean was established.