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First stepping stones of alternative refurbishment modular system leading to zero energy buildings

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Abstract

Housing stock is one of the major energy consumers in Europe, or the Czech Republic respectively, and it is not easy to reach European 20/20/20 target with an envelope insulation only. Therefore a deep renovation alternative consisting of prefabricated insulating panels, implementation new smart HVAC systems and use of renewable energy sources is presented. In this article, boundary conditions and limitations of various aspects of such solution are described and the possible use is shown, particularly on a reference building in Milevsko, Czech Republic, representing the most common Czech multi-family housing sample.

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Keywords: Deep renovation; energy efficient buildings; prefabrication; MORE-CONNECT; zero-energy building.

1. Introduction

1.1. Energy performance of Czech housing stock

Building sector together with construction industry covers over 25% of the total energy consumption in Europe, in numbers, it was 11,303 petajoules in 2014. The very same proportion may be applied for the Czech Republic [1]. An important part of the national residential building stock is represented by multi-family housing with more than two million flats in 211,252 objects. 73.7% of those buildings were constructed before 1979 when the first version of Czech Standard coping thermal resistance of building envelope (ČSN 73 0540:1979) was issued [2]. That means they were built without any legislative restriction in terms of energy consumption or energy savings.

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The key requirements under the European Energy Performance of Buildings Directive are that all new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings 2 years earlier) and EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.) [3]. At the same moment Energy Efficiency Directive orders that EU countries renovate at least 3% of buildings owned and occupied by central government and EU governments should only purchase buildings which are highly energy efficient [4]. The Renewable Energy Sources Directive (RESD) requires that EU reaches a 20% share of energy from renewable sources by 2020; 10% share of renewable energy specifically in the transport sector by 2020; and increase the proportion of energy from renewable sources to improve energy security [5].

To support the European targets, several subsidy programs for energy retrofitting of both public and private buildings have been running. However, only 36% of a residential block of flats were somehow refurbished (either replaced windows, insulated façade or insulated roof) by the year 2014. The similar percentage might be applied also for other 1.5 million of single-family houses, where exact numbers due to very often do-it-yourself approach are not available.

1.2. Drawbacks of typical renovation techniques and alternatives

The most frequent way to reduce the energy consumption of existing buildings so far was to insulate the roof, apply an External Thermal Insulation Composite System (ETICS) and install new windows. However, this in-situ done renovation may constitute a significant intervention into regular lives of inhabitants for a longer time and closure the envelope with a diffuse barrier (such as ETICS and airtight openings) may negatively affect the indoor environment.

Moreover, such solution is only a partial step to reduce energy consumption. With this procedure, it is not possible to get to nearly zero or zero energy levels. Only thermal insulation installed on the building envelope, no matter how thick it is, cannot achieve sufficient U-values to balance energy losses from commonly used energy sources. ETICS with a thickness exceeding 300 mm does not provide any significant improvement, the efficiency of such solution (value for money) rapidly decreases and technically, it may be difficult to anchor for it is very light and prone to the wind and other climate effects.

The heating, ventilation and air-conditioning (HVAC) systems upgrade, however the typical renovation remains only on the direct replacement of the same system. Implementation of renewable energy sources are also needed and possible in the typical renovation. With airtight building envelope, it is also necessary to design a new smart ventilation system to provide sufficient fresh air to the building users. But all those upgrades result in another serious impact into the building and into the lives of inhabitants.

Last, but not least, impacts resulting from used materials should be evaluated [6]. In short, a deep and complex renovation that uses environment-friendly materials and can be conducted in very short time is still missing.

1.3. New approaches to retrofitting of residential blocks

In order to achieve the required renovation rates across EU and thus speed up the process of energy retrofitting the residential buildings and to overcome the issues presented above, an H2020 project MORE-CONNECT was initiated. MORE-CONNECT tries to solve the problem by developing prefabricated, multifunctional renovation elements for the total building envelope (façade and roof) and installation/building services. These elements can be combined, selected and configured by the end-user, based on his specific needs. This information can be used as input into advanced Building Information Modelling systems to control and steer the further production process of these elements. In this way, unique series of one can be made in a mass production process for the same reduced price of mass production [7].

1.4. Objectives and methods

The main objectives of the presented paper are to summarize the starting points for the design of a complex retrofitting system for a typical Czech residential post-war building, define basic sets of requirements on the modular renovation system and present a conceptual study of such system applied to a reference residential building.