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Correlation of energy efficiency and thermal comfort depending on the ventilation strategy

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Abstract

Designing energy efficient building it is important to achieve low level of energy consumption and to provide high parameters of the thermal comfort. This research is devoted to ventilation which has effect on both the comfort of the building and its energy efficiency. The IDA-ICE 4.7 software was used as a tool providing a detailed study of the building's indoor climate, energy balance and energy efficiency. The thermal properties, the hourly loads for equipment, occupancy and lighting were set for the two-storey residential building situated in Baltic sea costal. Natural and mechanic ventilation was simulated and analyzed. The comparison of internal air overheating and energy consumption depending on the ventilation strategy was made. The results show that use of natural ventilation with window's opening is effective in case of large window area but in case of north oriented room with 50% window to wall ratio mechanic system is more efficient.

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Keywords: Thermal comfort; ventilation system; IDA-ICE; energy savings; building energy simulation

1. Introduction

Over the years the building sector is identified to be one of the most resource consuming areas in EU and Russia. For example, the construction and use of buildings in the EU account for about half of total final energy consumption (Report on Resource Efficiency Opportunities in The Building Sector 2014). Consuming significant amounts of non-renewable energy resources leads to their gradual disappearance, increasing complexity of their

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production, and as a result, it causes an increase in the acquisition cost. Besides the construction process is characterized by a large number of non-recyclable waste and harmful emissions of carbon dioxide into the atmosphere [1]. These factors make us think about reducing total energy costs and using renewable energy sources.
In many European countries the construction of buildings with low energy consumption is regulated and promoted at the national level even by limiting the heat consumption of the houses under construction to 60-70 kWh / (m^2 year) (Energy Performance of Buildings Directives 2010). In addition, there are green building standards which are dynamically used in practice for comprehensive assessing the full life cycle of the project on a number of criteria. The ultimate goal is to reduce the negative impact on the environment, create a comfortable environment for human's life, to control the consumption of energy and material resources effectively [2].

One of the main problems which can occur even to the buildings with good energy performance is summer overheating. In order to prevent this the house needs cooling system. In the EU according to the Energy Performance of Buildings Directive the goal is to reduce the energy consumption for cooling the building and at the same time to improve the indoor climate and to prevent overheating [3]. In Estonia during the building design process dynamic indoor temperature simulations are required to provide summer thermal comfort compliance verification certificate as a part of the EPC (Engineering, procurement and construction).

In Russia SP 50.13330.2012 is used for building energy performance evaluation which sets energy saving classes depending on their energy consumption for heating and ventilation. However, this set of rules does not give a comprehensive estimation of the project design, it's indoor air quality and cooling. Russian study highlights importance of correct energy design in unsteady environmental conditions [4].

A number of studies is devoted to investigating methods of energy saving and thermal comfort with the help of simulation in IDA Indoor Climate and Energy software (IDA-ICE) [5]. These results have shown simulation results accuracy and correlation with real measured parameters [6].

It is important to find the balance between building thermal insulation level, type of ventilation systems and thermal comfort [7]. For example, increasing the thickness of thermal insulation layer and using the mechanical ventilation system with heat recovery significantly decrease energy consumption by about 45%, but there is a risk of overheating, which is needed to be prevented [5]. Work done by D. Bajare shows that extra thermal mass, latent heat, can have a negative impact on overall thermal comfort due to limited possibility for heat discharge [8]. Thus PCM material are not taken into account in this research.

The purpose of this study is to investigate the influence of different ventilation strategies on annual energy consumption, indoor quality and thermal comfort of the residential building which is situated in Saint-Petersburg, Russia.

2. Methods

During the research, computational analyses were carried out using the IDA Indoor Climate and Energy (IDA-ICE) 4.7 software. IDA-ICE is a tool for dynamic simulation of thermal comfort, indoor air quality and energy consumption in buildings. Accuracy of this simulation tool was studied by Travesi J et al. who conducted an empirical validation study of models in IDA-ICE, related to the thermal behavior of buildings and HVAC equipment [9]. It was concluded that agreement between simulated and measured data was good and disagreements were similar to the measurement's uncertainty. IDA-ICE was validated according to the prEN 13791 by Kropf and Zweifel in 2001.

Analyzed building model was created using Autodesk Revit software and after it was transferred to the simulation software in the IFC format.

The method proposed for the study is the analysis of the building model realized in the energy simulation software. The following parameters are investigated: annual energy consumption (total, heating, cooling) and thermal comfort depending on the chosen system of ventilation which are presented in Table 1.

Table 1. Types of ventilation system

TYPE OF VENTILATION SYSTEM	№	NAME OF VENTILATION SYSTEM IN IDA-	DESCRIPTION	INFILTRATION SET IN IDA-ICE