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ROLE OF VENTILATION IN IMPROVING ENERGY EFFICIENCY IN BUILDIGS

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Abstract

Heat recovery ventilation (HRV) - is a way to reduce heat consumption in buildings by heating up the incoming cold outdoor air with warm indoor air in a specifically designed airflow exchanger. In a building where the heat consumption design is planned to be below 50 kWh/m2 per year, it is practically unachievable with natural ventilation while providing LBN 231-03 provisions for human-friendly micro-climate. Research objective: To demonstrate efficiency of the heat recovery ventilation system that could develop further recommendations for decision-makers, incorporating them to be a mandatory requirement in the next high-efficiency renovation projects. At the moment in Latvia there are no regulations, which would define ventilation as a mandatory requirement for building renovation process. However, in 06.12.2012., Latvia adopted article 5 of "Building Energy Efficiency Law", which sets out the requirements that must be followed by a designer when renovating, reconstructing or planning new buildings. Research bases: renovated buildings in Liepaja with European Structural Fund and Climate Change Financial Instrument aid, where heat recovery ventilation is installed. Research objectives: To compare two renovated municipal buildings where heat recovery ventilation systems are installed, by their specific heat consumption (kWh/m2 per year). Research methods: literature analysis, interviews, statistical data analysis, statistical data processing. Result of the research: to develop recommendations for decision-makers about including heat recovery ventilation in the list of minimum renovation requirements to be eligible for the European Structural Fund support.

Keywords: *heat recovery, recuperation, CO2 reduction*

1. Introduction

As a result of ever-increasing energy costs there is a need for innovation that can help save financial and natural resources. About a third of the consumed heat amount in buildings is lost due to drafts, so to reduce the cost of heat people began to think about pressurizing buildings - renovations. [11] Building thermal insulation program in Latvia has been operating since 2005. Liepaja is actively engaged in this process, and by May 1, 2013, 162 buildings were renovated. [7th] However, the analysis revealed a number of significant weaknesses in project implementation quality. The main weakness is that ventilation is in the list for carrying out the renovation project only as a supported activity, so it is not a mandatory requirement and is rarely planned in other projects. [3]

To find out why this activity is rarely included into the renovation projects authors interviewed Janis Roga, the senior region brigade officer of Kurzeme National Fire and Rescue Service on July 24, 2013. [5]

From the answers obtained in the interview, it can be concluded that people in Latvia are aware of the ventilation's necessity, but there is insufficient information thereof. The most significant error associated with inaccuracies in the projects is incorrectly calculated air exchange amount. Ventilation system in Latvia is put into service with reception / delivery act. The amount of air exchange in Latvian buildings is regulated by Latvian construction standards (LBN) 211-08 "Multi-storey residential buildings." The absolute minimum of fresh air in Latvia is determined by LBN 231-03 "Construction of residential and public buildings heating and ventilation", and is 15 m^3 / h per person. [8] A building manager in Latvia is responsible for the shared ductwork, but each individual apartment channel management is the responsibility of the apartment owner. Ventilation system inspection is being monitored by the building manager, once every two years, but the new fire safety rules will require it to be taken annually (not yet accepted, known). [8]

Meanwhile, when renovating old houses and building new ones, they are improved with sealed, air-tight windows and doors; insulation and condensation barrier improvements are put in place, upgraded facade finish and slot openings sealed with tight material are to ensure density of buildings and thermal stability. New projects anticipated sealing of houses and builders got to know new materials to meet upcoming customer requirements. Eventually, buildings became more efficient, although people in these buildings began to feel uncomfortable, because healthy microclimate did not develop there. [8]

Draughts, which were sealed, played significant role in house ecosystem, they provided fresh air and at the same time removed the polluted air. Ventilation system construction became topical issue in "sealed" buildings. Further on, authors will evaluate necessity of ventilation in buildings and compare different types of ventilation systems.

2. Ventilation necessity

There are three main reasons why buildings should be ventilated:

1. Provision of sufficient amount of air to breathe. If the building is air-permeable, than air supply to such building is not a problem. Currently, the amount of such buildings is small, but some of the new block (modular) design provides extremely high air tightness, which raises concerns that natural ventilation is unable to perform its duties.
2. A possibility to cool down the housing during the summer.

Given the intended use of these houses, the local climate and the high cost of refrigeration, cooling is not being addressed as very important. A similar situation is also observed in the commercial sector, opening a window in the office is considered to be justified. High-efficiency air-conditioning systems are used only in rare cases due to high cost for acquisition and integration thereof, but it is very common around the world, especially in apartment buildings, for instance, in the Mediterranean, the U.S., etc.

3. Provision of air pollution output and reduction of concentration of pollutants in the room. From all indoor air pollution types, the most significant is water vapour and carbon dioxide output, but there are other components that are no way less important. [4]

Underestimating ventilations necessity may cause a variety of human health and wellness-related problems, as well as building maintenance problems.

3. Air exchange necessity

Problems with ventilation do not appear only in already renovated buildings, but also in new buildings. According to the energy efficiency requirements for buildings, they're required to be airtight, so air infiltration through the building structural elements is nonexistent, but effective ventilation by opening windows is financially unviable due to heat loss. [12]

Life without adequate ventilation in modern sealed homes creates humidity and pollution. Humidity occurs while cooking food, washing clothes, bathing and breathing. If the room is too humid, water condenses on the windows and it can lead towards structural degradation. High humidity area is a good place for mould, mildew, fungi, dust mites and bacteria. Mould spores and dust easily travel through the air and freely circulate through housing, potentially increasing the number of symptoms and allergic reactions. [10]

Hereafter, the authors performed a comparison of the three ventilation systems.

3.1 Natural ventilation

In the case of natural ventilation, air intake and exhaust from the room is going through its windows, doors, opening air shafts, as well as through ventilation ducts in the walls. [14] Air exchange is a result of outdoor and indoor temperature, pressure and wind exposure difference (see Figure 1). [13]

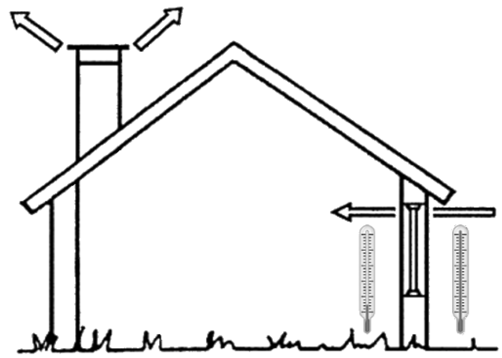

Figure 1. Natural ventilation principal scheme in a vacuum-sealed building

3.2 Mechanical ventilation without heat recovery

A mechanical ventilation system moves air by using fans. Compared to natural ventilation, mechanical ventilation has some advantages: a virtually unlimited work range, productivity is not dependent on the weather; you can change the supply air parameters, organize appropriate air flow and leakage in certain areas and clean the air before conducting into the premises and into the atmosphere.

Disadvantages may be addressed as a sound insulation necessity, because of the accelerated air flow circulation rate in ducts, and the need to consume electrical energy for moving the air around the ducts (see Figure 2). [1]

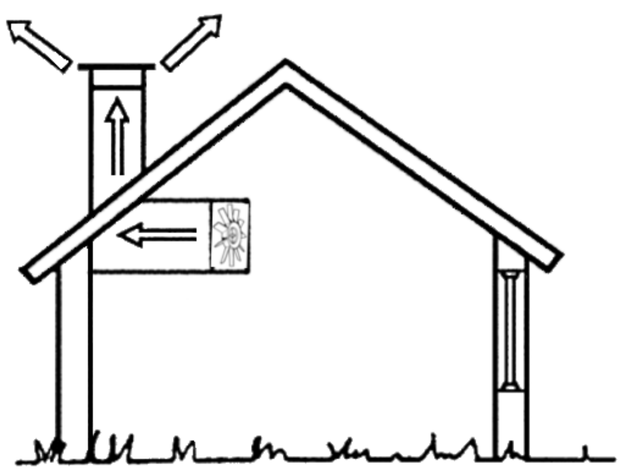

Figure 2. Mechanical ventilation principal scheme

3.3 Heat recovery ventilation (HRV)

Heat recovery ventilation (HRV) is in some ways similar to a balanced ventilation system, it uses the extracted warm air to heat the incoming cold air flow, without both streams being mixed. Generally, such heat transfer unit consists of two fans:

1. *draws air outside from the premise;*

2. *lets in the fresh air.*

What makes HRV unique is the heat exchange unit. The heat exchange unit employs a counter-flow heat exchanger (counter current heat exchange) between the inbound and outbound air flow, in the same manner as does the radiator in your vehicle; conveying the heat from the engine to the external environment. The HRV consists of a narrow channel changing series through which air flows enter and leave. The incoming cool air flowing from the outside into the house is being heated by the warm air flow, but the air flows do not mix (see Figure 3). [11]

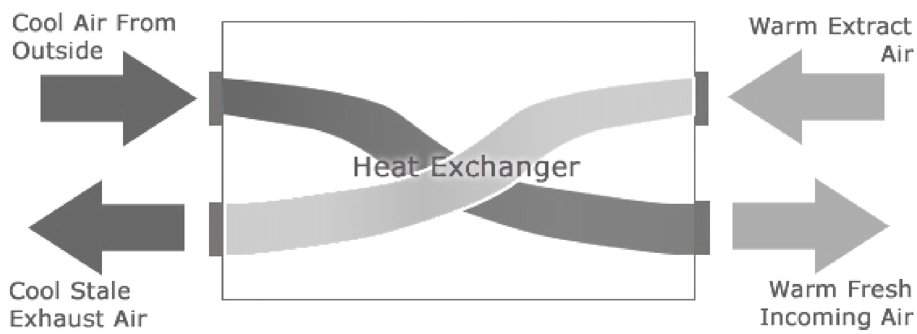

Figure 3. Heat exchanger unit activity diagram

HRV systems can be grouped in three categories, depending on what kind of heat exchanger unit is being used:

1. <u>Rotary heat exchanger (Class A - efficiency 85%).</u>

The rotary heat exchanger is installed in the section of the supply-exhaust AHUs. Ventilations rotor unit is being mounted on bearings, consisting of flat and corrugated aluminium strips that make up the air flow channels. Warm exhaust air heats up aluminium tape, and while the rotor is turning this heat is returned to the air intake system to heat up the cool air (see Figure 4). Variable rotor speed drive system allows for maximum heat efficiency and energy recovery level adjustment. Efficiency - up to 85% of heat return. Air exchange sector minimizes dirty (exhaust)

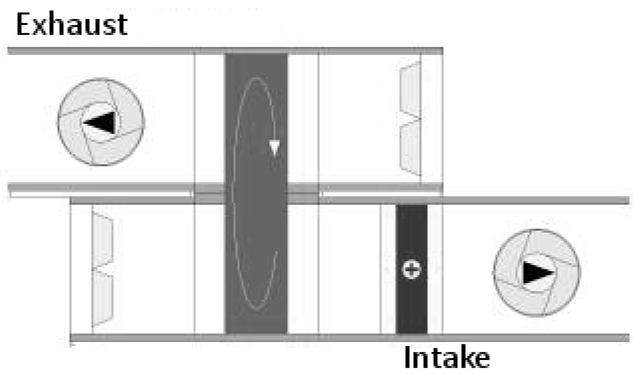

Figure 4. Rotary heat exchanger activity diagram

air leakage and mixing with the fresh air supply. In addition, bristle seal and cutting line is deployed to reduce air leakage around the rotor. Air flooding is possible within 2-5% range. [9]

2. Cross (plate type) heat exchanger (Class B - Effectiveness of up to 70%).

Cross-flow heat exchanger is the most popular type of HRV because its cost is relatively small and it can be installed in a simple individual ventilation system component. It is also fitted with an inlet section - exhaust air treatment units. Cross-flow heat exchanger consists of cross-shaped aluminium plates, separated by transverse alternating air flow isolated supply and exhaust streams (see Figure 5). Exhaust air heats up this plate, which in turn gives the heat to the incoming air. Efficiency - up to 70% of heat return. These type of HRV's have a very high air supply and exhaust removal efficiency - up to 99.9%. [9]

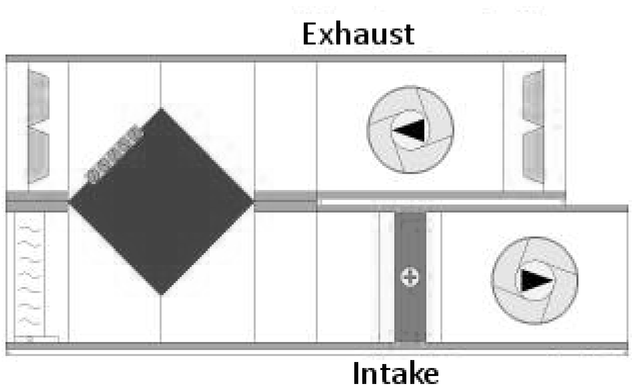

Figure 5. Cross (plate type) heat exchanger activity diagram

3. Glycol (water) system (Class C - efficiency 45%).

Glycolic air recovery system is used when it is necessary to separate (even long distance) the supply and exhaust air treatment equipment. One heat exchange unit is located in the exhaust air stream (cooler), which receives heat from warm rooms - outgoing air flow goes through a conducting liquid or heat agent (water and glycol solution) and it transmits heat to the heat exchanger, which is installed in the fresh supply air stream (see Figure 6). Glycol system also requires installation of a fluid circulation pump to transfer fluid from one heat exchanger to another. These systems have the lowest recovery efficiency - up to 45% of heat return. Supply and exhaust air flow is 100% separated. [9]

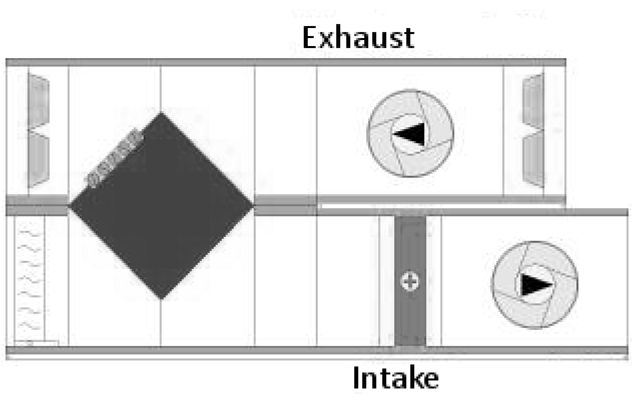

Figure 6. Cross (plate type) heat exchanger activity diagram

Whatever type of HRV system you choose, it is also necessary to set the incoming air heater (capacity depends on the type of recovery, potential temperature differences – the outside air / space exchange rate), which in the cold period will reheat the incoming air to the desired temperature (usually room temperature). There are certain exceptions - low productivity ventilation units, which are fitted with a rotating heat exchanger, they tend to be without an extra heater, but it should be noted that at low outdoor temperatures this equipment will not be able to heat up outdoor air to room temperature. And finally, it should be remembered that the supply ventilation with or without recuperation, with a powerful or less powerful heater is not designed for heating. Air heating is necessary to prevent heat losses that occur from ventilating out smothered air inside the room, to prevent condensation, etc., but the heat exchanger is necessary to make use of the heat and to reduce operating costs. [9]

Further on, to find out the real situation and to assess the effectiveness of HRV authors examine the situation in Liepaja. Liepaja was chosen because authors have a good cooperation with local government and it is easy to look at the studied local government buildings: Liepaja Christian preschool (KPII) and Liepaja A. Pushkin secondary school (2.VSK). These buildings were selected basing on the renovation results in energy consumption, as shown in Table No. 1. Both buildings have a class A rotary heat exchanger installed, which has the highest efficiency. The projected efficiency for these buildings is 76-79%.

Table 1. Heat consumption for KPII and 2.VSK 2007 -2012[2]

Local government institution	Year	The average historical consumption (MWh)	Area (m^2)	The average historical consumption (kWh/m^2)	Consumption (MWh)	Consumption (kWh/m^2)	Economy
KPII	2007-2010	468	1867	250,67			
	2011				182	97,48	61%
	2012				207	110,87	56%
	2013				203	108,73	57%
2.VSK	2007-2010	713	9961	71,58			
	2011				491	49,29	31%
	2012				508	51,00	29%
	2013				547	54,91	23%

Heat consumption savings are shown in percentages as how specific consumption stands up against the historic consumption and is being calculated as follows:

1. The average historical energy consumption by subtracting the heat consumed for the year.

2. The resulting difference further divided by the average historical heat demand and multiplied by 100% we gain savings.

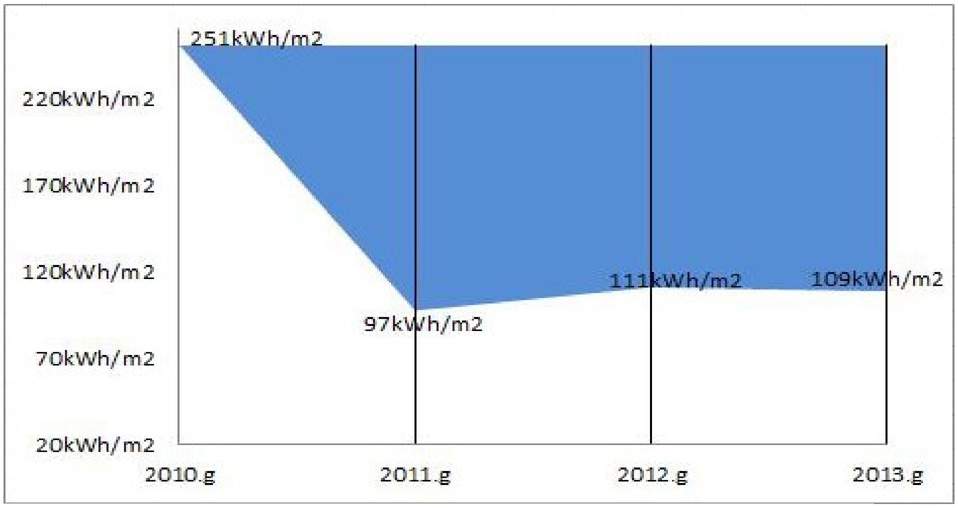

Chart 1. KPII heat consumption since the renovation in 2010

eclined by 61% from 251kWh/m2 to 182 kWh/m2, instead of the planned 76%. This can be explained by irregular equipment operation, because the equipment design and installation of the building was not adapted to the appropriate volume and load parameters, resulting in a significant increase in power consumption. In the coming years, a slight increase in thermal energy consumption is observed, but it can be explained by the lower average outdoor temperature during the heating season.

In the 2.VSK HRV is installed in only 1/3 of the building, so the heat energy saving percentage is

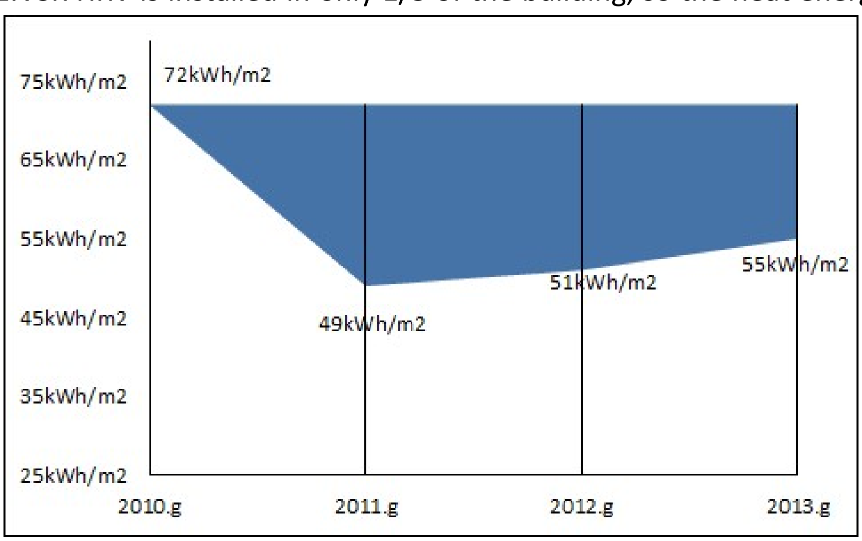

Chart 2. 2.VSK heat consumption since the renovation in 2010

lower. If the HRV was installed throughout the building, savings would increase. Instead of the projected 76% efficiency, only 31% is achieved, since HRV is installed only in one part of the building. This part cannot be considered as a separate unit in the building as a other energy efficiency measures were applied, as well as the HRV is operated briefly but regularly.

Heat consumption per 1 m^2 differs significantly:

2.VSK has it around 50 kWh/m2 per year and increasing outdoor temperature in 2012 and 2013, increases heat consumption only by 2-5 kWh/m2 per year or about 4-10%.

KPII savings are greater than half of the 2.VSK, but the consumed heat amount per 1 m2 is about 48 kWh/m^2 per year and it is higher than it was for 2.VSK in 2011. Outdoor temperature increases by the same number of degrees in 2012 and 2013, the heat consumption increased by 25 kWh/m^2 or 26%.

Therefore, authors conclude:

1. building capacity is directly related to heat savings - the bigger is the building volume, the higher are total heat savings;

2. lack of qualified professionals who can make a full customization facilities for each individual building;

3. a specialist would be desirable, such as energy supervisor that would be in charge of buildings energy stability.

Authors recommend responsible decision-makers to consider and incorporate author's proposals for minimum requirements in order to get funding from the European Structural Funds projects etc., to improve buildings energy efficiency. Hereafter, authors will explore the HRV system stability improvement opportunities for both local and multi-apartment buildings.

4. Conclusion

Conducting this research, authors have concluded that:

1. HRV is not a mandatory requirement for heat insulation measure improvement in blocks apartments;

2. There are no normative acts in Latvia that determine if a mechanical ventilation system cleaning is necessary.

3. Each building requires an individual approach to select the most appropriate solution for the ventilation system and the constructed system regulatory framework;

4. Local government buildings in Liepaja have trained personnel within, thus ventilation system maintenance in efficient and economic operation mode is possible.

5. HRV operation in apartment buildings may not be effective due to the actions of individual persons, which would require the development of building energy efficiency, materials (maintenance instructions).

Authors have developed the following proposals:

1. In order to qualify for the European Structural Fund support to increase building energy efficiency, it is necessary to include public building ventilation as a mandatory requirement for heat insulation improvement measures;

2. In order to ensure the building energy efficiency sustainability, each building requires an energy supervisor, that would be in charge of heating, water supply, ventilation, electricity and waste management;

3. It is recommended to develop natural and HRV user manuals for apartment house residents usage in order to inform how to properly ventilate with minimum heat loss and to provide optimum microclimate during the heating season;

4. It is necessary to continue exploring energy efficiency and more efficient HRV application in apartment buildings.

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