



## Capacity of Building Energy Efficiency in Liepaja

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Ventilation with recuperation is a means of reducing heat consumption per square meter below 50 (kWh/m<sup>2</sup>) in Latvia through proper project design and trained personnel.

The aim of this research is to show necessity for a ventilation system with recuperation. This research would further permit preparing recommendations for responsible decision-makers. There are no regulatory enactments that would provide ventilations indispensability during the renovation process in Latvia. The recommendation for ventilation with recuperation should be incorporated during the renovation as a mandatory requirement in Latvia.

Renovated buildings with European co-financing in Liepaja city have been used as a research basis. Different renovated building groups are compared: those without ventilation, with ventilation, ventilation with recuperation. Each one of these building groups will have more than one object. The obtained data will be heat consumption per square meter (kWh/m<sup>2</sup>). It is not possible to achieve good results with badly designed projects as well as with non-trained personnel, therefore this system is quite often either not used or ignored. Ventilation with recuperation is to be a mandatory requirement in renovated buildings.

During the research it has been realized that the available information is not sufficient to compare renovation processes in other countries of comparable climatic conditions.

It would be preferable to meet researchers working on similar themes to be able to share mutual experience and to promote co-operation in this field.

*Keywords: ventilation, heat recovery, recuperation, CO<sub>2</sub> reduction.*

### 1. Introduction

Heat recovery ventilation (HRV) is a means of reducing 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 is planned to be below 50 kWh/m<sup>2</sup> per year, it is practically unachievable with natural ventilation, while providing LBN 231-03 provisions for human-friendly micro-climate. (Natural Resources Canada's Office of Energy Efficiency, 2012)

**Research objective:** To demonstrate efficiency of the heat recovery ventilation system that could develop further recommendations for decision-makers, incorporating them as 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, on December 6, 2012 Latvia adopted Article 5 of the "Building Energy Efficiency Law", which sets out the requirements that must be followed by a designer when renovating, reconstructing or planning new buildings.

**Research basis:** renovated buildings in Liepaja with the European Structural Funds and the Climate Change Financial Instrument aid, where heat recovery ventilation is installed.

### 2. Methods

#### 2.1. Study area

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, therefore to reduce the cost of heat people began to think about pressurizing buildings - renovations. (Namsons, 2013). In Latvia the building thermal insulation program has been operating since 2005. Liepāja is actively engaged in this process, and by May 1, 2013, 162 buildings were renovated. (Tidens, 2013b) However, the analysis has revealed a number of significant weaknesses in the project implementation quality. The main weakness is that in the renovation project ventilation is only as a supporting activity, thus it is not a mandatory requirement and is rarely planned in other projects. (LIAA, 2013)

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

From the answers obtained it can be concluded that people in Latvia are aware of the need of ventilation, but the information is insufficient. The most significant error associated with inaccuracies in the projects is an incorrectly calculated air exchange amount. In Latvia the ventilation system is put into service with the reception / delivery act. The amount of air exchange in Latvian buildings is regulated by the Latvian construction standards (LBN) 211-08 "Multi-storey residential buildings." The absolute minimum of fresh air is determined by LBN 231-03 "Construction of residential and public buildings heating and ventilation", and is 15 m<sup>3</sup>/h per person. (Roga, 2013). A building manager is responsible for the shared ductwork, but each individual apartment channel management is 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 done annually (not yet accepted) (Roga, 2013)

Meanwhile, when renovating old houses and building new ones, they are improved with sealed, airtight 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 anticipate sealing of houses, whereas builders get to know new materials to meet upcoming customer requirements. Eventually, buildings have become more efficient, although people in them feel themselves uncomfortable, because healthy microclimate does not develop there (Roga, 2013).

Draughts, which are sealed, play significant role in the house ecosystem, they provide fresh air and at the same time remove the polluted air. Ventilation system construction has become a topical issue in "sealed" buildings.

**Research objectives:** to compare two renovated municipal buildings where heat recovery ventilation systems are installed, by their specific heat consumption (kWh/m<sup>2</sup> per year).

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**Research methods:** literature analysis, interviews, statistical data analysis, statistical data processing.

**Result of the research:** developed 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.

### 3. Results and discussion

#### 3.1. 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, then 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 buildings, 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, where 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.A., etc.
3. Provision of air pollution output and reduction of concentration of pollutants in the room. Out of 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 (Roger, 2005).

Underestimation of ventilation necessity may cause a variety of human health, wellness-related, as well as building maintenance problems.

#### 3.2. Air exchange necessity

Problems connected with ventilation do not appear only in already renovated buildings, they also do in new buildings. According to the energy efficiency requirements for buildings, they are required to be airtight, thus air infiltration through the building structural elements is nonexistent, while effective ventilation by opening windows is financially not viable due to heat loss (Katins O., 2013).

In modern sealed homes life without adequate ventilation 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 (Klenk, 2000).

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

### 3.3. Comparison of the three ventilation systems

#### 3.3.1. 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 (PME 1984). Air exchange is a result of outdoor and indoor temperature, pressure, and wind exposure difference (see Figure 1) (Plavenieks, 2008).



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

#### 3.3.2. 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, where 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) (A. Kreslins, 1995).

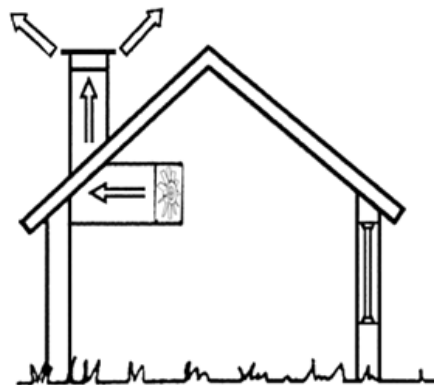


Fig. 2. Mechanical ventilation principal scheme

#### 3.3.3. 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, which:

1. draws air outside from the premises;
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 environment. HRV consists of a narrow channel changing series through which the air flows enter and leave. The incoming cool air flowing from the outside into the building is being heated by the warm air flow, but the air flows do not mix (see Figure 3) (Namsons, 2013; Natural Resources Canada's Office of Energy Efficiency, 2012).

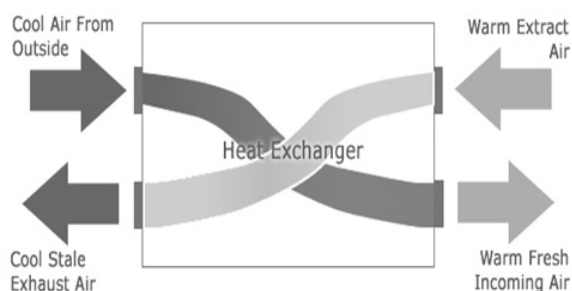


Fig. 3. Heat exchanger unit activity diagram

HRV systems can be grouped into three categories, depending on the kind of a heat exchanger unit being used:

1. Rotary heat exchanger (Class A - efficiency 85%).

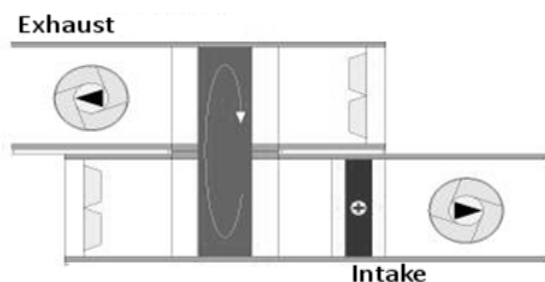


Fig. 4. Rotary heat exchanger activity diagram

A rotary heat exchanger is installed in the section of supply-exhaust AHUs. A ventilation 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 the 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). The variable rotor speed drive system allows for maximum heat efficiency and energy recovery level adjustment. Efficiency is up to 85% of heat return. The air exchange sector minimizes dirty (exhaust) air leakage and mixes it with the fresh air supply. In addition, a bristle seal and cutting line are deployed to reduce air leakage around the rotor. Air flooding is possible within 2-5% range (Klimats24 2013).

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

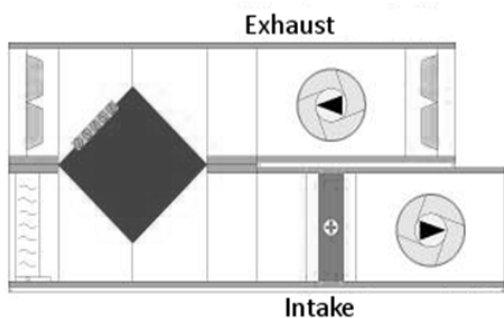


Fig. 5. Cross (plate type) heat exchanger activity diagram

A 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. The 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 is up to 70% of heat return. These types of HRVs have a very high air supply and exhaust removal efficiency is up to 99.9% (Klimats24, 2013).

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

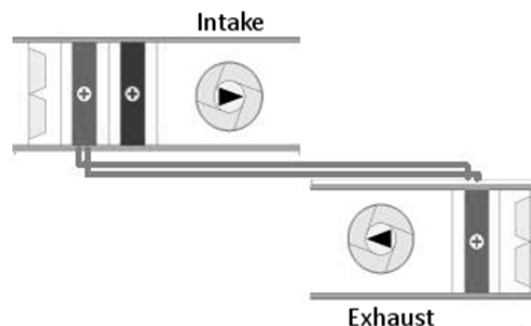


Fig. 6. Diagram of glycol (water) heat exchanger activity

Glycolic air recovery system is used when it is necessary to separate (even within 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. The supply and exhaust air flow is 100% separated (Klimats24, 2013).

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 the room temperature). There are certain exceptions, namely, 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 the 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 (Klimats24, 2013; Natural Resources Canada's Office of Energy Efficiency, 2012).

#### 3.4. Results of assessing the effectiveness of HRV in Liepaja

Liepaja was chosen because the authors have a good cooperation with the local government and it is easy to study the local government buildings: Liepaja Christian preschool (KPII) and Liepaja A. Pushkin secondary school (2.VSK). These buildings have been under complex renovation, meaning that “complex renovation” is energy efficiency measure set, where it

can slightly differ on plinth and hot water supply, ventilation system, as well as replaced window proportion:

1. Upper floor covering, buildings plinth, buildings foundation, basement covering, and comprehensive external wall insulation regarding Latvian construction standards LBN 002-01 demands;
2. Heat providing system renovation, equipping all radiators in the building with thermostatic valves and individual billing system regarding a consumed heat amount;
3. Hot water system renovation;
4. Windows and external door replacement;

5. Ventilation system renovation without heat recovery (Online data base, 15). Liepaja Christian preschool (KPII) and Liepaja A. Pushkin secondary school (2.VSK) have ventilation with heat recovery.

These buildings have been selected on the base of the renovation results in energy consumption, as shown in Table No. 1. Both buildings have a class A rotary heat exchanger installed, whose efficiency is the highest. The projected efficiency for these buildings is 76-79%. Data are gathered from those of the accountancy and the interviews with buildings energy supervisors.

Table 1. Heat consumption for KPII and 2.VSK 2007 -2012 (Tidens 2013a)

Local government institution	Year	The average historical consumption, MWh	Area, m <sup>2</sup>	The average historical consumption, kWh/m <sup>2</sup>	Consumption, MWh	Consumption, kWh/m <sup>2</sup>	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 is obtained by subtracting the heat consumed for the year.
2. The resulting difference is further divided by the average historical heat demand and multiplied by 100% and savings are gained.



Fig. 7. KPII heat consumption since the renovation in 2010

After renovating KPII, in the next season its heat consumption declined by 61% from 251kWh/m<sup>2</sup> to 182 kWh/m<sup>2</sup>, instead of planned 76%. This can be explained by irregular equipment operation, because the equipment design and installation of the building were 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.

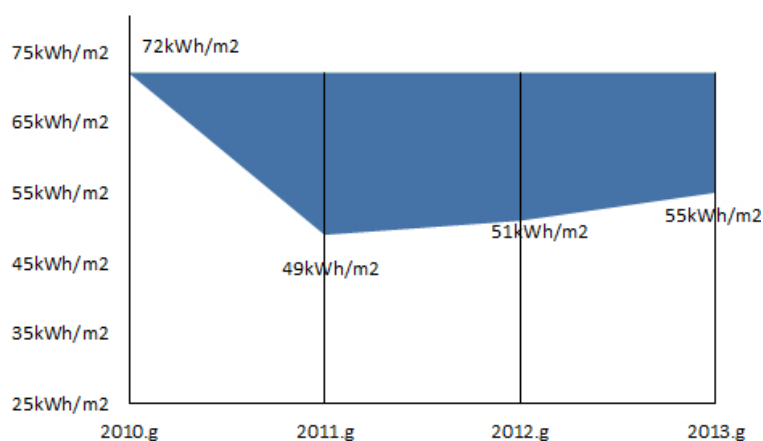


Fig. 8. 2.VSK heat consumption since the renovation in 2010

In the 2.VSK HRV is installed in only 1/3 of the building, therefore the heat energy saving percentage is lower. If HRV were 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 the other energy efficiency measures were applied, and HRV is operated briefly but regularly.

Heat consumption per 1 m<sup>2</sup> differs significantly:

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

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

Therefore, authors conclude that:

1. Building capacity is directly related to heat savings - the bigger volume of the building, the higher total heat savings;
2. There is lack of qualified professionals who can make full customization facilities for each individual building;
3. A specialist is desirable, such as energy supervisor, who would be in charge of building energy stability.

#### 4. Conclusions

Authors recommend responsible decision-makers to consider and incorporate their proposals of minimal requirements for applying for the funding from the European Structural Funds projects to improve the building energy efficiency. Hereafter, authors will explore possibilities of HRV system stability improvement for both houses and apartment buildings.

Having done this research authors have concluded that:

1. HRV is not a mandatory requirement for heat insulation measure improvement in apartment buildings;
2. In Latvia there are no normative acts that determine whether cleaning of mechanical ventilation system 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 the personnel within, thus efficient and economic maintenance of ventilation systems 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. To qualify for the European Structural Fund support to increase building energy efficiency, public building ventilation is to be included as a mandatory requirement for heat insulation improvement.
2. To ensure the building energy efficiency sustainability, each building requires an energy supervisor to be in charge of heating, water supply, ventilation, electricity, and waste management.
3. Natural and HRV user manuals for apartment building residents should be developed to inform them how to ventilate properly with minimum heat losses and how to provide the optimum microclimate during the heating season.
4. Studies on energy efficiency and more efficient HRV application to apartment buildings are to be continued.

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## Pastatų energijos naudojimo efektyvumo Liepojoje vertinimas

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*(gauta 2013 m. gruodžio mėn.; atiduota spaudai 2014 m. kovo mėn.)*

Vėdinimas su rekuperacija yra pagrindinis būdas, kaip Latvijoje galima būtų sumažinti šilumos sunaudojimą vienam kvadratiniam metrui daugiau negu 50 kWh/m<sup>2</sup>. Tai atlikti galima rengiant atitinkamus projektus ir tinkamai išmokus personalą. Tyrimo tikslas – įrodyti vėdinimo sistemos su rekuperacija reikalingumą ir naudingumą. Šis tyrimas taip pat galėtų būti kaip pagrindas rengiant ir teikiant rekomendacijas valdančiosioms institucijoms ir joms priimant atitinkamus su tuo susijusius sprendimus. Latvijoje nėra norminių aktų, nustatančių vėdinimo sistemų būtinumą ar reikalingumą atliekant pastatų renovaciją. Atliekant tyrimą buvo bendrai susitarta, kad vėdinimas su rekuperacija turėtų būti įtrauktas į teisės aktus kaip būtinas reikalavimas renovuojant namus.

Tyrimė įvertinti Europos Sąjungos fondų finansuoti naujai renovuoti pastatai, esantys Liepojoje. Atliekant tyrimą buvo palygintos įvairios rekonstruotos pastatų grupės: be vėdinimo, su ventiliacija, su vėdinimu, sujungtu su rekuperacija. Buvo įvertintas daugiau nei po vienas kiekvienos grupės objektas. Pateikiami gauti šilumos sunaudojimo vienam kvadratiniam metrui (kWh/m<sup>2</sup>) duomenys. Neįmanoma pasiekti gerų rezultatų blogai parengus projektus, taip pat neišmokus personalo, todėl ši vėdinimo sistema yra dažnai nepanaudojama arba yra tiesiog ignoruojamas jos poreikis.

Atliekant tyrimą buvo susidurta su turimos informacijos nepakankamumu ir reikiamos neprieinamumu siekiant atlikti išsamų renovacijos procesų palyginimą su kitomis šalimis, kuriose panašios klimato sąlygos.