The 9th International Conference "ENVIRONMENTAL ENGINEERING"
22–23 May 2014, Vilnius, Lithuania
SELECTED PAPERS
eISSN 2029-7092 / eISBN 978-609-457-640-9
Available online at *http://enviro.vgtu.lt*

Section: Energy for Buildings

Energy Performance Contracting for Multi-family Residential Buildings in Latvia. First Steps

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Abstract

Energy efficiency of buildings has become a significant issue in Latvia and across Europe. More than a half (by heated area) of Latvian housing stock consists of multi-family buildings. 63% of buildings are panel houses built during the Soviet era when no one thought about energy efficiency issue and energy resources was very cheap. Today, energy prices are increasing, the EU sets targets to increase energy efficiency, reduce of GHG emissions and promote the use of renewables. Building renovation is a sustainable approach for Latvia to achieve these objectives because the housing sector is a huge consumer of energy – 40% of total energy consumption. A great way to promote such renovations is to use Energy Performance Contracting (EPC) concept. EPC is a legal contract between the beneficiary and the provider (an ESCO) of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (works, supplies or services) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement.

In Latvia, EPC+ contracting has been recently applied to the comprehensive renovation of multi-family residential buildings. A study is being carried out on 12 projects, which have been implemented over the last 5 years. Measurements and calculations have been carried out. Based on 2013 data, on average space heating consumption of fully completed buildings is down to 77 kWh/(m^2 a) and network circulation losses is down to 4.5 kWh/(m^2 a), meaning a combined figure of 81.5 kWh/(m^2 a). The energy savings of the renovated building stock are calculated at 55%.

On average space heating consumption of buildings partly completed is expected to be down to 72 kWh/(m^2 a) and network circulation losses down to 2.4 kWh/(m^2 a), meaning a combined figure of 74.4 kWh/(m^2 a). The energy savings of the renovated building stock are calculated at 65%.

Keywords: energy efficiency; Energy Performance Contracting; multi-family buildings.

Nomenclature

COP	coefficient of performance
EPC	Energy Performance Contracting
ERDF	European Regional Development Fund
ESCO	Energy service company
EU	European Union
GHG	Greenhouse gas
VAT	Value added tax

1. Introduction

Latvian housing stock consumes up to 40% of total energy consumption of Latvia. Energy efficiency in housing area has become a very important issue in Latvia and across Europe. Heating prices will increase in future significantly, while the physical condition of multi-family buildings, which were built in Soviet era, will become worse. Therefore inhabitants will have to pay more and more for heating and maintenance.

Directive 2012/27/EU requirements for EU Member States are 3% of public sector buildings have to be renovated every year starting with January 2014 as well as energy distributors and/or energy sales companies have to reach 1.5% savings in

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http://dx.doi.org/10.3846/enviro.2014.279

end-user sector every year [1]. Reduction of GHG emissions of 20% and 20% increase in energy efficiency are targets set by Europe's growth strategy "Europe 2020" in climate change and energy sustainability field [2].

Building comprehensive renovation is a sustainable approach but EPC is a tool how to avoid from issues mentioned and reach targets listed above and to preserve dwellings through energy efficiency measures for next generations.

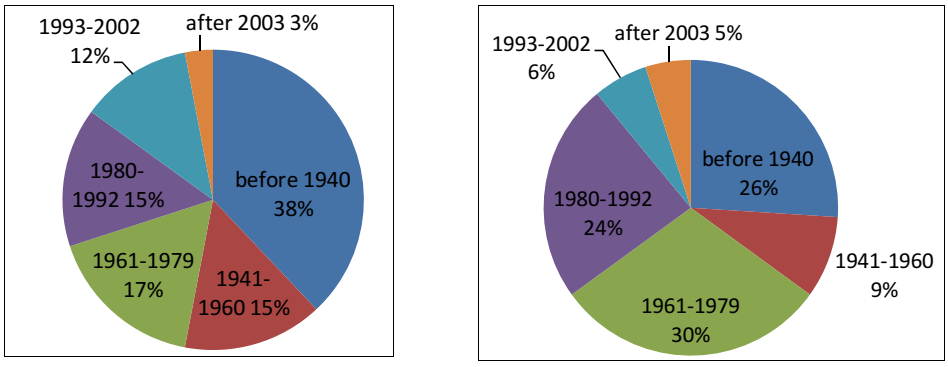
EPC has been used throughout Europe for upgrading and renovating public buildings and improving energy performance in industry and commercial sector [3, 4].

However, multi-family residential buildings were addressed seldom by this business model. A study carried out by Edward Vine [4] results showed that many ESCOs did not target the residential sector. In Czech Republic ESCOs were targeted 50% of their activity in the municipal sector, Italy and Lithuania respectively 90% and 100%. In Finland EPCs were provided in the industrial sector 60% of ESCOs' activities. Nine ESCOs targeted 10–40% of their activity in the commercial sector. EPCs were provided in residential sector in only 7 countries of 15 not exceeding 10% of ESCOs activities in this sector.

The vast majority of these existing multi-family buildings in Latvia, and Post-Soviet Countries in general, has not undergone any major energy conservation improvements and has the same energy infrastructure as when they were built. This means an enormous energy savings potential.

1.1. Existing housing stock in Latvia

At the end of 2009 the total housing stock was 87 million m^2 heated area according to database of Central Statistical Bureau of Latvia, total heated area of multi-family buildings (three or more apartments) – 50.5 million m^2. Figure 1 represents distribution of multi-family buildings by construction years.



(a) (b)

Fig. 1. Multi-family building distribution by number (a) and by total area (b),
Total number of multi-family buildings-38.8 thousands.[source: database of the State Land Service]

Statistical data shows that 26% (by total area) of multi-family buildings were built before 1940 which most of cases are historical and law protected. Most of buildings (63%) were built in Soviet period when energy and heating was cheap and no one considered energy efficiency issues. In Latvia average normalized energy consumption for space heating is 180 kWh/(m^2 a). In the worst cases total specific energy consumption may reach up to 300 kWh/(m^2 a) Consumption is calculated on the heated area. The energy consumption can be reduced for space heating to 70 kWh/(m^2 a) when comprehensive renovation has done according to Regulations Regarding Latvian Construction Standard LBN 002-01 [5]. In 2014 there will be made changes in legislation with stricter regulation to improve thermal performance of renovated and new buildings.

The maintenance costs and inflation rate were analyzed for residential buildings in this paper. Figure 2 represents statistical data according to database of Central Statistical Bureau of Latvia. Sanitary and technical maintenance, management and service staff were taken into account in the maintenance costs.

At the beginning of 2000 and 2001 the maintenance costs were 15 Eurocents increasing 2.8 times till 2012. It shows how important is the comprehensive renovation of residential buildings. As it is seen in Figure 2 starting from 2006 Latvia experienced a very rapid growth and increasing of inflation. Then in 2008 a bubble burst occurred causing the economic crisis in Latvia. Maintenance costs came to their previous growth rate after two years.

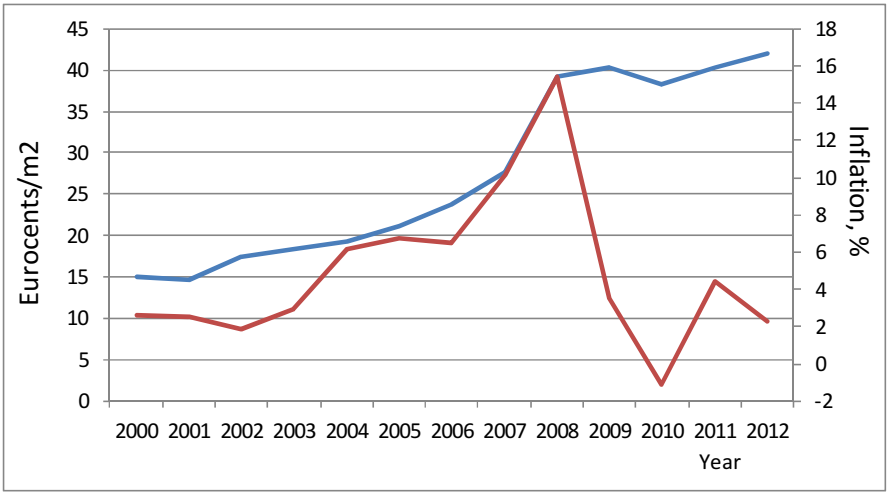


Fig. 2. Average maintenance costs of multi-family buildings and inflation rate

1.2. Renovation rate till 2013

The renovation of multi-family buildings in Latvia till 2009 was carried out mainly at the level of pilot projects, reaching 1–2% of buildings in total. From 2009 till summer of 2013 a small increase in the speed of multi-family building renovation was achieved thanks to resources of EU Structural funds. After all the projects launched during planning period 2009–2013 will be carried out, the amount of renovated buildings will reach only approximately 4% [6]. In this program a little more than 1200 buildings will be renovated with a support of subsidies. Gatis Zogla [7] has developed a model of system dynamics, combining seven policy support tools for renovation of multi-family buildings in Latvia. The results of the study showed that by using all the tools covered in the model that enhance energy efficiency, only 26.6% of Latvia`s First Energy Efficiency Action Plan`s goal (reduce by 2701 GWh in housing sector) would be reached.

The first multi-family building EPC project was commissioned in 2010 by RENESCO Ltd., the available ERDF co-financing was also attracted. In Latvia the implementation of ESCO principles in the market is hindered because of regulatory, administrative, structural and financial barriers. Only one company actively provides energy services in the housing sector [7]. Until the summer of 2013 nine EPC projects have been implemented and additional 11 signed and under development.

1.3. EPC market in Latvia

EPC is a legal contract between the beneficiary and the provider (an ESCO) of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings [1].

EPC can provide substantial energy savings in Latvia using the principle of repaying the investments directly from the saved energy costs. EPC allows facility owners and managers to upgrade ageing and inefficient assets while recovering capital required for the upgrade directly from the energy savings guaranteed by the ESCO. The ESCO takes the technical risk and guarantees the savings.

However, while there has been slight growth in Latvian EPC market over the last three years, it can be considered not well developed in Latvia. Angelica Marino *et al.* [8], D. Blumberga *et al*. [9] and K.Zvaigznitis *et al.* [10] provide extensive and in-depth overview about main obstacles that hinder the development of EPC market in Latvia. Numerous obstacles were identified in studies, for example, mistrust from clients, public procurement rules, complexity of the concept, lack of support from government, lack of funding.

Claudio Rochas [11] has summed up recommendations, provided specific solutions how to increase transparency and trustworthiness of EPC market development.

2. Materials and methods for comprehensive building renovation with energy performance contracting

Housing sector in Post-Soviet Countries, including Latvia, considerably differs from Western European housing sector. In Latvia there is inherited a large housing stock, unfortunately it`s thermal performance does not comply with modern energy efficiency requirements. In addition, the technical condition of buildings deteriorates and the exploitation phase is coming to an end. Despite mentioned challenges, these buildings provide home for hundreds of thousands of people and highly valued infrastructure. Because these Soviet time multi-family buildings is such an asset, it is an obligation of Latvia and also other European countries to support building renovation, putting all the effort and investing accessible resources.

EPC+ is a new and effective tool in multi-family building renovations, it was created because usually people lack financial resources and knowledge to renovate housing on their own. Why EPC+? Typically, EPC provides 5–10 years contract [12], during the period only energy efficiency activities are implemented to achieve planned energy savings in the object (outdoor and indoor lighting, boiler houses, production buildings, schools, hospitals). But renovation of multi-family building must be more that just energy efficiency activities, attention must be paid also to the social aspect – clean and safe environment. Therefore EPC+ proposes comprehensive renovation of multi-family buildings in Latvia and the rest of Eastern Europe. Additional activities generate additional costs, that is why the contract investigated in the publication is for a period of 20 years, so that ESCO could regain investments. Comprehensive renovation includes technical aspects (external walls insulation, window replacement, heating system renovation, etc.) and also social aspects (activities not related to energy efficiency – renovation of staircase, roof, safe and clean environment, preserved housing for the next ~50 years). Thus, there are also activities implemented that do not reduce energy consumption, therefore these specific investments must be covered with energy efficiency activities, that increases the payback period of the ESCO investments.

There are a lot of benefits for inhabitants provided by EPC+:

- Renovated building and guaranteed comfort;
- High quality of renovation work and its longevity guarantees;
- Predictable and agreed payment amounts for heating;
- All the expenses of the project are paid by ESCO from its resources;
- Apartment owners do not take any risks;
- After the contract has expired, all the equipment, all systems and installations in good working condition are transferred to the building`s apartment owners;
- Increase in residents managing experience;
- Preservation of the building for next 40 – 50 years;
- Clean environment and improved quality of life;
- 20–25% reduce in management costs;
- The real estate's value increases.

2.1. Calculation procedure under RENESCO's Energy Performance Contract

The calculations used in RENESCO's Energy Performance Contract are based on international guidelines for Measurement and Verifications of Energy Efficiency Projects like the International Performance Measurement and Verification Protocol (IPMVP).

The revenue of RENESCO is linked to the energy savings that will result from the implementation of a variety of energy conservation measures.

There is a very simple formula for measuring savings:

Energy Savings = Base Years Energy Use – Post Retrofit Energy Use + or – Adjustments

RENESCO has adapted this formula to the residential sector, where tenants are used to pay a monthly heating fee for square meter as:

Heating tariff (EUR/m^2 month) = Base Years heating tariff (EUR/m^2 month) + or – Adjustments

It is very important to understand where these numbers come from and especially how adjustments are applied. Adjustments are made to more realistically compare post retrofit conditions to the base year conditions (weather that differ from the base years or different heating tariffs or different indoor temperatures). If these factors were not accounted for, it is possible that savings would be improperly calculated too low or too high.

Therefore the adjustment of the energy costs baseline for space heating is calculated using the following formula:

$$ET_{A,S} = ET_B \times \frac{(TO_S - TI_S)}{(TO_B - TI_B)} \times \frac{SA_S}{SA_B} \quad (1)$$

where:

ET_B	Baseline tariff	EUR/m^2/month
TO_B	Average outdoor baseline reference temperature	ºC
TI_B	Average indoor baseline reference temperature	ºC
SA_B	Baseline district heating tariff without VAT	EUR/MWh
TO_S	Average outdoor temperature for the settlement period	ºC
TI_S	Average indoor temperature for the settlement period	ºC
SA_S	District heating tariff for the settlement period	EUR/MWh
$ET_{A.S}$	Adjusted settlement tariff	EUR/m^2/month

2.2. Technical solutions

The building envelope refers to the basement, walls, windows, doors and ceiling of a building. It plays the leading role in the energy losses of a structure. The remaining energy is lost through gaps and vents in the fabric, which allow warm air to leave and cold air to enter the space (either deliberately through ventilation or uncontrolled through gaps and cracks).

This energy lost has to be supplied by the heating system. The rate at which heat is supplied depends on:

- The temperature difference between the inside and outside of the building;
- The insulation properties of the building envelope;
- The amount of fresh air entering the building either by controlled ventilation or through poorly fitting windows doors or joins in walls.

RENESCO significantly improves the energy performance of existing building by:

- improving the insulation properties and air tightness of the building envelope;
- controlling indoor air temperature;
- regulating the amount of fresh air entering the building.

The renovation measures can roughly be split into the following categories:

1. Preventing heat loss out of the building envelope:
   - adding an additional outer wall of insulating material;
   - replacement of windows and entrance doors;
   - insulating the attic floor and the basement ceiling.
2. Preventing losses in circulating heat and hot water through the building;
   - insulating and decreasing the length and volume of the heating network;
   - decommissioning the current hot water networks which are highly inefficient, non-insulated, over-dimensioned, corroded and calcified with a much shorter, small diameter, copper and plastic network.
3. Preventing overheating in apartments by reducing heat delivery in times when it is not needed. Currently heat is being provided 24/7 without any adjustment to sun radiation or heat produced by people through cooking, lighting, electronic devices. Therefore residents often open the windows to let out excess heat. The following measures not only save energy, but make the overall climate in the building more comfortable:
   - installing thermo regulators on all radiators with maximum setting at +21,5 ^{o}C;
   - installing monitoring system measuring temperature in the apartments to adjust total heat delivery to the building based on real demand and be able to objectively judge any complaints from residents
4. Preventing losses from the ventilation losses. Ventilation of a building provides fresh air and removes contaminants generated inside buildings to ensure healthy indoor air quality. In most of the Latvian multi-family residential buildings, ventilation is achieved naturally and totally uncontrolled. This is a main source of energy losses, and in post-renovated building takes about 30–40% of the delivered energy for space heating. The installation of a mechanical ventilation system with heat recovery not only save energy, but provides the proper air quality all year around.
5. Repairs or improvement to halt and prevent structural problems caused by corrosion. These problems can also cause unnecessary energy losses and, if not treated in time, can lead to serious problems with the building's functioning during the contract period:
   - repairing cracks in walls and foundation;
   - repair of roofs (almost all buildings require major reconstruction works of their roofs);
   - hydro insulation of basement to protect against rainwater entering the basement and foundations.
6. Discretionary improvements to the looks, comfort and overall impression of the building which can best be done as part of the overall renovation:
   - renovation of the staircases and entrances;
   - repairing, removing or replacing of balconies (might also be necessary due to safety issues);
   - Small improvement such as installing sensor lighting in halls, installing automatic door openers, repairs of cold water networks, etc. Measures related with power savings which could be considered is smart metering. I. Laicane *et al.* [13] have conducted research on results of implementation of smart metering in Latvian households.

3. Results and discussion

Currently RENESCO has fully renovated the following stock of buildings:

- 13 Gaujas Street, Valmiera
- 31 Kovarnu Street, Cesis
- 6A Caunas Street, Cesis
- 17B Saules Street, Cesis
- 8A Viestura Street, Cesis
- 10A Viestura Street, Cesis
- 5 Vilku Street, Cesis

Before renovation these buildings were consuming on average 142 kWh/(m^2 a) for space heating and 40 kWh/(m^2 a) for network circulation losses, meaning a total consumption of 182 kWh/(m^2 a). On top of this, 26 kWh/(m^2 a) were used on average for domestic hot water preparation.

The ex-post energy consumption of these buildings has been significantly reduced. Based on 2013 data, on average space heating consumption is down to 77 kWh/(m^2 a) and network circulation losses is down to 4.5 kWh/(m^2 a), meaning a combined figure of 81.5 kWh/(m^2 a). Still 26 kWh/(m^2 a) are used by tenants for domestic hot water preparation.

Compared to the ex-ante figures, the energy savings of the renovated building stock for space heating and circulation losses are calculated at 55%.

This ex-post energy consumption of the buildings renovated has been analyzed, based on available metered data and normalized to normal degree days as prescribed by the Latvian building code [14]. The results are summarized in Figure 3.

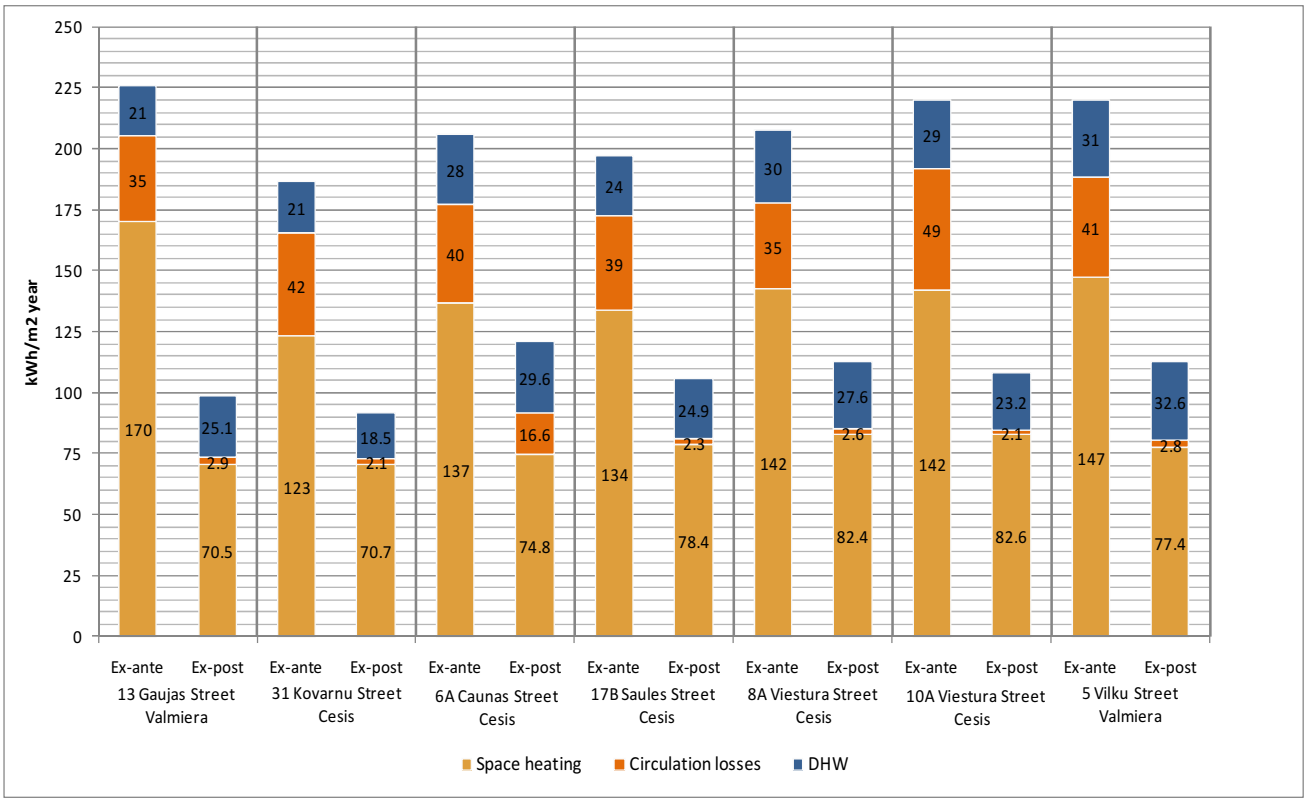


Fig. 3. Ex-ante and ex-post energy consumption for RENESCO renovated buildings

The buildings located in 31 Kovarnu Street in Cesis and 13 Gaujas Street in Valmiera are the ones performing the best. These buildings have been the first renovated by RENESCO, and the heating systems have been fine tuned during the first season of operation.

The rest of the buildings in Cesis were only commissioned at the end of 2012. The heating systems were tuned in the beginning of 2013 (January and February).

The higher circulation losses in 6 Caunas Street are resulting from the use of bathroom towel heaters in summer, which is specifically requested and paid by tenants.

In this current stock of buildings, the needed air changes are assured by natural ventilation, which is not the smartest solution. This becomes a main source of energy losses in renovated buildings, which can even be up to 30–40% of the delivered energy for space heating.

In the next portfolio of building, RENESCO has installed a new mechanical ventilation system with heat recovery in two buildings, hence gaining deep insight in this solution which will likely become a standard for every Renesco's renovation in the future.

3.1. Estimated energy savings for buildings under current renovation

In 2013 RENESCO has been working on the renovation of the following buildings, some of which were finished in autumn 2013 and some of which will be fully finished by spring 2014:

- 28 Stacijas Street Sigulda
- 6 Kajas Street, Sigulda
- 11 Zirnu Street, Cesis
- 17 Zirnu Street, Cesis
- 21 Zirnu Street, Cesis

Before renovation these five buildings were consuming on average 185 kWh/(m^2 a) for space heating and 35 kWh/(m^2 a) for network circulation losses, meaning a total consumption of 220 kWh/(m^2 a). On top of this, 20 kWh/(m^2 a) were used on average for domestic hot water preparation. The building located in 28 Stacijas Street in Sigulda is without a central domestic hot water circulation system but in this project the first heat pump project has been implemented, where two old coal fired boilers were replaced with this modern technology. From the preliminary data analysis the COP of the system is about 3.65, which is slightly below the expected average value of 4. This underperformance was investigated and a problem of flow rate in the ground heat source collector was detected. The problem was solved in January 2014 and the expected seasonal COP of 4 shall be reached starting from 2014.

Pellet boilers could be used in multi-family buildings for space heating as well. A. Žandeckis *et al.* [15, 16] have carried out a study on pilot project in 2 K. Barona Street in Sigulda where the first solar and pellet combisystem in Latvia was introduced.

The preliminary data collected in 2013 and 2014 and the lesson learned from the building already renovated by RENESCO have been used for calculating the expected ex-post energy consumption of these five buildings. On average space heating consumption is expected to be down to 72 kWh/(m^2 a) and network circulation losses down to 2.4 kWh/(m^2 a), meaning a combined figure of 74.4 kWh/(m^2 a). Still 20 kWh/(m^2 a) used by tenants for domestic hot water preparation.

Compared to the ex-ante figures, the energy savings of the renovated building stock for space heating and circulation losses are calculated at 65%.

The expected results are summarized in Figure 4.

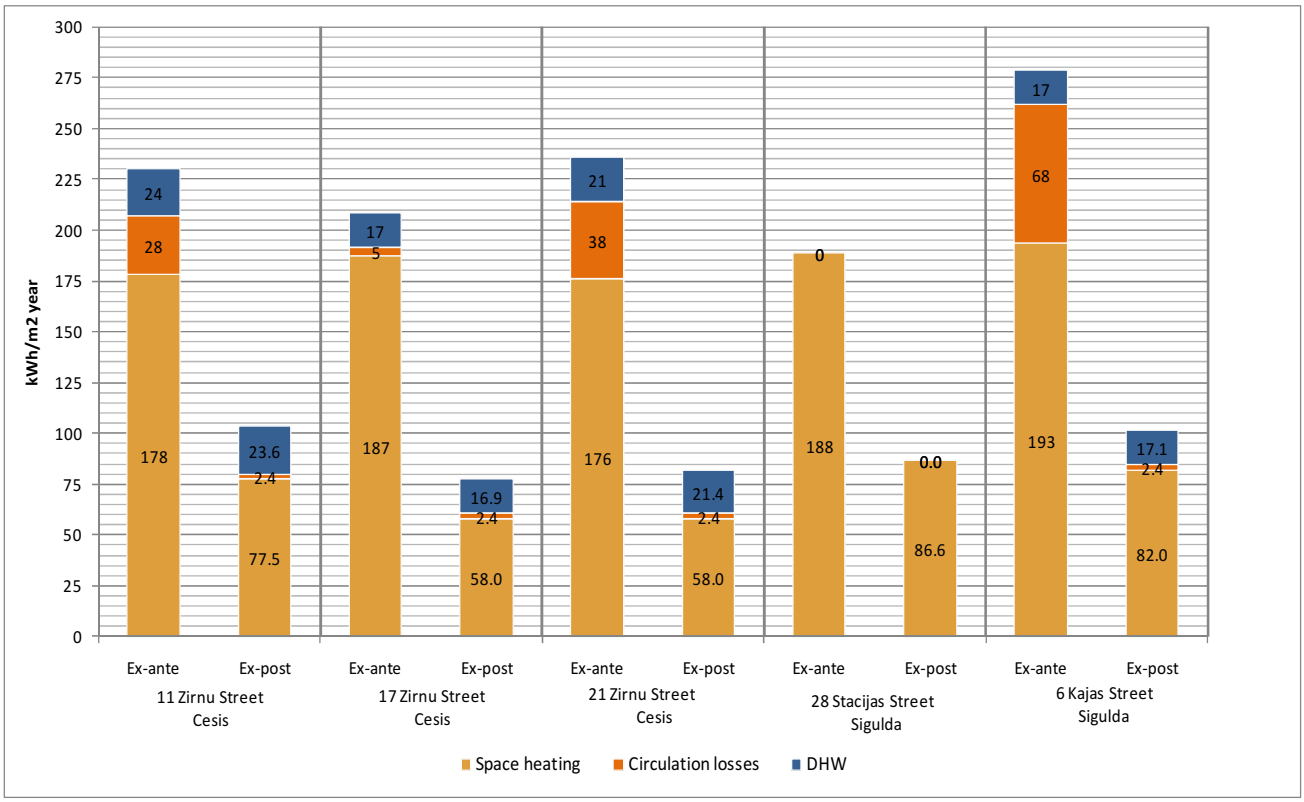


Fig. 4. Ex-ante and ex-post energy consumption for RENESCO newly renovated buildings. Ex-post energy data extrapolated from 2013 and buildings already renovated by Renesco

The buildings located in Zirnu 17 and Zirnu 21 are equipped with mechanical ventilation with heat recovery system. The most conservative expectation for these buildings suggests final energy consumption for space heating between 55–60 kWh/(m^2 a). Fine tuning and operation of the systems could bring energy consumption down to 50–55 kWh/(m^2 a).

The total energy consumption (space heating plus circulation losses) of all 12 buildings were determined 4276 MWh per year before energy efficiency measures. Implementing comprehensive renovation energy savings was obtained of 2388 MWh/a or reduction of 645 tons CO_2 emissions per year. Emission factors 0.264 tCO2/MWh (district heating) and 0.340 tCO2/MWh (coal) were used for calculations [17].

4. Conclusions

In Eastern Europe the market for renovation of multi-family residential buildings with EPC+ has an enormous potential, Latvia alone, more than 50m m2. Latvia has an housing problem: 1) old housing stock made between 1940–1992, 2) lack of maintenance in the last 20+ years, 3) high energy consumption – waste of energy resources which costs Latvia €0.75b according to the data of Central Statistical Bureau of Latvia.

Maintenance costs of the stock are rising, both due to general inflation (labour market) but as well as because of increased maintenance costs due to deterioration of the housing stock.

EPC+ appears to be a promising solution for addressing two problems:

- Achieving energy saving to comply with EU targets;
- A solution to the growing housing crisis in Latvia.

The study carried out shows that it is possible to reach significant energy savings and reduction of CO2 emissions and one ESCO company has proven that the model works. The total energy consumption (space heating plus circulation losses) of buildings were determined 4276 MWh per year before energy efficiency measures. Implementing comprehensive renovation there were obtained energy savings of 2388 MWh/a or reduction of 645 tons CO_2 emissions per year.

On average space heating consumption of fully completed buildings is down to 77 kWh/(m^2 a) and network circulation losses are down to 4.5 kWh/(m^2 a), meaning a combined figure of 81.5 kWh/(m^2 a). The preliminary energy savings of the renovated building stock are calculated at 55%, further financial savings may be achievable on the basis of these initial projects as can be seen in the projects under current execution.

On average space heating consumption of buildings currently under renovation is expected to be down to 72 kWh/(m^2 a) and network circulation losses down to 2.4 kWh/(m^2 a), meaning a combined figure of 74.4 kWh/(m^2 a). The energy savings of the renovated building stock are calculated at 65%.

Future work: a comparative analysis (technical/economical) will be carried out of the buildings renovated with EPC+ and the buildings renovated either by a housing maintenance company or a home owner association.

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