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HEAT INSULATION OF MULTI-APARTMENT HOUSES IN LATVIA: FUTURE PROBLEMS IN THE REGIONS

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Abstract. In 2009, the heat insulation of multi-apartment houses was initiated in Latvia using financial assistance of the European Regional Development Fund. In the future, problems will emerge with heat-uninsulated houses being partially uninhabited, as the population prefers living in heat-insulated houses and the population is likely to decrease not only in rural but also urban areas, while heating for heat-insulated houses is considerably cheaper and the lifetime of such houses after their heat-insulation (renovation) increases. Therefore, the research aim of the paper is to examine the socio-economic problems to be caused by heat-uninsulated multi-apartment houses in Latvia's regions in the future. The research found that heat-insulated houses had an implicit heating discount at the expense of heat-uninsulated houses, and the paper developed a methodology for calculating implicit discounts. In a long-term, it will contribute to their occupancy and consequently the degradation of heat-uninsulated houses. This might affect Latgale region the most, followed by Vidzeme region, while such a problem is the least specific to Pieriga region. Among cities, this problem will be the most specific to Daugavpils, followed by Rezekne; a relatively better situation might be expected in Jelgava and Jurmala.

Keywords: heat insulation of multi-apartment houses, implicit discount, Latvia

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Introduction

Soviet period buildings are energy inefficient. For this reason, it is necessary to heat-insulate such buildings, which allows considerably reducing expense on heating. Latvia's policy documents, e.g. the National Development Plan of Latvia for 2014-2020, Guidelines for Energy Sector Development 2007-2016, the Energy Sector Long-term Strategy 2030 etc. have set an objective to increase the energy efficiency of buildings (Ministry of Economics, 2013).

The first energy efficiency programme was implemented in Latvia in the period 2009-2013. It was desirable to launch the heat insulation of buildings in Latvia earlier – during the years of fast economic growth – when energy prices reached high levels – or at least when the global financial crisis began, which most affected the construction industry that lacked construction orders. Approximately 1000 multi-apartment house renovation projects were implemented under the European Regional Development Fund's activity "Improvement of Heat Insulation of Multi-apartment Residential Buildings" (Investment and Development Agency…, 2013). On a national scale, it is not a lot, as there are approximately 25000 multi-apartment houses to be heat-insulated (Ministry of Economics, 2013).

The heat insulation of multi-apartment houses provides not only gains but will also cause certain problems in the future. Therefore, the research aim of the paper is to examine the socio-economic problems to be caused by heat-uninsulated multi-apartment houses in Latvia's regions in the future, and the subordinate specific tasks are as follows:

1) to describe the economic aspects of heat supply for heat-insulated and -uninsulated buildings;
2) to identify the problems to be caused by heat-uninsulated multi-apartment houses in the future;
3) to identify the regions the mentioned problems will manifest themselves the most.

The paper used the Central Statistical Bureau of Latvia, the Lursoft company and other information sources and employed the following research methods: analysis, synthesis, deduction, time series analysis, a case study and forecasting. Since this problem has not been researched in Latvia, the paper developed a methodology to calculate implicit discounts received by heat-insulated buildings.

Research results and discussion

1. Economic aspects of heat supply for heat-insulated and uninsulated buildings

Heat-insulated (renovated) buildings consume considerably less thermal energy, on average 35-50 %, in some cases 60 % (Public Utilities Commission, 2015) and even less (the author's estimates based on Jelgavas nekustama ipasuma parvalde LLC data). Consequently, the expense on heating seems to be lower by the mentioned percentage decreases. However, the problem is more complicated, as the price (tariff) of heating consists of various costs, the main of which are fuel, electricity, maintenance and depreciation of equipment and wages (Fortum Jelgava, 2015); fuel and electricity are variable costs that depend on the consumption of thermal energy, whereas the other mentioned costs are fixed costs. Every building is located at a different distance from the place of thermal energy generation; accordingly, the length of heating networks and their related costs and other costs – electricity and thermal energy losses – (mostly fixed costs) are different. The energy efficiency of every building is also different – the less energy efficient a building is, the more it consumes fuel and electricity (mostly variable costs).

One can consider two extreme options: 1) a building is located close to the thermal energy generation place and it is energy efficient (both part of its fixed costs and its variable costs are low); 2) a building is located far away from the thermal energy generation place and it is energy inefficient (costs are high). The heating enterprise, of course, calculates both fixed and variable costs and sets an average tariff. Accordingly, a building located close to the thermal energy generation place and being energy efficient implicitly cross-subsidises a building located far away from it and being energy inefficient. Nevertheless, the tariff on thermal energy is the same for all consumers, and the mentioned differences are not taken into account. After buildings are heat-insulated, the difference in energy efficiency significantly changes. In the result, the consumption of fuel, electricity etc. by such buildings will decrease (due to the decrease of their variable costs), whereas their fixed costs (maintenance and depreciation of equipment, wages etc.) that are incurred providing heating to heat-insulated buildings do not change.

If thermal energy production cost consisted of only variable costs, such a problem would not exist. But there are fixed costs, the proportion of which is high. The key component of variable costs is fuel, and in case of natural gas heating it accounts for more than 60 % of total cost, while in case of using biomass it is lower (Public Utilities Commission, 2015). So, variable costs comprise about half of total cost. Nevertheless, consumers pay their central heating enterprise for actually consumed thermal energy based on a single tariff. This factor results in: 1) revenue decrease for the heating enterprise, reducing its profit, if it is a private company (it cannot operate without profit and does not wish to work with a declining profit) or losses are suffered if it is a municipal enterprise (which often operates with no profit); this will lead to a situation that the company/enterprise has to raise its tariff or at least not to decrease it in case, for example, the fuel purchase price has fallen; 2) heat-uninsulated buildings will partially cover the fixed costs of heat-insulated buildings.

If, for example, the thermal energy consumption of a building decreases by 50 % after it has been heat-insulated, its total expense on heating also shrinks by 50 % – such a building, of course, consumes 50 % less fuel (and other variable costs) but it pays fixed costs also by 50% less, although these costs actually do not change; it means that the fixed costs of a heat-insulated building (50 %) will be paid by all the remaining heat-uninsulated buildings. The building gets an extra approximately 25 % implicit discount (at a ratio of variable to fixed costs of 50:50). Besides, the lower the proportion of variable costs in total cost for a heating enterprise, the greater discount heat-insulated buildings get.

A number of equations have to be considered and created to evaluate this factor.

A floor area that is centrally heated in a city (urban area) can be expressed as follows:

$$A = A_1 + A_2, m^2 \tag{1}$$

where A_1 – total floor area of heat-uninsulated buildings, m^2;

A_2 – total floor area of heat-insulated buildings, m^2.

The revenue of a heating enterprise:

$$TR = A \times t, EUR \tag{2}$$

where t – tariff (price) on thermal energy, EUR/MWh.

Since there are both heat-uninsulated and -insulated buildings:

$$TR = TR_1 + TR_2 = A_1 \times t + A_2 \times t \times k, EUR \tag{3}$$

where TR_1 – revenue from the supply of thermal energy to heat-uninsulated buildings, EUR;

TR_2 – revenue from the supply of thermal energy to heat-insulated buildings, EUR;

k – coefficient taking into account the thermal energy savings of heat-insulated buildings.

$$k = 1 - e \tag{4}$$

where e – thermal energy savings (50…70% or in terms of decimals it is 0.5…0.7; it is assumed to be, on average, 0.6);

k = 1-(0.5…0.7) = 0.3…0.5. It is assumed on average k = 0.4.

The more buildings are heat-insulated (A_2 increases), the more the revenue R_2 and the total revenue R of the enterprise decrease. The consumption of fuel (variable costs) by the enterprise also decreases but it only partially offsets the decrease in its revenue. For this reason, the enterprise will be forced to raise its tariff, thus, compensating for the loss of revenue from both heat-insulated and heat-uninsulated buildings, which is not fair but diversifying the tariff also causes problems to the enterprise.

Further, it is necessary to express the floor areas of heat-insulated and -uninsulated buildings as shares of the total floor area heated by the enterprise:

$$a_1 = 1 - a_2 \quad (5)$$

where a_1 – share of the floor area of heat-uninsulated buildings;

a_2 – share of the floor area of heat-insulated buildings.

The total profit, TP, of the enterprise is equal to its total revenue, TR, minus its total production cost, TC (Boyes W., Melvin M., 1991), i.e. TP=TR-TC. It is derived from the equation that TR=TP+TC. Since total cost, TC, is subdivided into total variable (TVC) and total fixed cost (TFC), TR=TP+TVC+TFC, EUR.

Since there are both heat-insulated and -uninsulated buildings, the enterprise's total revenue from heat-insulated buildings may be expressed as follows:

$$TR_2 = (TP + k \times (TVC + TFC)) \times a_2, EUR \quad (6)$$

although (if the tariff were reduced for heat-insulated buildings only by the decrease in total variable cost) it should be expressed as follows:

$$TR_2^{'} = (TP + k \times TVC + TFC) \times a_2, EUR \quad (7)$$

The difference

$$\Delta TR = TR_2^{'} - TR_2, EUR \quad (8)$$

$$\begin{aligned} \Delta TR &= (TP + k \times TVC + TFC) \times a_2 - \\ &(TP + k \times (TVC + TFC) \times a_2 = \\ &= TFC \times a_2 - k \times TFC \times a_2 = \\ &= TFC \times (a_2 - k \times a_2), EUR \end{aligned} \quad (9)$$

The difference represents the amount of total revenue of the enterprise that is not paid by heat-insulated buildings – it originates from the total fixed cost incurred by the buildings.

Since the enterprise is going to raise the tariff sooner or later, with the heat insulation of buildings gradually taking place in a city, a (any) new tariff, t_1, may be calculated as follows:

$$t_1 = t \times (\frac{\Delta TR}{(TR_2^{'} - \Delta TR + TR_1)} + 1), EUR / MWh \quad (10)$$

After the tariff has been raised, a part of the enterprise's revenue will be collected from heat-insulated buildings, while the remaining (second) part will come from heat-uninsulated buildings. Therefore, the second part of revenue is an implicit discount (ID) that is paid by heat-uninsulated buildings to heat-insulated ones, and it can be calculated as the difference minus the revenue the enterprise collects from heat-insulated buildings after the tariff was raised, i.e.:

$$ID = \Delta TR - \Delta TR_2, EUR \quad (11)$$

$$\Delta TR_2 = (t_1 - t) \times A_2 \times k, EUR \quad (12)$$

The same indicator can be calculated by multiplying a percentage increase in the tariff by revenue from heat-insulated buildings before the tariff was raised:

$$\Delta TR_2 = (t_1 - t) / 100 \times TR \times a_2 \times k, EUR \quad (13)$$

ID for heat-insulated buildings, expressed as a percentage, can be calculated as follows:

$$ID = e \times \frac{TP + TFC}{TR}, \% \quad (14)$$

Let us examine an example with Fortum Jelgava, a company that supplies Jelgava city with thermal energy, and the process of heat insulation of buildings in this city. The company's turnover ranged from approximately EUR 18 to 24 mln (Lursoft, 2015) in the period 2012-2014 and its profit was about EUR 2 mln; it was assumed TR= EUR 20 mln. Since the company generates energy from woodchips, its TFC~TVC; it is assumed TFC=TVC. In this case TFC=(TP-TP)/2. According to calculations, TFC is approximately EUR 9 mln.

If 10% of buildings are heat-insulated in Jelgava, i.e. a_2 = 0.1, Fortum Jelgava, at the same tariff, will not gain ΔTR = EUR 0.66 mln (according to Equation 9). If 50 % of buildings are heat-insulated, then the company's revenue will decline by EUR 3.3 mln; if 90 %

– by EUR 5.94 mln (the author's estimates). As one can see, if half of all buildings are heat-insulated in Jelgava, Fortum Jelgava will operate with losses.

Further, let us assume that the company raises the tariff from time to time in order to have the same profit. If 10 % of buildings are heat-insulated, in order to regain EUR 0.66 mln, the company has to raise its tariff by about 3.5 %; at 50 %, to regain EUR 3.3 mln, the tariff has to be raised by about 23.6 %, and at 90 %, to get back EUR 5.94 mln, its tariff should be raised by approximately 64.6 % (the author's estimates).

Further, one can calculate the next most important indicator – the size of implicit discount paid by heat-uninsulated buildings to those being heat-insulated. If 10% of buildings are heat-insulated, according to Equation 11, it totals EUR 0.63 mln, at 50% – EUR 2.36 mln and at 90% – EUR 1.29 mln. The max value of EUR 2.48 is reached at 61% (the author's estimates).

The more buildings are heat-insulated in the city, the more the heating company has to raise its tariff and the relatively more heat-insulated buildings compensate for the decrease in the company's revenue. If 10 % of buildings are heat-insulated, after the tariff is raised, heat-uninsulated buildings will pay an implicit discount of EUR 0.63 mln or cover 95.7 % of the estimated loss of EUR 0.66 mln, while heat-insulated buildings (since they are small in number, only 10 %) will offset only 4.3 % of the revenue decrease for the company. At 50 %, heat-uninsulated buildings will pay an implicit discount of EUR 2.36 mln or cover 71.4 % (of the loss of EUR 3.3 mln), while heat-insulated buildings will compensate 28.6 % for the loss. At 90 %, it will be a discount of EUR 1.29 mln or 21.7 % (of the loss of EUR 5.94 mln), while heat-insulated buildings will compensate 78.3 % (the author's estimates).

The implicit discount to be paid by heat-uninsulated buildings if measured per m^2 of floor area, with the proportion of heat-insulated buildings increasing from 10 to 50 and 90 % and the proportion of heat-uninsulated buildings decreasing from 90 to 50 and 10 % (1.8 and 9 times, respectively), will increase from EUR 0.63 to 2.36 and 1.29 mln (3.7 and 2.0 times) (based on Fortum Jelgava data for 2012-2014). In total, it is 6.7 and 18 times, respectively, more, which is a very high relative increase (the author's estimates). In absolute figures, in this case, the discount is also large. Assuming that 90% of buildings are heat-insulated in Jelgava (they are mainly residential buildings), the remaining 10% of buildings will have to cross-subsidise the heat-insulated buildings at EUR 1.29 mln. Given the fact that expenses of the 10% of heat-uninsulated buildings on heating, compared with the initial situation when not a single building was heat-insulated in Jelgava, amount to about 10% of the total revenue of Fortum Jelgava or EUR 2 mln, an implicit cross-subsidy they would additionally pay to heat-uninsulated buildings is about 65% of their initial expenses or EUR 1.29 mln. It is a considerable additional financial burden for the 10% of heat-uninsulated buildings, compared with heat-insulated buildings. The author believes there is no reason to consider a case where all multi-apartment houses (100%) that need to be heat-insulated will be heat-insulated. The reason is that, firstly, banks will be reluctant to finance heat insulation activities in suburbs and other places having no prospects because of the declining population. Such a scenario would not come true only in one case – if the population does not significantly decrease in the future, which is unlikely. Secondly, giving guarantees for the heat insulation of multi-apartment houses by the government in all cases under the circumstances when the population is declining and will be declining would mean the waste of funds.

2. Socio-economic problems caused by heat-uninsulated houses in the future

The heat insulation of buildings, including multi-apartment houses that comprise the largest share of floor area to be heated in any urban area is an efficient activity allowing reducing fuel cost and other variable costs. It is particularly important if natural gas is used, as the price of it might be high due to oil price hikes and this resource is imported from Russia as an unpredictable country. It also reduces pollution in the environment. Yet, at the same time, it worsens the financial situation of heat-uninsulated houses – they will be forced to implicitly cross-subsidise heat-insulated houses. The higher the proportion of multi-apartment houses is heat-insulated, the larger implicit cross-subsidy is paid by heat-uninsulated houses to heat-insulated ones. Besides, it has to be taken into account that the population in the country as a whole and its regions and cities, with a few exceptions, is declining and this process is likely to be continuing. The fastest population decrease takes place in rural areas, as residents move to cities, while part of them goes to developed EU Member States where the income level is much higher than in Latvia. In cities where multi-apartment houses are mostly heat-insulated the population is also declining (see the next subchapter). Even though the population declines fast, residential floor area per household or resident, at the same time, increases. According to data, in 2005 the average number of rooms per household was 2.4, and that per household member was 0.9; in 2014, the indicators were 2.9 and 1.2, respectively. It means that with increase in income in Latvia, households and their members use a greater residential floor area. The average apartment size, too, increased in Latvia from 60.1 m^2 in 2007 to 65.8 m^2 in 2014 (CSB, 2015). Yet, such a trend, in the opinion of the author, will only partially solve the problems of population decline and unoccupied apartments.

This situation creates several problems:

1) because of the declining population, there will be unoccupied apartments in multi-apartment houses in the future

2) the segment of the market of multi-apartment houses (mostly the so called serial houses built in the Soviet period) will diversify – there will be heat-insulated houses that look better, their maintenance costs are lower and their market price is higher – and there will be heat-uninsulated houses with completely opposite characteristics;

3) prosperous residents will move to heat-insulated houses. Such houses will be fully occupied, of course, at the expense of heat-uninsulated houses in which poorer individuals are going to reside;

4) a different situation will be observed between the centre of a city and its suburbs – residents usually prefer living in the centre of a city. Consequently, the most problematic situation with heat-uninsulated houses will emerge in suburbs, particularly with those being very energy inefficient, as the energy efficiency of houses built in the Soviet period is quite diverse – it differs even two times.

In heat-uninsulated houses, especially in suburbs, the proportion of apartment owners who are not able to timely pay their home bills will increase. There will be apartments whose owners cannot be found (e.g. living abroad). The heating enterprise might not supply heating to such apartments. It is a partial solution, as thermal energy moves from apartments being heated, and in the result heating cost will increase for such apartments.

As a result, the amount of debts on heating, home management and other services will increase. Since the largest home expense involves heating, the heating enterprise, especially if it is not owned by the local government, might decide not to supply heating to heavily indebted houses, thus creating big problems not only to indebted apartment owners but also to those having no debts. The market price of apartments in such houses will significantly fall, and if their owners are not able to establish a local heating system for their houses, their market price will approach a zero value. It will be difficult for the owners of such houses to sell their apartments. If the apartment debts are larger than the apartment market price, it will not be possible to sell such apartments. Inability to solve this problem will result in larger expenditures of local governments on assistance to their problematic residents.

The problem with partially unoccupied houses in suburbs and other small urban areas in Latvia will not arise to the same extent, as there are differences across its regions and cities.

3. Regions where the socio-economic problems will manifest themselves the most in relation to heat-uninsulated multi-apartment houses

The key factor determining whether multi-apartment houses are fully or partially occupied, i.e. if they are not endangered in a long-term through their remaining lifetime is the population and its change. Yet, the population does not change (decrease) equally in all the regions and cities of Latvia. It requires examining relative population changes in the regions and cities over a long period (Table 1). This trend is unlikely to change in the future too even in a long-term, e.g. over the next 10 or 20 years, which will be crucial for the heat insulation of multi-apartment houses, i.e. if houses in suburbs and small residential places are not heat-insulated during about the next 10 years, it will not be prudent to heat-insulate them and it will be difficult or even impossible to get a loan for this purpose. The key reason is the lack of residents living in such houses, and banks are aware of it right now.

As regards houses in city centres, the period of their heat insulation will be defined, in the author's opinion, by the payback time and their lifetime. The lifetime of serial houses whose average age in Latvia is about 40 years, according to experts, could last for other 40 years in case they are properly maintained. The payback time of investment in the heat insulation of houses under the second heat insulation programme (its support intensity may reach 35 % of total cost) will be about 10-15 years (the author's estimate). The support intensity for next such programmes is not known, which, given the great role of heat insulation of houses, will be likely implemented in Latvia. Perhaps this intensity will be reduced and financial resources will also get more expensive; consequently, the payback time can reach even 20 years (the author's estimate). So, if after about 20 years houses are not heat-insulated, from the financial perspective, there is no reason to do it, as investments will not pay back during their remaining lifetime.

As shown in Table 1, the population in Latvia decreased quite steadily, about 5-6 % in every five years. The only region where it increased, except for the last period, was Pieriga. Its specific is that mostly wealthy residents, which build private houses and do not live in multi-apartment houses needing to be heat-insulated, settle there. The next relatively favourable region is Riga where the population decrease slowed down at least in the last period. In contrast, the situation in the other regions is unfavourable, particularly in Latgale. A slightly better situation may be observed in Vidzeme, followed by Kurzeme and Zemgale. Even though the decrease in the period of 15 years was quite similar both in Riga and Zemgale, i.e. 16-17 %, the decline in Riga region (city) slowed down, whereas in Zemgale it accelerated.

Table 1

Changes in the population in Latvia's regions and cities, %

	2005/2000	2010/2005	2015/2010	2015/2000
LATVIA	-5.54	-5.74	-6.34	-16.61
Riga region (Riga)	-7.06	-5.45	-4.82	-16.36
Pieriga region	1.78	2.59	-1.69	2.66
Vidzeme region	-6.42	-8.95	-8.79	-22.28
Kurzeme region	-6.34	-7.46	-8.80	-20.95
Zemgale region	-4.69	-6.41	-7.43	-17.43
Latgale region	-8.72	-10.78	-10.35	-26.99
Daugavpils	-7.19	-10.54	-9.93	-25.21
Jelgava	-0.09	-4.34	-6.14	-10.30
Jekabpils	-4.33	-5.50	-8.77	-17.53
Jurmala	-4.00	-3.18	-4.06	-10.83
Liepaja	-6.56	-5.79	-9.87	-20.66
Rezekne	-7.54	-8.23	-12.37	-25.65
Valmiera	-2.54	-4.44	-9.49	-15.71
Ventspils	-3.16	-6.30	-9.04	-17.47

Source: author's calculation based on CSB data

Among cities, the fastest decrease was observed in Rezekne, and the decrease even accelerated. The next fastest population decrease was reported in Daugavpils where it slightly slowed down in the last 5 years. The population decreased slower in Jelgava and Jurmala, even though the decrease accelerated in Jelgava, whereas in Jurmala it was quite steady.

On the whole, there will be not a single city and almost no region where the problem of insufficient occupation of heat-uninsulated multi-apartment houses will not arise in the future.

Conclusions and proposals

1) Heating cost for heat-insulated buildings decrease by at least 50%, and such buildings get an implicit discount of about 25 % that is paid by heat-uninsulated buildings.

2) The higher the proportion of heat-insulated buildings, the greater financial burden (both absolutely (up to a certain proportion) and relatively) is additionally put on heat-uninsulated buildings through an implicit discount.

3) The population will prefer living in heat-insulated houses, while heat-uninsulated multi-apartment houses (first of all, in suburbs) will be partially unoccupied in the future because of the population decrease, which negatively affects the maintenance and even existence of such houses, causing additional problems, expenditures and tax losses for local governments.

4) The problem of heat-uninsulated multi-apartment houses will be the most specific to Latgale region and its cities, whereas Pieriga region will have the least problem.

5) Institutions involved in the heat insulation of multi-apartment houses, in cooperation with local authorities, are advised to foster the heat insulation of those houses whose relative costs (per m^2 of floor area) are the lowest (houses with a large number of apartments and those being very energy inefficient).

6) Local authorities are advised to timely design an action plan for heat-uninsulated multi-apartment houses and their dwellers, as they will not be properly maintained and will start turning into slum houses because of the lack of residents.

7) It would be possible to diversify the heating tariff for heat-insulated and -uninsulated multi-apartment houses, but it is not advisable, as it will hinder the process of heat insulation of houses in the country.

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