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DYNAMICS OF APARTMENT BUILDING RENOVATION INVESTMENT COSTS BASED ON ESTONIAN REOVATION GRANT SCHEME

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Abstract.

While energy prices have increased substantially recently, we also observe that renovation prices have increased twofold wihtin last decade. This could seriously affect the motivation to invest in building renovations because of negative yield and in turn jeopardise the carbon reduction plans. Therefore, we attempt to show some evidence of renovation cost dynamics based on sample of 112 apartment buildings which received state support for deep energy renovations during 2010 and 2017. We found that investments started out very cautiously in 2010. Eventually renovations were embraced as rational investment and renovations ambitions grow with prices. Construction price index grow during the study period 20 percent and renovations over two times. We could not confirm the popular hypothesis that demand pressure will also increase prices. However, most significant increase of renovation price was due to the additional construction works and quality improvement. This was especially evident after the redesign of grant rules in 2015 which allowed more indirect construction works to be eligible for the subsidy.

Keywords: Energy renovation, construction cost, procurement, apartment buildings.

1. Introduction

As buildings are one of the largest sources of energy consumption in Europe, deep energy renovation of buildings is the most feasible method towards decarbonised economy. European Commission strategy “A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives” [1] objective is to at least double the annual energy renovation rate of buildings by 2030 and to foster deep energy renovations.

To meet decarbonisation targets all EU member states have prepared national long-term renovation strategies. The Estonian renovation strategy [2] aims to renovate 22 % of the building stock by 2030, 64 % by 2040, and the rest by 2050. Current goal is to renovate apartment buildings to energy performance level, which was equivalent to a new building in 2018 which classifies as near zero energy building’s standard for renovations. Active renovation promotion, subsidy programme and other supportive measures have resulted in deep energy renovation of 150 large apartment buildings in average per year. However, the annual need for renovation is approximately 500 apartment buildings [3], with a total area of 600 000 m^2 per year in order to achieve carbon neutrality targets by 2050.

It is evident that there is an urgent need to speed up the renovation pace. However, there are several renovation barriers that hider the renovation adoption [4]. The investment capability is found to be one limiting factor to achieve deep energy renovation targets [5, 6]. Investments are evaluated by comparing costs with benefits. While home improvements are not usually addressed as investment projects, deep energy efficiency renovations are so expensive and complex that the decisions to renovate are always related to profitability of the costs. Investing in energy efficiency should be a simple dilemma whether to pay the high energy bills or service the bank loan for renovations. However, deep energy renovations usually are not self-sufficient as construction of proper ventilation system would increase the investment and operation costs. Therefore, increasing construction prices could become another substantial barrier which in turn might have significant influence on achieving wider climate goals, and securing the wellbeing and safety of the residents in severely depreciated buildings.

We observe that during the Estonian renovation grant programme which started in 2010, construction costs for renovations have been continuously increasing. In 2010 the annual average cost for net area of deep energy renovation was about 160 €/m^2, however a decade later, in 2020, the average cost rate has increased to 380 €/m^2. This large increase of 2.4 times significantly exceeds the construction price index for new build which grew 20 % during the same period. Such phenomenon proposes several difficulties for adoption of long-term renovation strategy.

On the one hand, growing prices decrease the attractiveness of energy renovations and render the incentive measures less efficient. On the other hand, uncertainty of renovation prices can hinder forecasting of long-term planning of renovation funds and evaluation of financial capacity of homeowners who are expected to invest in energy renovations with increasing rate within the next three decades.

So far analysts and planners have been operating with an average value of renovation price in calculating the forecast of renovation investment and incentives projections. However, there is little knowledge why renovation prices can exceed the price growth of the new build and more importantly whether such trends will extend to the near or long-term future.

Preconditions for carbon neutral economy require the supply side of renovations system to cope with the increasing demand [7]. Therefore, if the renovations costs are increasing due to the greater demand, regulators need to address such issues explicitly by focusing on the increasing the capacity of supply side.

Based on the data of Estonian renovation grant programme the current study aims to explain why renovation prices have been increasing more than expected by construction price index for new build. We also provide discussion in which we address the implications of such price trajectory for planning next iterations of renovation strategy. Doing so, we focus on three research questions:

- How typical renovation solutions have changed over time?
- How technical and quality requirements have affected renovation solutions?
- Why have costs changed within procurement biddings for renovations?

2. Methodology

2.1. Data collection

In the period 2010–2017, 561 apartment buildings In Estonia were deeply renovated using state renovation grant mediated by Fund KredEx. Although the average renovation price continued to increase also after the year of 2017, we were unable to extend the study period due to the limited of the data availability. Still, we can provide meaningful results because we cover two different grant periods within the 8 years.

First, we examine the overall renovation dynamics using the information provided form KredEx databases for the entire data. The relationships between building size, age and construction material are then analysed.

For more elaborate enquiry we used the sample of 112 projects which is about 20 % of the overall data. Buildings were chosen randomly, and sample's representativeness was evaluated by the number of apartments, construction time, location, and renovation cost. Contractors included in sample had renovated at least seven large apartment buildings within the study period and were therefore expected to provide comparable cost information mainly because of their similar in size, management, and salary system. All prices include value added tax.

2.2. Analysis methods

To eliminate the effect of general increase of construction prices and inflation, effect of construction price index was removed from the observed renovation cost, normalising all prices to the level of January 2018.

In the sample analysis, used construction solutions were mapped and three types of work were examined in more detail. At first, the most common solutions for additional insulation of facades are compared by the type of facade, insulation and finishing materials. Secondly, the reconstruction of the heating system of different apartment buildings is compared by the depth of construction works. Thirdly, the most common solutions for the construction of a mechanical ventilation system are identified and costs are compared. The cost per net area was compared for all three work types to identify how technological changes have affected the renovation cost.

Second part of the study seeks to determine to what extent the grant requirements changes have impacted the renovation cost. This approach is based on the regulation analysis which describes the work financed by the grant. The cost of observed components is deducted from the cost of the closed net area of the renovation and the extent to which the impact on the cost of the renovation has been directly added is assessed.

Third part of this study examines the energy efficiency ambitions of apartment association. The information about pre-construction 3-year period average energy consumption was collected and compared with after-renovation 3-year period average energy consumption. Accomplished energy savings were compared with renovation cost, to recognize possible relations.

3. Results

3.1. The dynamics of apartment buildings renovation costs

The average annual cost of deep renovations, in the period 2010–2018, have increased from the level of 160 €/m^2 to 330 €/m^2 (approx. 2 times). Figure 1 shows the average annual deep renovation cost. Largest price increase is in the middle of the period of the two grant measures, in the transition from one period into another. Since the conditions for the payment of support changed then, this work supports the hypothesis that the change in the support regulation is a major factor influencing renovation cost.

We found three cost-influencing aspects. First, construction cost is higher for smaller buildings. Management costs and the cost of mechanisms, scaffolding etc. play a bigger role in smaller construction projects, resulting in higher cost per net area. Secondly, old wooden buildings are more expensive to renovate than

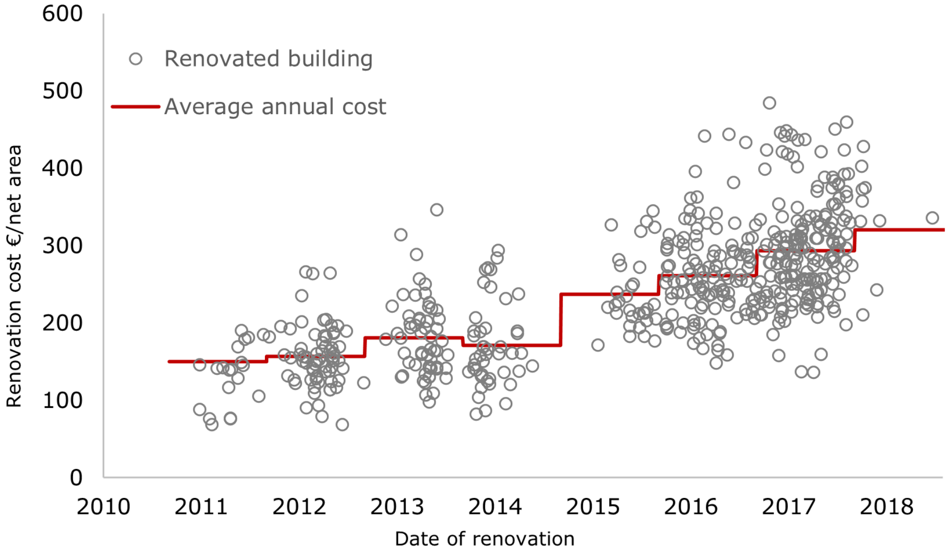

Figure 1. Renovation costs in 2010–2018.

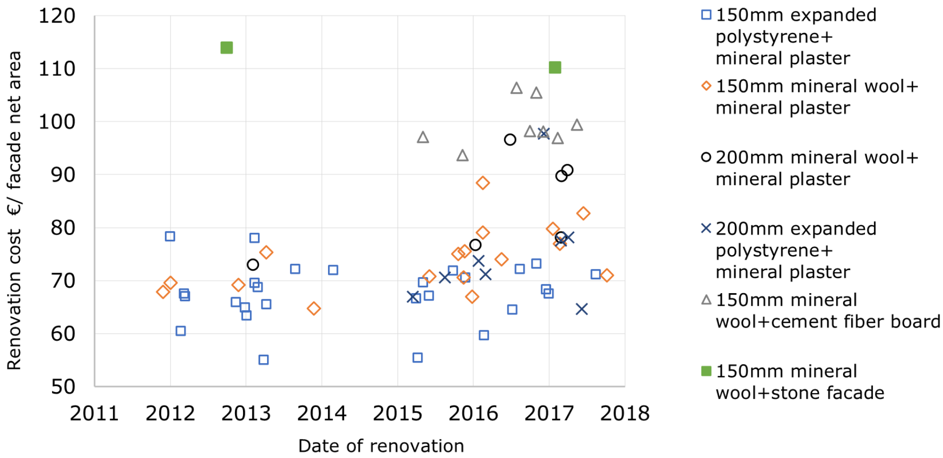

Figure 2. Common facade reconstruction technologies.

prefabricated concrete buildings. It is most advantageous to renovate a prefabricated house (better developed standard solutions and less effort is needed to strengthen the load-bearing structures). Wooden buildings are usually located in historically valuable areas and therefore require more personal approach. Thirdly, renovation of older buildings has higher costs and price variability is also higher. Both can be related to the performance of previous reconstruction works (some of the renovation works have already been done before). The result is also affected by the fact that among older buildings there are primarily wooden apartment buildings, as the construction of reinforced concrete large-panel buildings started a maximum of 60 years ago. And, as described in previous analysis, renovating wooden houses is more expensive.

3.2. Detailed analysis of mandatory renovation works

The increase in the unit price of additional facade insulation is influenced using increasingly common ventilated facade solutions, which are twice as expensive as plastered systems (average prices 60 €/m^2 and 100 €/m^2, respectively). The technology of plaster facades has changed. In addition to mineral plaster, silicone plaster is more often used, and wool insulation is used more often in facades than before, which is 1.4 times more expensive than expanded polystyrene insulation (Figure 2). It can be stated as a positive sign of increased awareness of residents and in the know-how of specialists that decisions are not only cost-driven, but technological aspects are also calculated.

The average cost of mechanical ventilation systems has increased from 32 to 43 €/m^2 in second renovation period (Figure 3). This due to the reason that natural ventilation systems and room-based ventilation solutions were banned as such systems do not offer proper ventilation and indoor climate. The construction of a mechanical ventilation system accounts for about 5 % of the price increase of renovation. In addition, the construction of the ventilation system involves

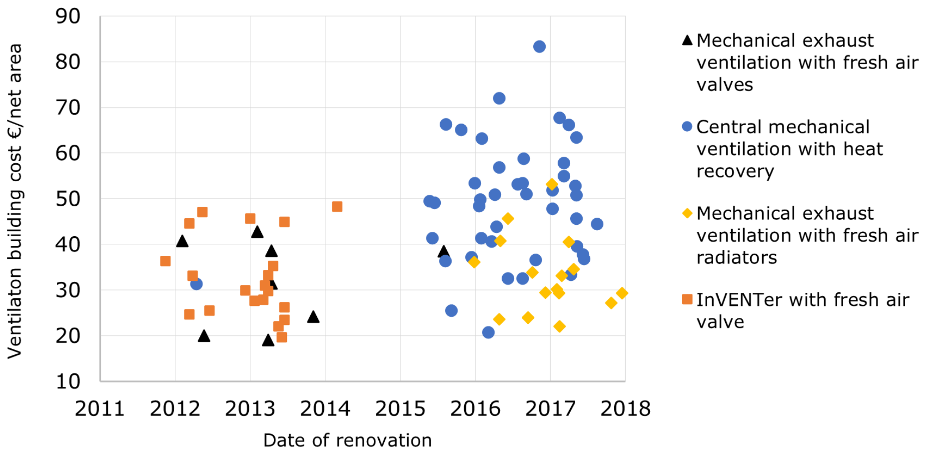

Figure 3. Common mechanical ventilation solutions.

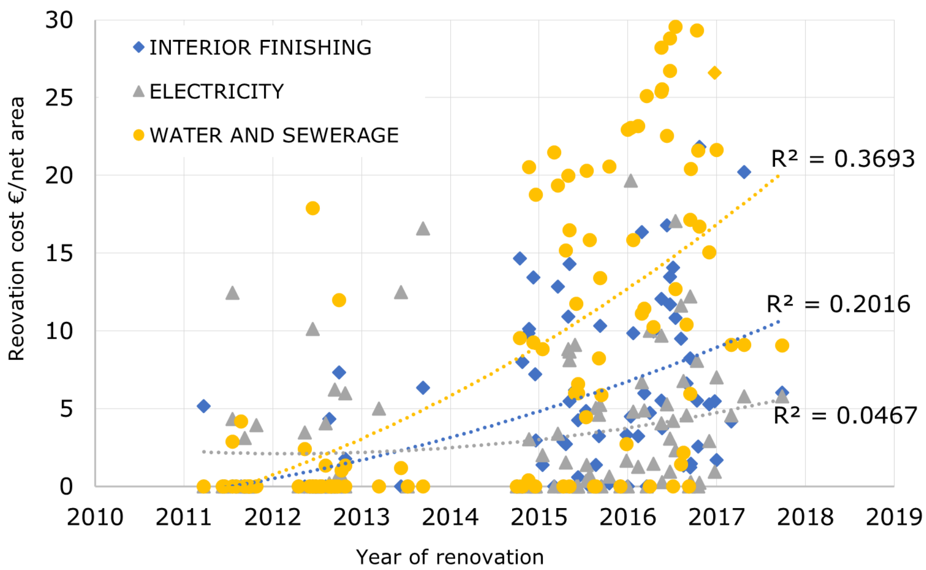

Figure 4. Cost of added renovation works during second grant scheme period.

additional works that were not previously performed or were performed less invasively (primarily interior finishing).

The cost of building an apartment-based 2-pipe heating system largely depends on the condition of the existing system and the renovation work carried out previously. Price variability is high, as the scope of work can be very different. The statistical t-test resulted in p value of 0.178, which indicates that there is a small probability of a statistically significant difference between prices in the total population, but this did not emerge due to high price variability when examining the sample. The more comprehensively the heating system needs to be renovated, the more expensive is the construction cost of this solution.

3.3. Mapping of added renovation works

Figure 4 describes which components the price increase consists of and how large the effect of these components have on the cumulative price increase. The exponential regression line well describes the significant increase in water supply and sewerage prices ($R^2 = 0.37$), slightly less, but also the prices of interior finishing works have increased exponentially. Added to that, the significant price increase comes from the addition of projects that have decided to reconstruct electricity systems in public areas. In other words an increase in the integrity of the works results in higher construction prices.

To summarize the share of the above-mentioned works in the price increase of renovation, in the first period the works related to interior finishing averaged 1 €/net area, in the second period already 8.3 €/m^2 (growth of 830 %, share in the total renovation cost 2.3 %). Water and sewerage work cost raised form 1.6 €/m^2 in the first period to 15.3 €/m^2 in the second period (growth of 956 %, share in the total renovation cost 4.4 %). High-current works costs surged form 2.5 €/m^2 to 4.5 €/m^2 (growth 180 %, share in the total renovation cost 1.7 %).

3.4. Energy ambitions

The energy savings found based on the weighted specific energy use of residential buildings in the second period range from 15-55 % and the correlation ($r = 0.0302$) shows that there is only a minor positive relationship between construction costs and energy savings.

There is also some increase in the energy efficiency ambition within the second period, but it is so small that it can be statistically random. On average, renovation works achieve energy savings of 38 %. Which is below the 50 % energy savings stated in the long-term renovation strategy[2]. We could not confirm that based on actual post-renovation energy uses such high energy savings were achieved on average.

4. Discussion and conclusions

The starting point of the search was the observation that renovation prices have increased 100 percent between 2010 and 2018 while construction price index for new build only grow 14 percent during that time. Therefore, it was evident that there are specific reasons for renovation prices to grow.

For understanding the causes for price change, we observed a sample ($n = 112$) of renovations that were supported by state renovation grant ($n = 561$) and were therefore carefully documented by grant manager. While the price information was obtained from procurement bidding documents, technical renovation solutions were gathered by analysing project designs of the sample buildings.

We observed that housing associations were quite modest at investment size during the beginning of the grant programme. Therefore, those constructions were significantly cheaper than renovations in later stages. Energy conservation ambitions also were mediocre and contractors lacked sufficient experience to deliver deep energy renovations. We must also note that enterprises that started to offer the renovation services were mostly newly established while experienced new builders were cautious about entering the renovation market. Gradually the deep energy renovations established itself as rational and working concept and more ambitious energy saving decisions were made. This, however, increased the project prices.

To run for state grant, one had to comply with the technical and quality requirements that were established for achieving energy efficiency targets. We observed that the changes in grant requirements in 2015 added several eligible construction tasks and allowed additional indirect energy saving works to benefit from the grant programme. More importantly, the highest ambitions in efficacy were rewarded with even higher share of subsidy, mainly to boost integrated renovations. This in turn resulted with the adoption of more expensive solutions and additional works pushed the average prices around 40 % higher compared to the previous stage in 2010–2014.

At the beginning of the study, there was speculations that renovation grants could over-stimulate the market and induce price rally because of the significant increase of supply. While this is quite valid and obvious notion, however, we could not establish such cause in our case, because price growth was mostly explained by additional works and unit prices of separate elements did not show significant price increase during the study period. Informal interviews furthermore demonstrated how supply chains shift profit from general contractor to subcontractors in hot market conditions where there is pressure from demand side for additional construction volume.

The latest average prices in 2020 for deep energy renovations are about 380 €/m^2. The performance and quality that is available for this price is significantly better than the renovations a decade ago and fulfilling the renovation ambitions for colder climates like Eastern Europe and Scandinavia.

In terms of planning state funds and estimating overall renovation investment need, there are still some studies necessary. For example, we observe trends form onsite renovations to prefabricated elements. However, currently such methods are more expensive than traditional fully onsite renovation. Some latest pilots in Estonia indicate for about 500 €/m^2 for prefabrication. It is expected as larger volumes and automation could eventually lower the costs but this is yet to be observed. This, however, calls for new inquiries for understanding the price impact of emerging renovation technologies.

On the other hand, we see some examples of ambitious pilot project to test the limits of current renovation technology. Renovation prices in innovation projects of *SmartenCity* [8] and *MoreConnect* [9] reached almost 800 €/m^2. If there is a trend to move towards such projects, renovation prices will most certainly exceed the level of growth of the new build again.

As the planning of renovation strategy is influenced by renovation costs, we suggest analyst and planners to have a deeper look into the causes of price change in their region. By understanding the price change, one reduces the uncertainty in planning for carbon neutrality.

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References

[1] EU COM/2020/662 final. A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives. Brussels, 2020. [2021-07-09]. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0662

[2] Ministry of Economic Affairs and Communications. Long-term strategy for building renovation. Tallinn, 2020. 89 p.

[3] K. Kuusk, T. Kalamees. Estonian grant scheme for renovating apartment buildings. *Energy Procedia* **96**:628–637, 2016. https://doi.org/10.1016/j.egypro.2016.09.113

[4] S. D'Oca, A. Ferrante, C. Ferrer, et al. Technical, financial, and social barriers and challenges in deep building renovation: Integration of lessons learned from the H2020 Cluster Projects. *Buildings* **8**(12):174, 2018. https://doi.org/10.3390/buildings8120174

[5] P. Tuominen, K. Klobut, A. Tolman, et al. Energy savings potential in buildings and overcoming market barriers in member states of the European Union. *Energy and Buildings* **51**:48–55, 2012. https://doi.org/10.1016/j.enbuild.2012.04.015

[6] K. Kuusk, T. Kalamees. Retrofit cost-effectiveness: Estonian apartment buildings. *Building Research & Information* **44**(8):920–934, 2016. https://doi.org/10.1080/09613218.2016.1103117

[7] L. Lihtmaa, T. Kalamees. Preliminary assessment of preconditions to deliver carbon neutrality in apartment buildings by 2050. *E3S Web Conferences* **172**:18004, 2020. https://doi.org/10.1051/e3sconf/202017218004

[8] R. Ahas, V. Mooses, P. Kamenjuk, R. Tamm. *Housing Estates in the Baltic Countries. The Urban Book Series*, chap. Retrofitting Soviet-Era Apartment Buildings with 'Smart City' Features: The H2020 SmartEnCity Project in Tartu, Estonia, pp. 357–375. Springer International Publishing, Cham, 2019. https://doi.org/10.1007/978-3-030-23392-1_17

[9] P. Pihelo, T. Kalamees, K. Kuusk. nZEB renovation with prefabricated modular panels. *Energy Procedia* **132**:1006–1011, 2017. https://doi.org/10.1016/j.egypro.2017.09.708