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Cost analyses of energy-efficient renovations of a Moscow residential district

Satu Paiho*, Rinat Abdurafikov, Ha Hoang

VTT Technical Research Centre of Finland, P.O. Box 1000, 02044 VTT, Finland

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ABSTRACT

This paper estimates the costs of adapting three different holistic energy renovation concepts both in the buildings and at the corresponding residential district in Moscow. The results represent a baseline for the decision makers when planning implementations of holistic energy renovations in Russian residential districts.

In the buildings, the estimated costs included both mandatory less energy efficient repairs and suggested energy efficiency improvements. At the building level, the costs of different renovation packages varied between €125 m^{-2} and €200 m^{-2} depending on the selected renovation package. The estimated district renovation costs include both the renovation costs of the buildings and the costs of improving district energy and water infrastructure. At the district level, the costs of the main cases per inhabitant varied between €3360 and €5200.

The net present values for different building and district level renovation packages for a 20-year period were also calculated using different interest rates and annual energy price growth rates. The results suggest that renovation of a district may be more feasible than renovation of individual buildings.

1. Introduction and literature review

For economies in transition such as Russia, the technical greenhouse gas (GHG) reduction potential for the building stock in 2030 ranges between 26 and 47% of the national baseline (Ürge-Vorsatz & Novikova, 2008). About 60% of Russia's multi-family apartment buildings are in need of major capital repair (IFC & EBRD, 2012). This also offers an opportunity to reduce the environmental load of energy used in buildings and thus improve the sustainability of existing cities and neighbourhoods.

Retrofit should comply with the sustainable development requirements (Raslanas, Alchimoviene, & Banaitiene, 2011). Often, a main component of the sustainable retrofit decision is to reduce costs and increase the return on the retrofit investment. However, in certain situations where existing buildings are in disrepair and in need of major retrofit to enhance their service lives, building owners should not necessarily choose sustainable retrofit projects based on the return on investment alone (Menassa & Baer, 2014). Gorgolewski, Grindley, and Probert (1996) point out that economic indices show only comparative energy benefits, and acknowledge that in practice other non-energy considerations may well prove to be the deciding factor in determining the nature of the refurbishment to be undertaken. Anyway, it is vital to estimate the costs and benefits of different renovation solutions before making any decisions.

In Russia, the multi-family apartment buildings are typically heated with district heating (The International CHP/DHC Collaborative, 2009). Due to the technical structure of the district heating used in Russia (Eliseev, 2011), the heating cannot usually be controlled in the buildings. Then, improving the energy-efficiency solely in buildings seldom reduces the heating energy production and the resulting primary energy consumption. So, in order to support the sustainable development in Russian residential districts whole districts, instead of just single buildings, should be renovated holistically including renovations of the related infrastructure.

Previous recent studies (Paiho et al., 2013; Paiho, Hoang, et al., 2014) show remarkable energy saving potentials of a Moscow Soviet-era residential district by adapting different holistic energy renovation concepts both in the buildings and at the district level and taking into account the whole energy chain from production to consumption and thus considering not only building scale renovations, but also improvements on the energy supply systems. In the buildings, the concepts focused on measures reducing heating and electricity demand, reducing water use, and improving ventilation. At the district level, the focus was in improving the related energy and water infrastructure as well as introducing energy production

* Corresponding author. Tel.: +358 50 3315160.
E-mail address: Satu.Paiho@vtt.fi (S. Paiho).

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from renewable sources in the most advanced concepts. In addition, Paiho, Hoang, et al. (2014) analyze the emissions of different energy production scenarios. Even though the examinations were made as case studies to one pilot area, their results can be generalized to other similar residential areas existing in Moscow as well as in other locations and countries including Soviet-era residential buildings.

This paper continuous the work even further by assessing the feasibility of the different building and district energy renovation concepts in the same pilot area in monetary terms and testing the profitability of the renovation solutions over a 20 year period. We also test if it is possible to provide some baseline cost data, which does not exist at the moment, for the decision makers in charge of the potential implementation of such holistic district renovations.

1.1. Literature review

Even research from the 1990s indicates the need for energy-efficiency improvements of the Russian housing (Martinot, 1998; Opitz, Norford, Matrosov, & Butovsky, 1997). Still, several recent references (Bashmakov, Borisov, Dzedzichek, Gritsevich, & Lunin, 2008; Filippov, 2009; Garbuzova & Madlener, 2012; Masokin, 2007; the World Bank and IFC, 2008; UNDP & GEF, 2010; UNDP, 2010) show considerable potential for improving energy-efficiency in Russian residential buildings and the related infrastructure in districts. However, there are only a few scientific papers related to energy renovations of Russian residential districts (Paiho et al., 2013; Paiho, Hoang, et al., 2014). Even less work is reported about the economic analyses of the energy-efficiency measures or energy renovations of Russian residential districts. Some partly relevant literature is available from Soviet-era residential buildings from other countries. In the following, this literature related to cost analyses made about renovating Soviet-era apartment buildings is shortly reviewed and reference data and information given for assessing the results of this study in a relevant context.

In a general level, Bashmakov (2007) assesses that technologies already applied in Russia may cost-effectively halve its energy consumption. Bashmakov (2009) estimates energy-efficiency potentials and costs of various energy supply and consumption sectors in Russia. Incremental capital costs of implementing the energy efficiency potential were assessed at the following values: in power generation at about $US 106 billion; in district heating renovation at $US 27 billion; in pipeline transportation at $US 23–30 billion; and in buildings at $US 25–50 billion. These numbers show the significant modernization markets even if the exact values may differ.

One of the few recent economic investigations for the capital repair of Russian residential buildings, conducted in 2011 (IUE, 2011), suggests three different packages for capital repairs, which are different in terms of investment costs and estimated savings. All the packages include both basic improvements, such as repairing or replacing worn-out building parts, systems (including elevators) and devices, and energy-efficiency improvements, such as thermal insulation, space heating controls and consumption meters; interestingly, seemingly no improvement in ventilation systems are proposed. However, for example Biekša, Šiupšinskas, Martinaitis, and Jaraminienė (2011) claim that insufficient attention to the problem of ventilation could lead to large-scale and long-term health problems, and suggest obligatory installation of (mechanical) ventilation system for renovations. The investment costs of the packages estimated by IUE (2011) varied between €38 and €168 m^{-2} (considering RUR40 = €1) and the achieved maximum savings were 27% for the heating consumption, 11% for the electricity consumption, 18% for the gas consumption and 22% for the water consumption.

Kredex (2008) reports reconstruction of a Soviet-era apartment building in Tallinn, Estonia. The project included renovation of the roof, replacing windows, renewal of balconies, insulation of outer walls, renewal of the heating system, implementing electricity meters, and installing a metering and calculations system for sharing the heating costs between residents. The total costs were €128 m^{-2}. The reported savings from the energy audit before the renovation was around 50%, while measurement results after showed around 40%. Other benefits from the reconstruction were building aesthetics and comfort, since the inhabitants could adjust the heating according to their needs.

Zavadskas, Raslanas, and Kaklauskas (2008) assess the financial profit from several renovation scenarios of Soviet-era buildings in Vilnius. Renovating buildings does not only result in the benefit of reduced energy demand, but also improves the state of building structures and prolongs the expected lifetime of the building, thus increasing its market value. The need to generate several investment cases in order to determine a profitable solution for the renovation of a building is also highlighted. Even though neighbourhoods are considered, only improvements to buildings are analyzed. In addition, none of the suggested retrofit investment packages include renovation of ventilation systems.

Biekša et al. (2011) discuss about the multi-apartment renovation process in Lithuania. As a part of a case study of a group of residential buildings in Birštonas determination of the economic feasibility of the renovation process was done. Project payback time equalled to 16 years.

Raslanas et al. (2011) highlight the need to define retrofit scenarios for Soviet-era residential areas in Lithuania based on relevant strategies including the retrofit measures, their priority and their potential effect. However, the authors do not suggest the scenarios nor analyze any effects.

Ferrante (2014) presents alternative ways of investigating, planning, creating and managing sustainable urban environments, also by exploring the possibility to use energy retrofitting options as a social form of integration. The performed technical–economical evaluation demonstrates that energy efficiency in residential urban complex can be considered as an extraordinary opportunity to restore environmental, social and urban quality. The study was done in the Mediterranean context but the main ideas can be applied elsewhere too. Ferrante (2014) also discusses involvement of business investors, public bodies and local communities in the common efforts of decreasing of energy consumption in urban environments.

In order to introduce private investors, propose suitable business and financing models for renovating Russian residential buildings and districts, there is a need for baseline cost estimates and economic analysis. The literature review shows that the energy saving potential in residential districts built with Soviet-era buildings is huge, the same is true for amount of investments required, and this suggests there must be a significant market potential for businesses. At the same time, while there is little information available on renovation of Soviet-era buildings and almost no studies of district-level renovations. In addition, the costs and energy saving estimates for Soviet-era buildings from available literature usually do not include scenarios with mechanical ventilation systems, which are capable of ensuring good indoor air quality throughout whole year and enable heat recovery. This paper aims to contribute to existing knowledge by estimating investment costs of several renovation packages consisting of improvements in both buildings and district technical infrastructure, calculating net present values, as well as performing an analysis of sensitivity to such parameters as discount rate and energy price growth rate.