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A case study from Moscow

Satu Paiho | Rinat Abdurafikov | Ha Hoang | Malin zu Castell-Rüdenhausen | Åsa Hedman | Johanna Kuusisto

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Liiketoimintanäkökulmia neuvostoaikaisten asuinalueiden energiatehokkaaseen korjaamiseen. Tapaustutkimus Moskovasta. **Satu Paiho, Rinat Abdurafikov, Ha Hoang, Malin zu Castell-Rüdenhausen, Åsa Hedman & Johanna Kuusisto.** Espoo 2014. VTT Technology 154. 117 p.

Abstract

The majority of Russian housing stock was built after World War II and needs modernization. About 60% of the Russian multi-family apartment buildings are in need of capital repairs. When attaching energy-efficiency improvements to the mandatory repairs, implementing these is cheaper than taking separate measures.

District heating is mainly used for space heating in Russian apartment buildings. Due to the technical structure of the district heating used in Russia, energy renovations of single buildings seldom lead to reduced energy production. Energy production demands are reduced only if the residential districts and their various utilities and networks are renovated holistically. This publication examines the business aspects for energy-efficient renovations of Russian residential districts. One Moscow district is used in part as a case example.

In a previous study, alternative energy renovation concepts, called Basic, Improved and Advanced, reducing the environmental impacts of the residential apartment buildings in the Moscow case district were developed and analyzed. In this study, the different renovation concepts were analyzed from an economic point of view. At the building level, the costs of different renovation packages varied between €125/m^2 and €200/m^2 depending on the extent of the selected renovation package. All the building level packages covered improvements of external walls, windows and doors, upper ceiling, basement, ventilation, heating system, water and wastewater, electricity, gas, metering, and other improvements and costs but the selected products and solutions varied from basic through improved to advanced ones.

The district renovation concepts were aligned with the building renovation packages, and the costs of building renovations were included in the costs of improving district energy and water infrastructure in the pilot Moscow district. At the district level, the cost analyses covered district heating distribution and main pipe replacements, district heating substations, water distribution and main pipes, sewage water distribution and main pipes, electricity and main grid renewals and transformer substations. In addition, light bulbs for street lighting were included in all the packages except the basic one. Also, some renewable heating production alternatives were included in the two most advanced packages, and then district heating solutions were excluded from the calculations. At the district level, the costs per inhabitant varied between €3,360, €4,090 and €5,200 for the Basic, Improved and Advanced renovation packages, respectively. The costs of the additional alternatives per inhabitant were over €6,090.

In addition to the costs, 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. Both at the individual building level and the district level with most combinations of the interest rate and annual energy price growth rate the Improved renovation package turned out to be the most profitable. At the building level, the Advanced renovation package was the most profitable with low interest rates and high annual energy price growth rates, and the Basic package with high interest rates and lower annual energy price growth rates. At the district level, the Basic renovation package is the most profitable only with low interest rates and low annual energy price growth rates. At the district level, the Advanced renovation package is the most profitable even with low annual energy price growth rates and moderate interest rates. The most advanced packages including renewable energy production solutions are profitable only with low interest rates and high annual energy price growth rates.

Financing renovations is often a major barrier in any country. This topic is also addressed in this publication. Most of the housing units in apartment buildings are privately owned due to the free privatization after the Soviet collapse. However, no sustainable form of self-financing apartment renovations has existed, and former lessors of residential units still have the obligation to carry out capital repairs. Existing and new financing mechanisms, including public-private-partnership (PPP), are introduced in the publication. Regional and local budgets are still the main financing mechanisms for capital repairs in Russia.

This publication also examines possible business models for energy-efficient renovations of residential districts in Russia. An important part of this is the stakeholder analysis carried out by the relevant actors involved in district renovations in Russia. None of the business models analyzed as such suit holistic district renovations. Perhaps, even a completely new actor is needed to take over. Because of their complexity and scope, district renovations require cooperation of a wide range of stakeholders.

Keywords district renovation, efficient districts, energy-efficiency, business models, feasibility assessment, Russia

Liiketoimintanäkökulmia neuvostoaikaisten asuinalueiden energiatehokkaaseen korjaamiseen
Tapaustutkimus Moskovasta

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Tiivistelmä

Suurin osa Venäjän asuntokannasta on rakennettu toisen maailmansodan jälkeen ja tarvitsee uudistamista. Noin 60 % Venäjän asuinkerrostaloista on suurten peruskorjausten tarpeessa. Energiatehokkuuden parantaminen on halvempaa pakollisten korjausten yhteydessä kuin erillisinä toimenpiteinä.

Venäjän asuinkerrostaloja lämmitetään pääasiassa kaukolämmityksellä. Venäjällä yksittäisten rakennusten energiakorjaaminen harvoin pienentää lämmitysenergian tuotantoa, koska kaukolämmitysratkaisut ja -kytkennät poikkeavat suomalaisista järjestelmistä. Energian tuotantotarve vähenee vain, jos samalla korjataan kokonaisvaltaisesti sekä asuinrakennukset että koko asuinalueet ja niiden energia-, vesi- ja jätehuoltoinfrastruktuuri. Tämä julkaisu tarkastelee liiketoimintanäkökulmia Venäjän asuinalueiden energiatehokkaaseen korjaamiseen. Moskovaa käytetään osittain esimerkkinä.

Ympäristövaikutusten pienentämiseksi aikaisemmassa tutkimuksessa kehitettiin ja analysoitiin vaihtoehtoisia energiakorjauskonsepteja, nimeltään ”perus”, ”parannelt” ja ”kehittynyt”, neuvostoaikaisille asuinkerrostaloille ja moskovalaiselle esimerkkiasuinalueelle. Tässä julkaisussa eri korjausvaihtoehtoja tarkastellaan taloudellisesta näkökulmasta. Rakennustasolla korjausvaihtoehtojen hinnat asuinneliötä kohden vaihtelivat 125 €/m^2 ja 200 €/m^2 välillä riippuen valitusta korjauspaketista. Kaikki rakennustason korjauspaketit sisälsivät ulkoseinien, ikkunoiden, ovien, yläpohjan, kellarin, ilmanvaihdon, lämmitysjärjestelmän, vesi- ja jätevesijärjestelmien, sähkölaitteiden ja -järjestelmien, kaasuverkoston, mittaroinnin ja yleisten tilojen parantamisen, mutta valitut tuotteet ja järjestelmät vaihtelivat eri paketeissa.

Asuinaluetasolla tarkasteltiin moskovalaisen esimerkkialueen kaikkien asuinrakennusten ja alueen koko energia- ja vesi-infrastruktuurin korjausvaihtoehtojen kustannuksia. Aluetason järjestelmistä mukana olivat kaukolämpöputket, lämmönjakokeskukset, vesi- ja jätevesiputket, sähkö- ja kantaverkot sekä muuntamot. Lisäksi katulamput sisältyivät kaikkiin muihin paketteihin paitsi perusvaihtoehtoon. Edistyksellisimpiin vaihtoehtoihin sisällytettiin myös lämmöntuotantoa uusiutuvilla vaihtoehdoilla, jolloin kaukolämpöratkaisut jätettiin pois laskelmista. Aluetasolla kustannukset asukasta kohden olivat peruspaketille 3 360 €, parannellulle paketille 4 090 € ja kehittyneelle paketille 5 200 €. Edistyksellisimpien vaihtoehtojen kustannukset asukasta kohden olivat yli 6 090 €.

Kustannusten lisäksi laskettiin eri rakennus- ja aluetason vaihtoehdoille 20 vuoden ajalle nettonykyarvot eri korkokannoilla ja vuosittaisella energianhinnan kasvuprosentilla. Sekä rakennus- että aluetasolla ”paranneltu” korjauspaketti osoittautui kannattavimmaksi useimmilla korkokannan ja energianhinnan kasvuprosentin yhdistelmillä. Rakennustasolla ”kehittynyt” vaihtoehto oli kannattavin alhaisella korkokannalla ja korkealla energianhinnan kasvuprosentilla ja perusratkaisu korkealla korkokannalla ja matalalla energianhinnan kasvuprosentilla. Aluetasolla ”kehittynyt” ratkaisu oli kannattavin jo matalalla energianhinnan kasvulla ja maltillisilla korkokannoilla. Kehittyneimmät uusiutuvaa energiantuotantoa sisältävät vaihtoehdot olivat kannattavia vain matalalla korkokannalla ja korkealla energianhinnan kasvulla.

Korjausten rahoittaminen on usein suuri este missä tahansa maassa. Julkaisu käsittelee myös tätä aihetta. Venäjällä useimmat kerrostaloasunnot ovat asukkaiden omistuksessa, koska ne yksityistettiin ilmaiseksi Neuvostoliiton romahtamisen jälkeen. Kestävää mallia remonttien omarahoitukseen ei ole kuitenkaan ollut olemassa, ja entisillä vuokranantajilla on edelleen velvollisuus toteuttaa suuria korjauksia. Julkaisussa käsitelläänkin uusia ja nykyisiä rahoitusmekanismeja, muun muassa julkista ja yksityistä kumppanuutta (PPP). Venäjällä julkinen rahoitus on edelleen tärkein rahoitusmekanismi suuriin korjauksiin.

Julkaisussa tarkastellaan myös energiatehokkaan aluekorjaamisen mahdollisia liiketoimintamalleja Venäjällä. Tärkeä osa tätä on sidosryhmäanalyysi aluekorjaamisen toimijoista Venäjällä. Yksikään analysoitu liiketoimintamalli ei sellaisenaan sovellu kokonaisvaltaiseen aluekorjaamiseen. Ehkä tarvitaan jopa täysin uusia toimijoita. Joka tapauksessa aluekorjaamisessa tarvitaan toimijaverkostoja kokonaisuuden monimutkaisuuden takia.

Avainsanat district renovation, efficient districts, energy-efficiency, business models, feasibility assessment, Russia

Preface

The Russian apartment building stock is old and its energy efficiency is poor. About 60% of the multi-family apartment buildings are in need of major capital repairs. Building renovation is an important opportunity to upgrade buildings in order to meet current and future energy- and eco-efficiency requirements, including people's increasing needs for improved indoor air quality.

In Russian residential districts, building renovations alone are seldom sufficient, since typically the district heating supply cannot be controlled. So, if only building structures and systems are renewed, the same amount of heating energy will be produced and no energy savings will be achieved. Hence, it is important to consider renovation and modernization of whole residential districts. The district renovations would include renovations of the buildings and all their technical systems, modernization of heating energy production and distribution systems, renovation of local electricity production and transmission systems, renewal of street lighting, renovation of water and wastewater systems, and modernization of waste management systems.

This publication summarizes the results of the economic analyses performed and the business aspects considered in the ModernMoscow project. The project concentrated on building renovation in the Moscow District. The main objective was to prepare a wide feasibility study for the energy-efficient and sustainable renovation and modernization of a selected Moscow building stock. A previous VTT publication summarized the technical analyses performed on the project. Even though the analyses were carried out for a Moscow residential district, similar districts exist widely across Russia. In addition, comparable building typologies exist extensively throughout Eastern Europe. So, after updating the results to different climate conditions, similar solutions and concepts could be adapted much more widely.

The project was funded by the Ministry of Foreign Affairs of Finland. Since the climate in Finland is rather similar to that in Moscow and in the cold regions of Russia, many tried and tested building and energy solutions used in Finland could also be utilized there. In addition, Finnish experiences of cold climate buildings could be of use in updating Russian and East-European residential districts to become more energy-efficient.

In a technical sense, there is clearly a huge market for Finnish companies to respond to the great renovation needs in Russia. However, there are issues other than technical ones that need to be clearly analyzed before successfully entering the market. Financial and business aspects need to be understood too. The publication also includes chapters on the financing and the business model considerations of district renovations.

Contents

1. Introduction

Our globe has limited resources for supporting a growing population. According to some estimates, currently humankind uses approximately 1.5 times more resources than the rate of their renewal (Global Footprint Network 2013). Reduced use of energy, for example, through improved energy efficiency in existing building stock, is one of the main ecological goals together with reduced CO_2 emissions and increased use of renewable energy sources.

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). The corresponding economic potential ranges between 13 and 37% and the market potential is 14%, respectively. Possible measures with the largest potential are:

1. Pre- and post-insulation and replacement of building components, especially windows
2. Efficient lighting, especially shifting to compact fluorescent lamps (CFLs)
3. Efficient appliances such as refrigerators and water heaters.

Russian leaders have admitted that the modernization of the economy will not be possible without improvements in energy efficiency. This is demonstrated by the adoption of Federal Law No. 261-FZ "On Energy Saving and Energy Efficiency…", which clearly represents a significant move towards an increase in public awareness of the importance of energy saving, and presents substantial business opportunities for companies working in various sectors of the economy. (CMS 2009.)

Estimates suggest that Russia could improve its energy efficiency by 45% compared with 2005. Full use of the potential for electrical energy savings could reduce consumption by 36%; a more efficient use of thermal energy and reduction of losses in heating networks could save up to 53% of heat use; the potential for reducing natural gas consumption was estimated at 55% of the domestic consumption level in 2005, much exceeding the annual level of Russian gas exports in 2005–2008. (UNDP 2010.)

Around 14% of Russia's overall electrical energy consumption is attributable to lighting, corresponding to 137.5 TWh per year. The total lighting energy savings potential in Russia is considerable at over 40% or 57 TWh per year. (UNDP & GEF 2010.)

Russia has the world's biggest CHP (Combined Heat and Power) sector of any single country, with over 80 GWe of installed capacity. CHP accounts for 55% of the country's thermal capacity, and 37% of the total installed capacity. District heating (most of which is CHP) accounts for 70% of total heat supply. Much of the CHP capacity is technically and/or morally obsolete. While global efficiency values (approx. 72%) are borderline acceptable, electrical efficiency rarely reaches 20%. Worse, up to 20–25% of heat output is lost through dilapidated distribution systems, which are increasingly unreliable and need to be replaced. (Masokin 2007.)

Great technical opportunities for reducing expenditure on fuel and energy are available in Russian district heating systems; large-scale implementation of these in practice is the top priority objective, which cannot be achieved without adequate legislative and administrative support, including stimulation of energy conservation and attraction of advanced foreign technologies (Filippov 2009). Korppoo and Korobova (2012) address the main problems of the Russian heating sector: tariffs that fail to cover the costs of production and distribution, the massive need for modernization and the low quality of service. The investment needs for rehabilitating the district heating systems in Russia are estimated at $70 billion by year 2030 (Nuorkivi 2005).

It is estimated that more than 290 million m^2 or 11% of the Russian housing stock needs urgent renovation and re-equipment, while 250 million m^2 or 9% should be demolished and reconstructed (United Nations 2004). Walls and roofs of residential buildings have degraded due to inadequate repair over time (UNDP 2010). About 11% of Russian residential space has not been renovated for over 30 years (Interfax-CAN 2013). Some 58–60% of the country's total multi-family apartment buildings are in need of extensive capital repair, rising to 93–95 per cent in those apartment blocks with an average age of no less than 25 years (International Finance Corporation & European Bank for Reconstruction and Development 2012). In 2009, the total costs of capital repairs of apartment buildings in Russia amounted to 137.5 billion rubles (€3.14 billion) (IUE 2011a).

Technically, there is an extensive energy saving potential in Moscow residential districts (Bashmakov et al. 2008). Russia has vast energy resources (oil and gas), and it would be economically viable to export surplus energy rather than use it inefficiently domestically. Apart from energy-efficiency, high-quality renovation of buildings also improves the quality of indoor environment. Better energy efficiency combined with the use of renewable energy sources can also improve energy self-sufficiency in housing areas or individual households.

Natural gas and electricity are used for space heating not only in locations with decentralized heat supply, but also to meet minimum sanitary requirements for indoor comfort in settlements where heat supply systems fail to provide good quality services (Bashmakov 2009). In summertime 2 or 3 weeks' hot water cut-offs for district heating networks maintenance force residents to use electricity and natural gas so as to produce hot water for sanitary use. So, improving the efficiency of both district heating and buildings would allow for savings not only of district heat, but also of some electricity and natural gas.

The residential sector offers the greatest potential for improving energy efficiency in Russia (the World Bank & IFC 2008). Russian average heating energy intensity for multi-family, high-rise buildings is estimated at 229 kWh/m^2/year, whereas for new, multi-family high-rise buildings in Russia at 77 kWh/m^2/year.

The energy saving potential of Russia’s residential buildings exceeds 55% of their total energy consumption (UNDP 2010). Some 11 billion KWh could be saved each year merely by replacing 450 million incandescent lamps now used by the housing sector with luminescent lamps.

1.1 Renovation markets of Moscow residential districts

According to the most recent data, over 95% of Moscow dwelling space has been built since World War II, of which 52% of the residential buildings were built during 1951 to 1981 and 43% of the housing was built in 1981 or later. In practice, almost all brick, and large-panel buildings constructed before 1981 have a wear rate of more than 31 percent, i.e. they are subjects for capital repair (City of Moscow 2011). According to Rosstat (Construction in Russia 2010), there were over 3.8 million apartments in 39.8 thousand residential buildings in Moscow in 2009. The total floor area was 214 million m^2, and the average floor area of an apartment in Moscow was 55.8 m^2. As of 2012 the need for renovations was estimated at 108 million m^2 (over half of total floor area) in 26.3 thousand buildings based on their age (City of Moscow 2011).

In the Russian Federation, most of the apartment buildings were constructed between 1960 and 1985 during the Soviet era, and as a result the urban housing stock today consists mainly of a few standard building types (United Nations 2004). Each building series represents a specific building design (Opitz et al. 1997, Raslanas et al. 2011). From an architectural perspective, residential areas with typical apartment buildings look monotonous, lack vitality, and are less aesthetically pleasing (Raslanas et al. 2011).

In these buildings, natural ventilation dominates. Almost no buildings have mechanical ventilation (Bobrovitskiy & Shilkin 2010, Keikkala et al. 2007). Changing the inner layout of panel houses is hardly possible because the spacing between the external and internal bearing walls is narrow (Zavadskas et al. 2008, Raslanas et al. 2011).

Kuznetsova et al. (2011) assess that energy-saving technologies have a great market potential for technology developers, equipment designers, manufacturers, and investors. This concerns both the energy production side and the demand side in terms of demand management and regulation. However, Kuznetsova et al. (2011) point out that just a single product is unlikely to achieve strong representation, but rather a complex package of technical and instrumental solutions with a clear demonstration of achievable results will have much better market acceptance. The assessment was made for the St. Petersburg region but could be extended to Moscow as well.

Russia has enormous potential for renewables, but their current share in total electricity production is as little as 0.9%, excluding large-scale hydro power plants (Renewable energy use in Russia, 2009) and about 3% of the total primary energy supply (IEA Energy Statistics 2011a, 2011b). The statistics available (IEA Statistics 2011) suggest that the amount of heat produced using renewables is less than 0.5%, but Russia is not an impressive country in terms of photovoltaic development and number of installations. But, the annual insolation level in the Moscow region is the same as in Germany (Frankfurt), which is a leading country in terms of photovoltaic development, and it may even be somewhat higher during spring and summer months. These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center Surface Meteorological and Solar Energy (SSE) web portal supported by the NASA LaRC POWER Project (NASA Atmospheric Science Data Center 2013). The main disadvantages of photovoltaic applications are an insufficiently developed support structure for all renewable energy sources, including photovoltaics, and existing grid infrastructure, which prevents photovoltaic systems from being an easy grid integration.

Various other products are also needed when improving the energy efficiency of buildings and residential districts. They include, for example, windows and doors (Grishankova 2010), building automation systems (CABA 2007), lighting systems and products (UNDP & GEF 2010), heating systems and insulation products (Lychuk et al. 2012).

Overall, the Russian lighting market (UNDP & GEF 2010) is estimated to be worth around €1.6 billion (with €1.1 billion spent on lighting systems and fixtures, and €0.5 billion on light sources). The total market for electric lamps and lighting equipment products in Russia grew at an average annual rate of 10% over the 2007–2012 review period (Euromonitor International 2013). In the residential sector, the penetration rate of energy efficient light sources (CFLs) is very low compared to any western country (Zissis et al. 2010).

1.2 Waste management markets of Moscow residential districts

Waste management has become one of the most critical economic and environmental problems in Russia. Municipal solid waste (MSW) treatment is inefficient. Almost 96% of MSW is neither recycled nor re-used, but simply transported to huge landfills or, worse yet, thrown on illegal dumps. But now the Russian government has focused attention on problems related to waste management. The recycling target for industrial and municipal solid waste is 70% by 2020. At the moment, the Russian waste management market is still in an early stage of development, thus offering strong growth opportunities. The annual market volume of waste transportation and disposal is estimated as €1.25–1.5 billion. (Finpro BRUC 2013.)

It is expected that government support will largely drive the market towards more efficient operation in terms of waste processing and environmental safety. The Russian government's interest in waste management increases the interest of private investors as well. The local government authorities are looking towards international investors and foreign companies for the development of waste treatment projects through Public Private Partnerships (PPPs). (Finpro BRUC 2013.)

Currently, there is no site sorting of waste, and sorting at treatment plants is done mainly manually. Recycling services are growing in Moscow; there is a demand for waste management and waste processing technologies and services. The market is influenced by (Finpro BRUC 2013):

- The waste strategy of Moscow: 90% of Moscow waste is processed at 19 new waste recycling facilities (including landfills) that are to be built in the Moscow oblast by PPP projects.
- Change in waste composition due to economic development of the area; an increased share of packages, paper and plastic as well as organic waste.

2. Energy-efficient renovation of Moscow apartment buildings and residential districts

Paiho et al. (2013) describe three different renovation concepts for improved energy efficiency for both a typical Moscow apartment building and a typical residential district. The energy consumption of the different renovation cases were calculated and compared to the estimated present state. Different energy production scenarios for the district were also produced. The annual emissions for each energy production scenario examined were estimated. The purpose was to assess how low emission values could be achieved by comparing and combining technologies of energy generation, and clarify which of the combinations presented would be better in terms of emissions produced. In the following, the core results are summarized in order to give an overview of the analyses and the background to Chapters 3, 4 and 5. The details can be read from the reference.

2.1 The housing district selected

A typical residential district was selected for analysis. The district selected mostly represents the 4th Microrayon of Zelenograd, Moscow (longitude 37º east and latitude 55º north). Zelenograd is located about 35 km to the north-west from Moscow City center. The district dimensions are approximately 1 × 0.5 km. It represents a typical residential district of Moscow and the Moscow region with high-rise apartment buildings constructed for the most part in the 1960s and 1970s. The district has district heating. Renovation of such buildings and districts may be needed in the near future.

The apartment buildings in the area can be divided into groups according to the building series: II-57, II-49, AK-1-8, II-18 and Mr-60, which are apartment buildings constructed between 1966 and 1972. Each building series represents a specific building design (Opitz et al. 1997). There are also a few other newer buildings, but since these analyses concentrated on modernization of buildings, these newer buildings were excluded from the studies. According to the initial analysis the most common building type II-18 was selected for further analyses since a comparison of the demands of the buildings showed only minor differences (Paiho et al. 2013).

In total, there are approximately 13,800 residents in the buildings included in the calculations. The total floor area of the buildings studied is 327,600 m^2. The number of residents is estimated based on the assumption that the average occupancy rate per flat is 2.7 persons (United Nations 2004).

2.2 Selected renovation concepts

Selection of the renovation concepts started with an analysis of the current state, which was based on a review of the available literature and on original design U-values. The latter makes the analysis of the current state, and consequently the savings, rather conservative.

Three alternative renovation concepts were selected for the analyses both at the building and at the district level and named Basic, Improved and Advanced. The renovation cases were adjusted in such a way that each of them results in an improvement on a previous one when it comes to total annual energy consumption. The building level cases had different values for the following characteristics: the U-values of building structures (outer wall, base floor, roof, windows and doors), ventilation, air tightness factor, lighting (indoor), electricity and water consumption.

The basic renovation refers to minimum mandatory repairs as well as easy-to-do retrofit measures, making use of inexpensive products, available on the market, with modest energy properties. The improved renovation improves the thermal insulation of buildings to a level comparable with or higher than current Moscow requirements for new buildings and introduces exhaust mechanical ventilation, which ensures sufficient air exchange rate in apartments. The advanced renovation suggests use of even more progressive solutions, which were considered realistic.

The building level improvements included in the energy and emission analyses are listed in Table 1, the other building level renovation solutions are listed in Table 2.

At the district level, different energy renovation scenarios were analyzed in terms of energy demand and emissions. Each of the proposed Current, Basic, Improved and Advanced districts contained buildings with a corresponding level of renovation and additionally the improvements suggested in Table 3. It should be noted that the measures for space heating system adjustment in buildings are also included in Table 3.

Table 1. Building level renovation solutions included in the energy and emission analyses. If not otherwise stated, the improved and advanced concepts always include the solutions mentioned in the previous renovation.

Technology/ system	**Current status**	**Basic renovation**	**Improved renovation**	**Advanced renovation**
Structures: U-values (W/m^2K)				
• outer walls	1.1	0.5	0.32	0.15
• base floor	1.1	-	-	-
• roof	1.1	0.25	0.24	0.15
• windows and doors	2.9	1.85	1.5	1.0
Ventilation	Natural	Restoration of existing natural ventilation. Air inlet valves to ensure sufficient air exchange	Enhanced mechanical exhaust	Mechanical ventilation (supply and exhaust) with annual heat recovery efficiency 60%
Air tightness factor n50 (1/h)	6.5	4.0	2.0	< 2.0
Heating and hot water systems	Centralized regulation, no control over radiator temperature. Four-pipe system (centralized substations)	Replacement of radiators and pipes, pipe insulation, simple automated temperature regulators in buildings	Building heating substations and water heating (two-pipe system), thermostatic valves on radiators	
Electrical appliances and lighting		Energy efficient household appliances and lighting of public spaces	Energy efficient pumps and fans in new systems	Elevators – recovery breaking. Presence control of lighting in public spaces
Water supply systems (Consumption in l/day/occupant)	Old pipes and water appliances, building-level metering (272 / of which hot water 126)	Replacement of pipes, fixtures and appliances (160)	Installation of water saving fixtures and appliances. Remote meter reading (120)	Household-specific metering (100)

Table 2. Other suggested building level renovation solutions not included in the energy and emission analyses. If not otherwise stated the improved and advanced concepts always include the solutions mentioned in the previous renovation.

Technology/ system	Basic renovation	Improved renovation	Advanced renovation
Summer passive cooling	Venetian blinds	Windows with moderate solar heat gain coefficient	
On-site electricity production			Building-integrated photovoltaics
Water distribution/ piping system		Installation of remotely readable water meters (separate for cold and hot water)	Prefabricated, innovative piping solutions (may also include electrical wires and ventilation ducts)
Waste sorting	If enabled in the area: site sorting facilities for kitchens and waste collection areas		
Involvement of residents	Information to residents on energy-efficient lighting and appliances, water-efficient end-devices	Information on consumption and occupation patterns	Monitoring and benchmarking-based recommendations
Monitoring and operation		Communication infrastructure for real-time monitoring of energy and water consumption, remote meter reading	Smart meters integrated with building automation and monitoring systems

Table 3. District level renovation concepts compared to the current status. If not otherwise stated the improved and advanced solutions always include the solutions mentioned in the previous renovation.

Technology/ system	Current status	Basic renovation	Improved renovation	Advanced renovation
Energy production	Energy produced in large-scale plants, mainly using natural gas	Increasing energy-efficiency of energy generation processes	Reduction of emissions (e.g. change of fuel, or flue gas treatments)	Replacing fossil fuels with renewable energy sources (fuel cells, photovoltaic panels, heat pumps, etc.) and/or increasing plants' efficiency, e.g. increasing the share of CHP plants
District heating network (Heat losses, substations, flow/energy adjustment/ control)	Poor control High distribution losses	Replacing of distribution pipes (thus reducing distribution losses of district heating) Adding building-level substations and flow control valves		Heat generation plant is capable of adjusting production according to the variable heat energy demand. Heating network able to buy excess heat production from buildings, so-called heat trading (Nystedt et. al 2006) (for example excess solar heat production).
Electricity distribution	Electricity distribution networks design does not allow to feed locally produced electricity to the grid, one-way flow. In some cases networks operate close to their limits, low power factor possible, old equipment (e.g. transformers)	Replacement of old equipment and cables, power factor and harmonics compensation where necessary		The basic scenario & review of automation systems to allow for connection of distributed generation. Smart meters (in case of demand response and local controllable energy generation)
Lighting (outdoor)		Energy-efficient street lighting	Street lighting designed to avoid light pollution	Smart outdoor lighting (sensor driven), street lighting electrified with solar PV's

Water purification and distribution waste water collection and treatment	Drinking water not safe. High leakage rate in water and sewer networks. Improvement of sewage treatment efficiency where needed	Improved water purification technology. Refurbishment of water and sewer networks		Smart water network Block scale purification and treatment (to ensure safe local potable water and waste-water treatment)
Waste	Mixed waste collection > 60% municipal solid waste (MSW) landfilled (27% incinerated, 10% recycled)			Increased recycling and energy utilization: approx. 22% municipal solid waste (MSW) landfilled (24% incinerated, 54% recycled)
Flexible/ multi-functional use of spaces Dense city planning Transportation	Services are placed in nearby resident buildings, which reduces transportation needs. City structure is rather dense.	Safe cycle parking facilities at train and metro stations. Cycle lending system (bike pools)	Improved cycle routes, separating cycles from cars and pedestrians. Improved public transportation.	Charging points for electrical vehicles. Charging points with embedded PV panels.

2.3 Energy analyses of the alternative renovation concepts

2.3.1 Energy analyses of the building renovation concepts

The energy and water demand of a typical Russian apartment building (II-18) was calculated using the WinEtana building energy analysis tool developed by VTT Technical Research Centre of Finland. The tool calculated the building's energy flows based on structural properties, the characteristics of heating and ventilation systems, water use and drainage, and a set of electrical household appliances assumed to be in use in the building. The building energy and electricity consumption values were calculated for the current state and for the three renovation concepts (see Section 2.2).

The results of the calculations expressed in terms of annual energy consumption per floor area are summarized in Table 4 for each of the cases. The current annual heating energy consumption of the most common building type II-18 is 219 kWh/m^2,a and the annual electricity consumption is 47 kWh/m^2,a, respectively. The result is well in line with the study of The World Bank & IFC (2008). In each consequent (more advanced) renovation case the selected building consumes less heating energy than it does in the preceding one, but consumption of electricity is higher for the Advanced-case in comparison with the Improved-case. The reason for this was the change to a more advanced ventilation system. It should be noted that while improving the air tightness of walls, windows and roofs, improved ventilation is often needed to maintain sufficient air change and healthy conditions in apartments. In addition, the ventilation system in the advanced renovation recovers up to 60% of the heat of the exhaust air, which would otherwise be lost, and the solution resulted in additional substantial energy savings in the form of heat.

Table 4. The annual heating and electricity consumption per floor area for each renovation case.

	Current	Basic	Improved	Advanced
Heating consumption (kWh/m^2,a)	219	134	104	71
Electricity consumption (kWh/m^2,a)	47	37	35	39

Figure 1 shows a chart of energy consumption for building type II-18 for different renovation cases, including total energy consumption, heating consumption, electricity consumption, energy consumed for space heating, energy consumed for heating domestic hot water and building's energy losses. The total energy consumption is composed of total heating and electricity consumption, while the total heating consumption is a sum of space heating and domestic hot water heating. The losses curve represents the efficiency-based energy losses of the heating systems.

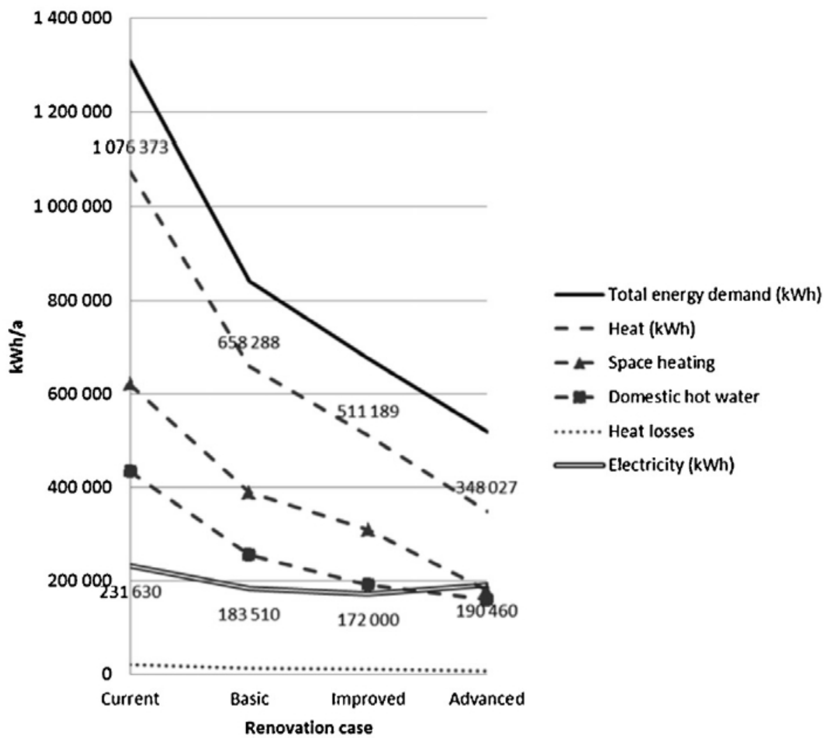


Figure 1. Energy demand graph for the different renovation cases of building II-18.

By implementing the Basic renovation concept, heat and electricity demand could be reduced to respectively 61% and 79% of the current situation. Corresponding numbers for the Improved concept were 47% and 74%, and for the Advanced 32% and 82% (see Figure 1).

2.3.2 Energy analyses of the district level concepts

The energy demands of several renovation district concepts (Table 3) were analyzed and compared to that of the Current concept. Based on the energy demands per floor area of the typical apartment building II-18 (Table 4), which was assumed to represent the average energy performance of residential building stock, and knowing the total floor area in the district, the annual energy demands relating to buildings in the district were estimated. The energy consumption of a residential district, besides energy use in buildings, also includes the energy use of outdoor and street lighting, the associated heat and electricity distribution losses occurring in energy networks as well as energy use associated with water supply and wastewater treatment. The resulting annual energy demands for the different district concepts are summarized on Table 5 and presented graphically in Figure 2. Looking at electricity and heating demand separately, it is noticeable that the potential for reduction of these are 34% and 72%, respectively.

Table 5. Resulting annual energy demands for the district concepts (MWh/a).

	Current		**Basic**		**Improved**		**Advanced**	
	Electricity	**Heat**	**Electricity**	**Heat**	**Electricity**	**Heat**	**Electricity**	**Heat**
Buildings	17 168	89 753	13 495	51 691	12 125	40 194	11 899	24 963
Street Lights	806		403		242		242	
Water and wastewater treatment	1 533	414	981	265	797	215	675	182
Total	19 507	90 167	14 879	51 957	13 164	40 410	12 816	25 146

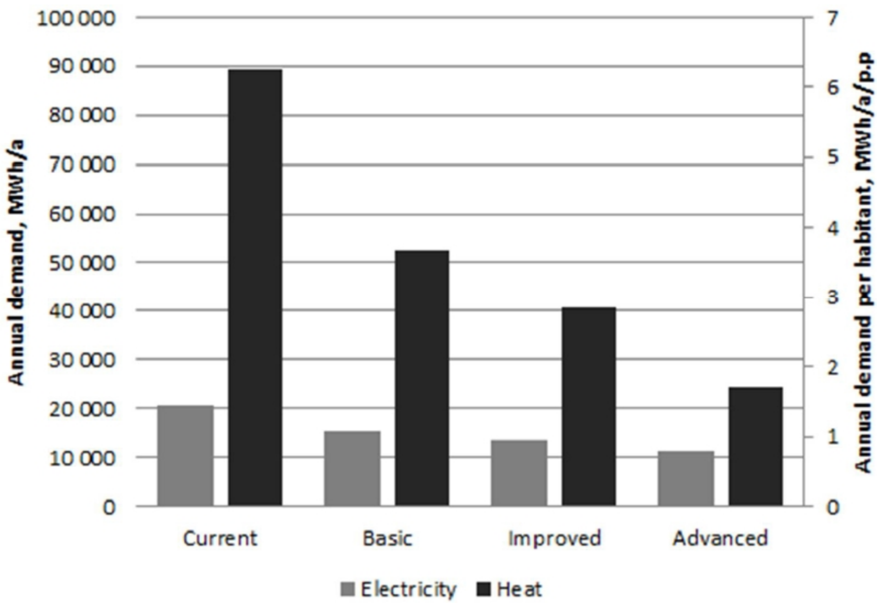


Figure 2. The annual energy demands for the different district concepts. The total demand is given on the left and the demand per inhabitant on the right.

It should be noted that transportation or other services resulting in further energy demand were not accounted for in the district energy analyses that have been carried out. Although these usually form a significant share of the total energy consumption in a district, they were left outside the scope of the analyses, where the focus was on buildings and energy infrastructure. Also, some of the improvements presented in the Table 3 are directly related to pollution or the comfort level of the inhabitants, and would not be noticeable in the results from the energy analyses.

2.4 Emission levels for the different district energy production scenarios

All the concepts presented were further extended with different scenarios of how the energy needed is either being supplied from the outside or produced within the area in order to evaluate the amount of emissions this would result in. Altogether, 11 energy production scenarios were analyzed: all the district concepts had two scenarios, and the Advanced had three additional scenarios envisaging use of solar and wind energy as well as ground-source heat.

The scenarios were analyzed in terms of generated CO_2-equivalents, SO_2-equivalents, TOPP-equivalents (mass-based equivalent of the ozone formation rate from precursors, measured as ozone precursor equivalents) and particulates. These values have been retrieved for each of the energy production technologies involved in the scenarios, and also account for the life cycle of the production unit.

Since almost all energy produced in the Moscow area comes from natural gas (City of Moscow 2009a), the scenario of heat and energy production from natural gas-powered CHP plants (Nat) was taken as a baseline for each of the district concepts. In order to evaluate the opportunity for using renewable energy, the scenarios where natural gas is replaced with biogas (“Bio”) were additionally examined. Table 6 summarizes the scenarios analyzed.

Table 6. Analyzed energy production scenarios for the different district concepts.

	Current	Basic	Improved	Advanced
CHP natural gas	x	x	x	x
CHP biogas	x	x	x	x
A3 scenario: solar panels, ground source heat pumps, electricity from the grid				x
A4 scenario: solar panels, ground source heat pumps, (certified) electricity from wind farms				x
A5 scenario: solar collectors, solar panels, ground source heat pumps, (certified) electricity from wind farms				x

For the Advanced district concept, the A3, A4 and A5 scenarios involving renewable energy were created in addition to the natural and biogas scenarios. In the A3 scenario, solar panels (PV) mounted on the roofs of buildings were calculated to cover 7.5% of the total electricity demand, while the rest would be bought from the grid. In this scenario all the heating needed would be provided by ground source heat pumps (GSHP), which would, on the other hand, consume a considerable additional amount of electricity. The A4 scenario differed from the A3 in the way that all the electricity supplied from public grid was bought from a wind farm (WF). In the A5 scenario, 30% of the energy needed for domestic hot water in the district was produced by solar thermal collectors (STH). In the latter case, less electricity is consumed by heat pumps, and the heat pump systems itself can be reduced, i.e. fewer boreholes (energy wells) are needed.

Generated emissions from the different scenarios are compared to each other and the value for the Moscow area (Moscow ref.) in Figure 3 (CO_2-equivalents), in Figure 4 (SO_2-equivalents), in Figure 5 (particulates) and in Figure 6 (TOPP-equivalents). The reference values for Moscow are average emission values resulting from the existing structure of energy production in Moscow, and they are higher compared to the baseline case with only natural gas-powered CHP plants, which suggests a potential for emission reductions in Moscow energy sector through expansion of the share of CHP plants and better interconnections of district heating networks.

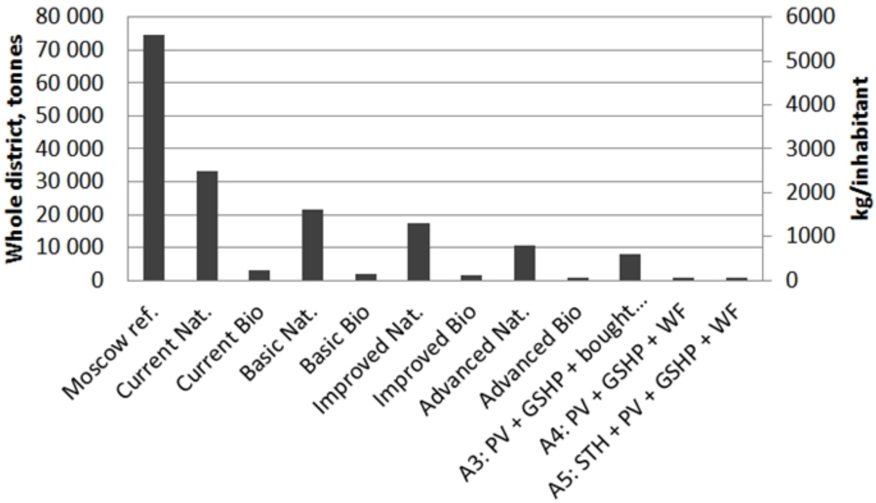


Figure 3. CO_2-equivalent emissions of the district energy production scenarios.

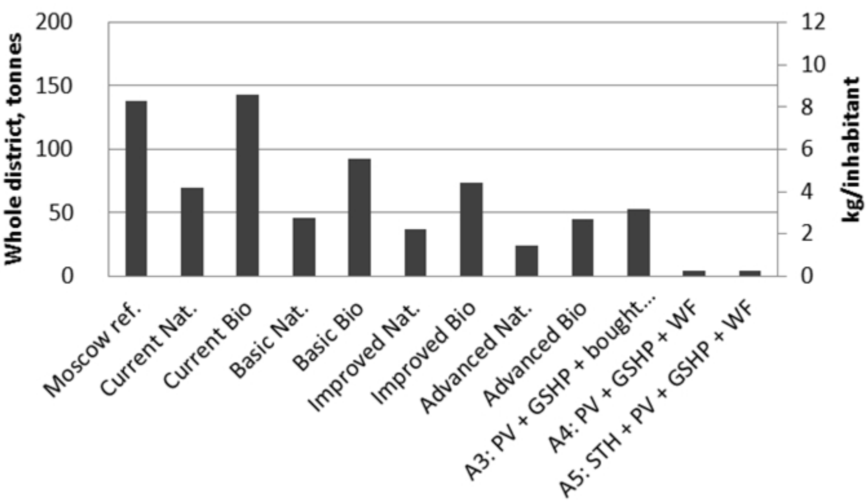


Figure 4. SO_2-equivalent emissions of the district energy production scenarios.

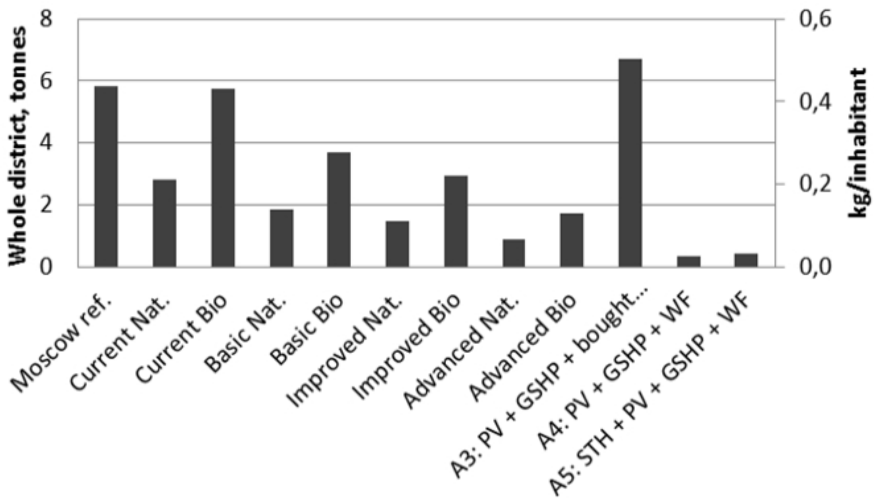


Figure 5. Particulates of the district energy production scenarios.

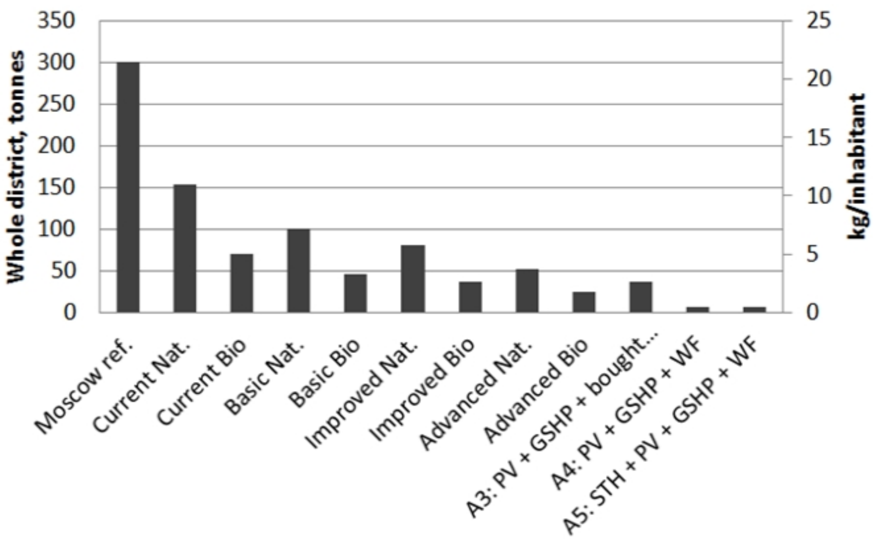


Figure 6. TOPP-equivalent emissions of the district energy production scenarios.

Using biogas instead of natural gas would result in lower levels of CO_2- and TOPP-equivalents but higher levels of SO_2-equivalents and particulates with all the solutions examined. The reduction potential is especially high for CO_2-equivalents, which can be reduced to below 10% for each scenario when switching to biogas. Buying electricity from the grid is not favorable and would cancel out the effect of using ground source heating pumps for reducing emissions in alternative 3.

By comparing the emission levels, it appears that alternative 4, involving PV, GSHP and WF, would generate fewest emissions. However, alternative 5, involving STH, PV, GSHP and WF, was almost as good an alternative, because energy produced by a ground source heat pump is considered to result in fewer emissions than energy produced by solar collectors, due to the fact that the electricity used by the heat pump was produced by wind energy. Storing excess heat from the solar collectors in the ground during hot seasons (summer) with help from GSHPs was not considered. Taking this into account could possibly have made alternative 5 the winning scenario.

The achievement of potential emission reductions, outlined in this section, depends on the scenario of energy supply, and correspondingly, on actions taken by energy companies in terms of choosing fuels and deploying renewables (e.g., wind farms). To stimulate this, at least in the Russian electricity sector, a regulatory intervention is needed (IFC & GEF 2012).

At the same time savings and emissions largely depend on energy demand in buildings and on-site energy production. Further study thus focused on building renovation concepts in greater detail.

3. Cost analyses

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). Anyway, it is vital to estimate the costs and benefits of different renovation solutions before making any decisions.

3.1 Review of existing principles of economic analyses

Bashmakov (2009) used three different definitions of energy efficiency potential when studying the extent of possible energy savings across various sectors of Russian economy. *Technical (technological) potential* was estimated with an assumption that the whole equipment stock in place is immediately replaced with the best available practically applied models. *Economic potential* was a part of technical potential, which can be cost-effectively implemented using public cost-effectiveness criteria: discount rates, opportunity costs (export price of natural gas), environmental and other indirect effects and externalities, etc. *Market potential* was a part of economic potential, which can be cost-effectively implemented using private investment decision-making criteria and, given the existing market conditions, prices and limitations. This differentiation of potentials is widely used in sectoral or country studies.

Another commonly used simple method for assessing the economical profitability of renovating apartment buildings is by comparing costs of energy saved to invested capital in order to see how quickly the investment is paid back (simple payback method). Return on invested capital is especially important when considering business models where investment is made by privately-owned organizations or residents themselves and it is assumed that the investment is paid back through energy savings.

The financial profit from several renovation scenarios of Soviet era buildings was assessed in a study performed by Zavadskas et al. (2008). The study points out that 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. In order to assess the market value of a building, the authors used a notion of market value ratio (MVR), which is the difference in the market value of the building before and after retrofitting divided by the retrofit cost. For assessing the cost effectiveness of the energy-saving measures, the authors used a decreased savings – to investment ratio (SIR), which is the present value of energy saved over the lifetime divided by the investment. Zavadskas et al. (2008) considered a retrofit case cost-effective once both the MVR and SIR ratios were positive. Zavadskas et al. (2008) further used these ratios as economic criteria for assessing various investment packages for renovation of buildings in Vilnius. The resulting MVR and SIR are shown in Figure 7 for two districts and suggest higher MVRs for more prestigious districts.

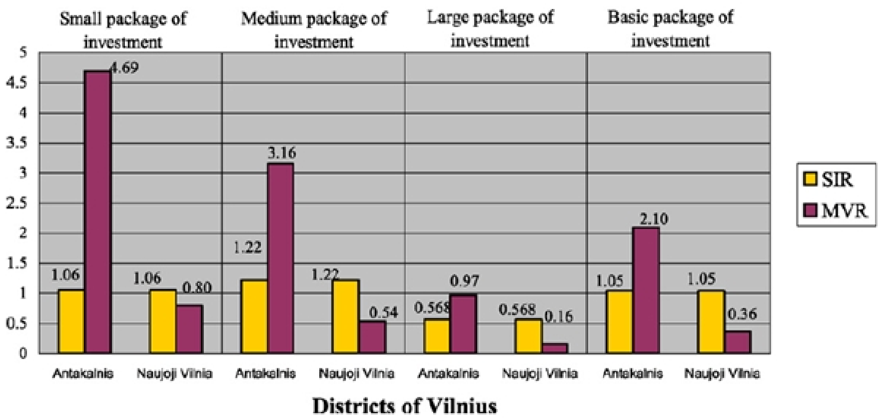


Figure 7. Retrofit effectiveness of a panel house 1605A (5 stories, 60 apartments, 3 staircases) based on SIR and MVR ratios (Zavadskas et al. 2008).

Zavadskas et al. (2008) highlighted the need to generate several investment cases in order to determine a profitable solution for the renovation of a building through the MVR and SIR ratios, correlation with urban development programs and consideration of the condition of the building and the local environment.

A similar “twofold benefit” of the renovation of buildings is also underlined by Martinatis et al. (2004), who suggest that both energy savings and the value added by rehabilitating building’s elements need to be included in the profitability assessment of building renovations. Martinatis et al. (2004) thereby introduced formulas to determine the profitability of renovation measures made in different parts of a building. The formula for calculating the cost of conserved energy (CCE), was

$$\mathrm{CCE} = \frac{I}{S} \times \frac{d}{1-(1+d)^{-n}} \qquad (1)$$

where I – investment cost (monetary unit) of a measure, S – annual savings (e.g., in MWh), n – lifetime of the measure and d – discount rate.

The idea is to compare the CCE with the actual cost of energy supplied in order to see which cost is lower. In this case the cost of the energy saved is lower than implementing energy saving measures makes sense. Arguing that the benefits of some energy saving measures are associated not only with energy saving, but also with the improvement in a building's overall durability and value, Martinatis et al. (2004) suggested dividing the investment cost, related to the rehabilitation of a building's element, into two parts. This introduces the term (1-k) into the formula for cost of saved energy:

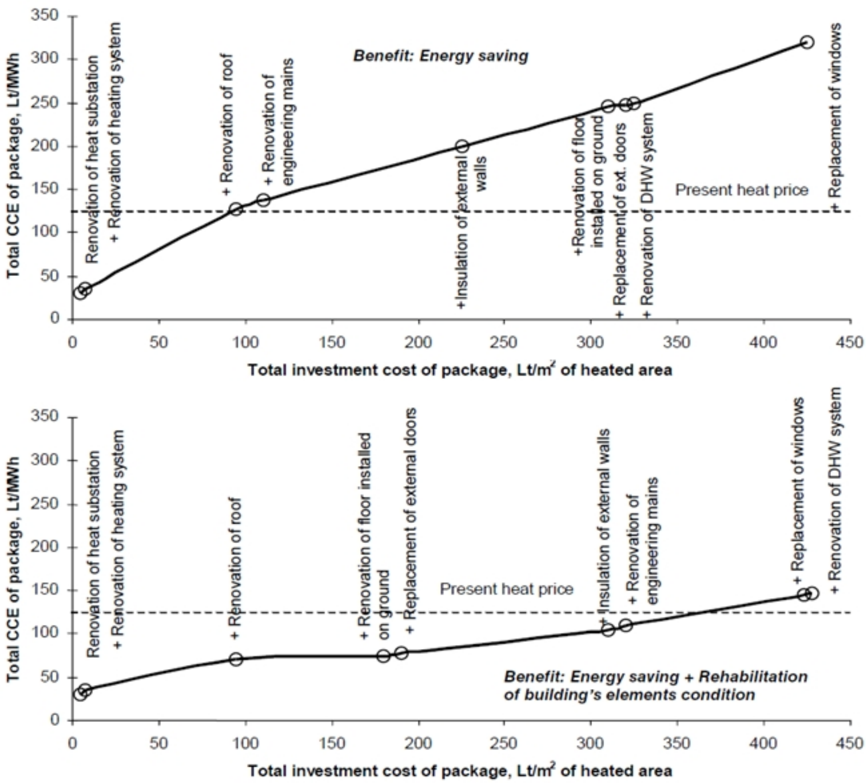
$$CCE_B = (1 - \kappa) \times CCE \qquad (2)$$

where κ represents a *coefficient of building element's rehabilitation*, which takes values in the range between zero and one, depending on the technical condition of an element.

Considering the linear function of the physical deterioration of an element, the coefficient k is defined as;

$$\kappa = \frac{actual\ age\ of\ an\ element\ in\ years}{lifetime\ of\ an\ element\ in\ years} \qquad (3)$$

Martinatis et al. (2004) also suggested further formulae to estimate the coefficient k using non-linear deterioration function. The term (1-k) in the formula (2) reduces the cost of conserved energy for relatively new building elements only a little, but makes it approach zero for worn-out elements. The approach was applied for estimating renovation measures for a school building from 1977 with a total floor space of 2,273 m^2, and the researchers found the results shown in Figure 8. By taking only the benefit from energy saving into consideration, the most cost-effective package would include implementation of only three measures. Once the profits from rehabilitating the condition of elements are included in the calculations, up to seven measures could be considered to be cost-effective. The costs of conserved energy were compared to local energy prices for heating.



Remark: Present heat price incl. VAT - 128.4 Lt/MWh (Vilnius town)

Figure 8. Determination of the optimal (total CCE lower than heat price) package of renovation measures for a school building in Lithuania. Only energy savings are considered in the upper chart, while the lower contains both energy savings and value added by rehabilitating the condition of the building's elements. (Martinaitis et al. 2004.)

The "twofold benefit" methodology presented by Martinaitis et al. (2004) is further explored by Biekša et al. (2011) when investigating the renovation process in multi-apartment buildings in Lithuania and applied to a real modernization project in a 5-storey apartment building with a total floor area of 1,336 m^2 (Figure 9).

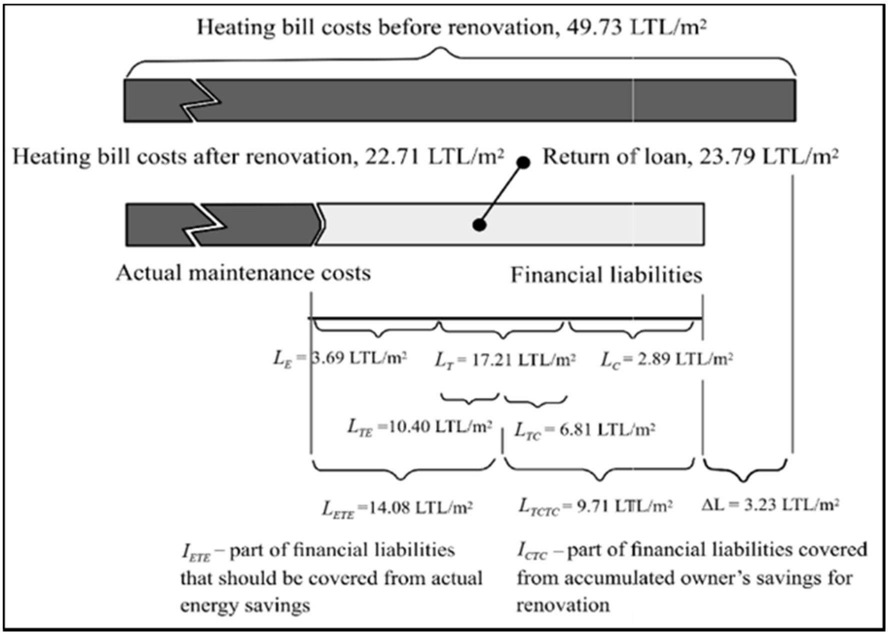


Figure 9. Application of the twofold method to an actual modernization project in Lithuania (Biekša et al. 2011).

It can be seen from Figure 9 that, although the heating bill after renovation was substantially reduced, financial liabilities also appeared, and residents continue paying almost the same amount as before the renovation. The financial liabilities (repayment of investment) is distributed into three components – (i) "purely" energy saving measures (LE), such as space heating system balancing or automation, (ii) "purely" construction measures (LC), related only to the renewal of building structures, and (iii) the twofold measures, having both energy saving (LTE) and building renewal (LTC) components. Biekša et al. (2011) suggest that only the share of financial liability attributed to energy saving should be covered from energy savings, while the rest – from building "purely" renovation funds, accumulated by owners. Assuming same payments before and after renovation, the share of liabilities, which may be covered by energy savings, increases with a rise in energy price. Biekša et al. (2011) highlight energy audits as a measure to mitigate risks, related to inaccurate estimation of practically achievable energy savings.

The results from a reconstruction of a Soviet-type apartment building built in Estonia during the Soviet era showed that there was a correlation between the energy saving forecast from an audit and the real measured savings (Kredex 2008). 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.

The economic appraisal of energy efficiency measures in a high-rise building by Gorgolewski et al. (1996) used economic indices to compare the profitability of selected energy saving measures applied in a typical high-rise dwelling erected in the UK in the 1960s. The economic index considers the changing value of money over time and is essentially same as the cost of conserved energy, the only difference being that the energy saved is expressed in monetary terms:

$$Economic\ index = \frac{Annual\ cost}{Value\ of\ energy\ saved} \tag{4}$$

$$Annual\ cost = \frac{Capital\ cost\ of\ the\ measure}{[1-(1+d)^{-n}]/d} \tag{5}$$

where n is the expected life of the measure and d is the discount rate (d = 4% was used).

An economic index of unity indicated that every pound spent yielded a saving of 1 pound. Gorgolewski et al. (1996) point out that these 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.

Dall'O' et al. (2012) used a simple payback method in financial evaluation of building envelope improvements in selected Italian municipalities. The information on building surfaces, available for retrofit interventions, was collected to form an energy cadastre. Using the estimated existing and post-retrofitting U-values of windows, roofs and façades, potential energy savings through envelope improvements were identified. Giuliano Dall'O' et al. (2012) claim that use of the method requires little effort while yielding high resolution results sufficient for municipal scale analyses.

The Buildings Performance Institute Europe (BPIE 2010) introduced a general methodology for comparing different packages of energy measures to be implemented on reference buildings in terms of economic optimum (Figure 10). The BPIE recommends the use of 31 CEN standards for calculations of energy performance combined with economic evaluation procedure of the European Standard EN 15459. The results of calculations could then be compared to environmental targets and other circumstantial requirements. Through iteration of the results and requirement, the economic optimum can be shifted to support either mid- or long-term targets.

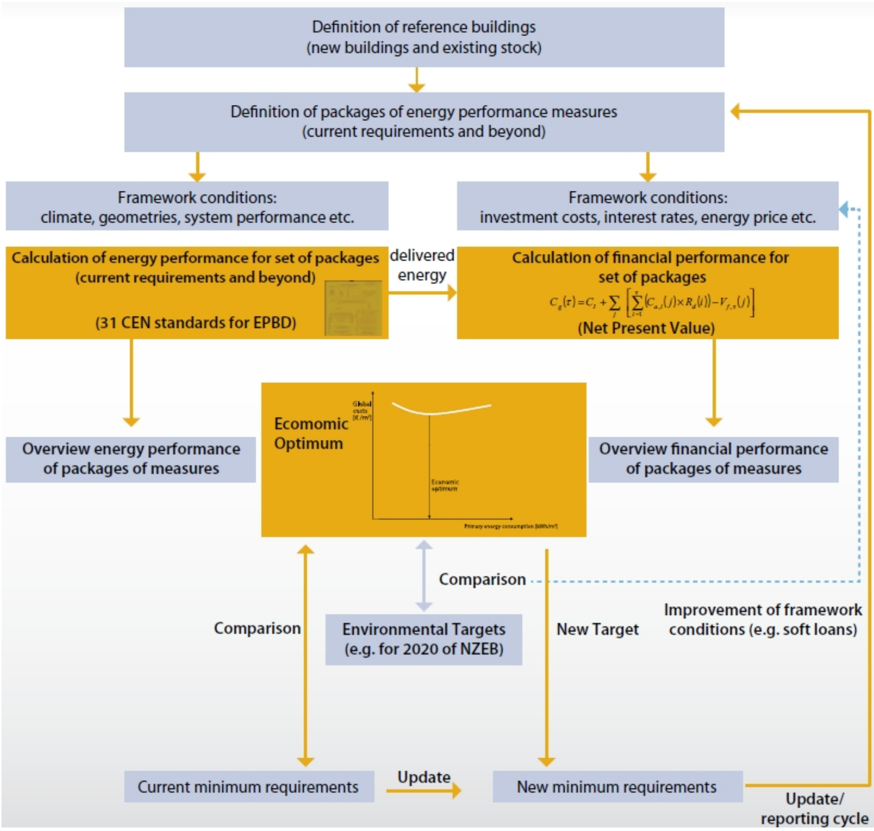


Figure 10. Comparative methodology flowchart introduced by the Buildings Performance Institute Europe (BPIE 2010).

3.2 Selected approach to economic analysis

In this study, focusing on business aspects of energy-efficient renovation of districts, we chose to consider economic attractiveness of investing into additional improvements compared to the basic capital repairs that will in any case be implemented in buildings. There are signs of emerging financing mechanisms for such basic capital repairs of apartment buildings in Russia (see Chapter 4). The suggested straightforward approach eliminates the need to consider division of an investment into energy-efficiency and structural renewal (the twofold method), since the latter is assumed to be covered by basic capital repairs, no matter whether these are entirely subsidized or paid by residents.

Apart from energy savings, there are other benefits that may result from the renovation of apartment buildings. These benefits are not as easily measureable as energy savings, but could improve, for example, thermal comfort, health, the living standard of residents and raise overall attractiveness of local urban environment. Neither these benefits nor increasing property value for owners were considered, since these are unlikely to benefit third-party investors. At the same time, stressing the additional benefits to be enjoyed by the residents may increase acceptance and possibly even encourage minor participation by (some) apartment owners in financing.

Some renovation solutions could result in multiple benefits, for example, the introduction of heat recovery ventilation which, while consuming additional electricity, results in considerable saving of heating energy, provides better indoor air quality and even enables centralized cooling. The benefit of using multiple energy conservation measures is not the sum of the benefits of using each individual measure due to the interactive nature among different building subsystems and different energy conservation measures (Ma et al. 2012). As the example of recovery ventilation demonstrates, the interdependencies may exist between types of energy resources, in particular between electricity and heating energy. In addition, consumption of water may also be associated with certain energy consumption (e.g., pumping or hot water heating). Therefore, rather than analyzing individual measures, it is reasonable to create renovation packages first and only then proceed with evaluation of their economic attractiveness.

The package, corresponding to the “to-be-implemented-in-any-case” basic capital repair was selected as a baseline, and baseline investment and level of resource consumption were determined. Consequently, the value of additional savings obtained as a result of implementing a more advanced renovation was compared to the associated increase of investment. In the case where implementation of more progressive renovation is profitable, there is a chance that a suitable business arrangement could be found.

A similar procedure was followed to identify the most appropriate renovation of districts, represented by groups of typical buildings and associated district infrastructure, to see whether renovation of an entire district may be more economical. No special corrections were made to consider economies of scale, mass procurement, etc.

The economic calculations were based on the use of net present value (NPV) method and accounted for the expected future growth of energy prices. The net present value of a renovation package is the difference between the present values of this package and a baseline package. Formula 5 was used to calculate the present value (PV) of a renovation package’s over a time period of t years:

$$PV = I + \sum_{t,r} \left(\frac{1+g}{1+d}\right)^{t} \times S_r \times P_r \qquad (5)$$

where I – initial investment; Sr, Pr – annual saving and initial price of resource r (electricity, heating, water); g – average growth rate of a resource price over period t [%/100]; d – discounting rate [%/100].

It should be noted that physical energy and water savings may vary somewhat year by year due to changing weather conditions, changing habits, varying stock and efficiencies of household appliances, etc.

3.3 Selected building and district renovation concepts

One of the recent investigations of packages for the capital repair of Russian residential buildings was conducted in 2011 (IUE 2011a). A capital repair was defined as "a package of repair and construction works aimed to eliminate defects in deteriorated building parts, to repair or replace them in order to restore the usability of the building with its performance characteristics being improved, which is to ensure an adequate level of the building reliability and comfort for living."

The study (IUE 2011a) suggested three different packages for capital repairs, which were different in terms of investment costs and estimated savings. All the packages (IUE 2011a) included 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 were proposed. Biekša et al. (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 varied between €35 and €155/m^2.

In this study, we have further investigated the renovation concepts from Paiho et al. (2013) by assessing their feasibility in monetary terms. The cost estimations for each building renovation case have been based on data from former renovation projects in Russia and mainly in Moscow. These costs have further been projected onto the district renovation cases to which costs from infrastructure renovation and energy system have been added. The renovation models would eventually lead to energy and water savings and could therefore become profitable in the future.

3.4 Building level cases

As mentioned earlier, our study included three building renovation models, one of which (the basic renovation) served as a reference case, where an attempt was made to restore building elements to their original condition, but some additional improvements took place. For example, installation of rather inexpensive space heating system controllers was considered necessary. Another example is installation of relatively inexpensive but modern windows, since the original designs were considered not to be acceptable by residents and even unavailable on the market. The basic renovation package does not meet current Russian construction requirements for new buildings, because only minor wall insulation was envisaged.

The two other renovation packages, closely matching the more progressive solutions presented in Paiho et al. (2013) and outlined in Table 1, were named accordingly – Improved and Advanced. Thus, all the three cases envisaged improvement measures for external walls/facades, doors and windows, roof, basement, ventilation system, heating system, water and sewage systems, internal networks of electricity and gas, consumption meters, and other improvements. The measures and their costs with the associated specific cost per square meter of floor area can be seen in Table 7. Table 8, lists the data sources used for Table 7. The set of measures included in the renovation packages was selected so that the expected energy savings were realized.

The **Basic renovation package** contains only the measures involving the restoration of building structures and systems, as well as improvements in thermal insulation in relatively easily accessible areas. The existing ductwork of the natural ventilation system is cleaned and restored where needed. Some improvements were made, even though these were not required, because it would be more feasible to implement them at this stage in combination with other measures than to implement them later separately. For example, renewal of the electricity network in combination with heating and water pipe system reparation could be cheaper since parts of the structures are open.

The **Improved renovation package** includes improvement of thermal insulation of walls to meet the current requirements for new buildings, installation of better performing windows, introduction of mechanical exhaust ventilation and building-level heat substations. It was assumed that the residents purchase water and energy-efficient appliances and fixtures for their own apartments in both the Improved and Advanced models. These investment costs were not included in the cost analysis in this study.

The **Advanced renovation package** includes further improvement of thermal insulation to reasonably high levels, although not the highest possible. Use of thermal insulating façade modules with embedded air supply ducts was envisaged. One of the considerable cost components of this package is a mechanical ventilation system with heat recovery from the exhaust air. This solution does not, however, only reduce heating energy demand but also improves the air quality in the apartments. The improvement in air quality was not considered in the cost calculations.

Preparing cost estimates for renovation packages was challenging due to various factors. First of all, the prices vary depending on contractors/suppliers. Secondly, there is an uncertainty in defining the scope of basic repairs, which may vary from building to building; our assumption, based on the literature review, was that no major structural improvements were needed. Furthermore, there is an interdependency of the measures needed and the total cost of implementing several measures is likely to be lower than their individual costs if implementation takes place separately. For example, the total cost of window installations and façade thermal insulation may be lower if implemented simultaneously. Although some of the costs are based on previous cases, the costs of some, such as for example, mechanical ventilation, were assumed to be close to those implemented outside Moscow.

The following building properties (II-18) were used for cost estimates:

- Total floor area: 4,911 m^2
- Roof area 410 m^2
- Total façade area: 3,060 m^2
- Area of apartment windows 670 m^2
- Other glazing: 28 m^2
- Area of walls: 2,355 m^2
- Building length/width/height/: 28/14.5/36 m
- Number of floors: 12
- Number of residents: 207.

Table 7. Measurements included in the renovation models and their cost per square meter of floor area [€/m^2]. Prices were calculated in rubles and converted to Euros assuming an exchange rate of 40 RUR/€.

	Basic		Improved		Advanced	
	Measure	Cost/m^2 of living area [€/m^2]	Measure	Cost/m^2 of living area [€/m^2]	Measure	Cost/m^2 of living area [€/m^2]
External walls	Sealing of joints, repair of external walls, painting and plastering [1]	7.24	Sealing of external walls seams [2]	7.31	Sealing of external walls seams [2]	7.31
	Thermal insulation of external walls 30 mm of mineral wool (MW) and/or polystyrene (PS), and plastering [2]	40.76	Thermal insulation of external walls (100 mm MW/PS) and plastering [2]	47.61	Thermal insulation as prefabricated elements or in-situ (200–300 mm. MW/PS) and plastering [2]	62.75
	Sum	**51.00**		**54.92**		**70.04**
Windows and doors	Installation of new windows [3]	9.45	Installation of new windows [3]	9.45	Installation of new windows [3]	9.45
	3-pane windows [3]	15.07	Energy efficient 3-pane windows [3]	19.54	Energy efficient 3-pane. 2 low-e glass panes windows [3]	21.32
			Adding vestibule to the front doors [4]	0.31	Adding vestibule to the front doors [4]	0.31
	Sum	**24.52**		**29.30**		**31.08**
Upper Ceiling	Repair of water insulation membrane, roof slopes for drainage [5]	0.73	Repair of water insulation membrane, roof slopes for drainage [5]	0.73	Repair of water insulation membrane, roof slopes for drainage [5]	0.73
	Thermal insulation 100 mm PS [2]	1.59	Thermal insulation 100 mm PS [2]	1.59	Thermal insulation 300 mm PS [2]	3.18
	Sum	**2.32**		**2.32**		**3.91**

Basement	Thermal insulation 100 mm PS to basement ceiling [2]	6.92	Add extra thermal insulation 100 mm PS to basement ceiling [2]	6.92	Add extra thermal insulation 300 mm PS to basement ceiling [2]	8.27
			Thermal insulation of basement walls 100 mm PS and plastering [5]	2.87	Thermal insulation of basement walls 300 mm PS and plastering [5]	3.43
	Soil removal and repair of asphalt strip protecting the foundation from penetration of surface water [5]	0.39	Soil removal and repair of asphalt strip protecting the foundation from penetration of surface water [5]	0.39	Soil removal and repair of asphalt strip protecting the foundation from penetration of surface water [5]	0.39
	Sum	**7.31**		**10.18**		**12.08**
Ventilation			Mechanical exhaust ventilation with constant pressure regulation [7+8]	1.53	Mechanical demand-controlled incoming and exhaust air ventilation with air-to-air heat recovery [7+8]	6.62
	Use existing concrete block-based ventilation routes of natural ventilation, cleaning and disinfection [6]	0.86	Use existing concrete block-based ventilation routes of natural ventilation to install new sealed ducts [7+8]	8.71	Use existing concrete block-based ventilation routes of natural ventilation to install new sealed ducts [7+8]	8.71
					Inlet ducts are embedded in the inner surface of the thick insulation of outer walls [7+8]	15.43
	Sum	**0.86**		**10.23**		**30.75**
Heating System	Automated space heating system control unit [1]	1.07	Building specific heating substation [9]	2.55	Building specific heating substation [9]	2.55
	Installation of balancing valves in riser pipes of heating system [1]	0.60	Installation of balancing valves in riser pipes of heating system [1]	0.60	Installation of balancing valves in riser pipes of heating system [1]	0.60
			Installation thermostat valves on radiators [1]	3.04	Installation thermostat valves on radiators [1]	3.04
	Replacement of pipes and thermal insulation	5.34	Replacement of pipes and thermal insulation	5.34	Replacement of pipes and thermal insulation	5.34
	Sum	**7.01**		**11.52**		**11.52**

Water & Wastewater	Repair of cold and hot water supply pipes, water pressure regulator, repair of building's sewage system [1]	0.82	Repair of cold and hot water supply pipes, water pressure regulator, repair of building's sewage system [1]	0.82	Repair of cold and hot water supply pipes, water pressure regulator, repair of building's sewage system [1]	1.49
	Sum	**0.82**		**0.82**		**1.49**
Electricity	Replacement of building equipment with energy efficient. Energy-efficient lamps to common areas [1]	0.06	Replacement of building equipment with energy efficient. Energy-efficient lamps to common areas [1]	0.06	Replacement of building equipment with energy efficient. Energy-efficient lamps to common areas [1]	0.06
	Replacement of worn out in-building electrical networks and main switchgear [1]	4.80	Replacement of worn out in-building electrical networks and equipment of input distribution devices [1]	4.80	Replacement of worn out in-building electrical networks and equipment of input distribution devices [1]	4.80
	Replacement of elevators [1]	12.98	Replacement of elevators [1]	12.98	Replacement of elevators [1]	12.98
			Occupancy sensors in common areas [9]	4.80	Occupancy sensors in common areas [9]	4.80
	Sum	**17.84**		**22.64**		**22.64**
Gas	Repairing of pipes and devices [1]	0.24	Repairing of pipes and devices [1]	0.24	Completely makeover of pipes and devices [1]	0.24
	Sum	**0.24**		**0.24**		**0.24**
Metering	Apartment metering (electricity and water) [1]	3.29	Apartment metering (electricity and water) [1]	3.29	Apartment metering (electricity and water) [1]	**3.29**
			Monitoring (regular check-up)	0.0	Smart metering [10]	5.13
	Sum	**3.29**		**3.29**		**8.42**

Other Improvements and Costs	Improving of public spaces and cost of design and estimation documentation and contingencies ditto [1]	9.80	Improving of public spaces and cost of design and estimation documentation and contingencies ditto [1]	9.80	Improving of public spaces and cost of design and estimation documentation and contingencies ditto [1]	9.80
	Sum	**9.80**		**9.80**		**9.80**
Total Cost in euro	**Basic package**		**Improved package**		**Advanced package**	
	Total, €	**613,820**	Total, €	**762,400**	Total, €	**992,640**
	Per square meter of floor area, €/m^2	**125**	Per square meter of floor area, €/m^2	**155**	Per square meter of floor area, €/m^2	**200**
	Per resident, €/person	**2,965**	Per resident, €/person	**3,680**	Per resident, €/person	**4800**

Table 8. List of used data sources for Table 7.

[Number]	Source
[1]	IUE (2011a)
[2]	Questionnaire to the major manufacturers of facade systems in Moscow (Vasiliev 2011)
[3]	An average value based on two sources for window prices and installation costs (Moskomekspertiza 2013, Spiridonov 2013)
[4]	Estimate based on a cost of 9 m^2 glazing and prices of windows (3)
[5]	Estimate based on cost documentation pertaining to a public procurement contract for renovation of apartment buildings in Moscow, buildings II-49 (order number 0173200001411000503) and II-18 (order number 0173200001411000498), retrievable using order number through online database available at http://zakupki.gov.ru/epz/order/quicksearch/search.html, "placement completed" (accessed 10.12.2013).
[6]	The estimate of the cost of cleaning and disinfection of existing channels assuming the total length of ducts 504 meters, and the prices for inspection of 70 RUR/m, cleaning 200 RUR/m, disinfection (including costs of an appropriate disinfectant) 63 RUR/m. Example price-list in Aeroteh (2013)
[7]	Cost based on design made to match the current channels and building properties of the II-18 building: 7 shafts with a height of 36 meters each, main exhaust duct consisting of 3-meter sections, which requires 12 connectors; 1 meter of distribution ducts of smaller diameter to each apartment, including air exhaust valve, T-shape connectors, roof ductwork 40 meters (ducts and connectors) and one roof-mounted air handling unit. The material costs were derived from Fläkt Woods (2013).
[8]	Installation cost of the ventilation system was estimated by using average costs from the Ratu database by Rakennustieto (0.48 €/m^2 of floor area) (Rakennustieto 2013).
[9]	Estimate based on Shilkin (2007)
[10]	The cost of one meter was set to €300, which otherwise could range between €100–400 according to Giordano et al. (2013).

3.5 District level cases

The district renovation concepts were aligned with the building renovation packages, and the costs of building renovations were included in the costs of improving district energy and water infrastructure. The projection of building renovation costs to district level was based on specific costs per square meter of floor area of buildings. Following the analysis of the existing infrastructure in a pilot district, it was decided to utilize a nodal representation, meaning that a node is a location where local distribution infrastructure is connected to main utility networks, the lengths of distribution legs is the same for electricity, heating, water and sewage lines and there are five such legs per node. In practice, this means that one district heating substation or one electricity distribution substation supplied energy to five apartment buildings. In addition, an estimated length of main/trunk utility lines, connecting the nodes with a district connection point located on the edge of the residential area, was allocated to each node. This allowed for distribution of a certain amount of district infrastructure to apartment buildings to make a further estimate of the costs of district infrastructure renovation attributed to one building and compares the costs and effects of building and district renovation cases. The distribution of infrastructure is presented in Table 9 (a list of used data sources is in Table 10). The specific district level costs for each renovation case were thereafter aggregated by extending them onto the total amount of residential floor area in the district. Parameters used for estimating the district level renovation costs were:

- Total living area: 327,581 m^2
- Total roof area: 31,230 m^2
- Total population: 13,813
- Total surface area of solar photovoltaic: 15,615 m^2
- Total surface area of solar collectors: 8,012 m^2.

Table 9. Costs of upgrading the surrounding infrastructure for the II-18 building.

Measure	Quantity	Unit	Cost per unit (+ installation cost) (€)	Total cost of measure (€)
District heating distribution pipe replacement [11]	40.00	meter	237.5	9 500
District heating main pipe replacement [11]	30.00	meter	487.5	14 625
District heating substation [11]	0.17	pcs.	237,500.0	39,583
Light bulbs for street lighting [12]	34.51	pcs.	412.5	14,237
Water distribution pipe [13]	40.00	meter	625.0	25,000
Water distribution main pipe [13]	30.00	meter	625.0	18,750
Water sewage distribution pipe [13]	40.00	meter	625.0	25,000
Water sewage main pipe [13]	30.00	meter	625.0	18,750
Electricity grid renewal [14]	40.00	meter	150.0	6 000
Main grid renewal [14]	30.00	meter	150.0	4 500
Transformer substation [14]	0.17	pcs.	250 000.0	41 667

Table 10. List of used data sources for Table 9.

[Number]	Source
[11]	Cost of replacement of pipes based on MOEK (2012)
[12]	Cost based on a case by a Russian manufacturer of LEDs (Optogan 2013)
[13]	Analysis of completed procurement tender documents of Moscow's water and sewage utility (Mosvodokanal), the costs of 1m for both water supply- and sewage pipe renovation in districts was estimated at the level of 25,000 RUR/m (Mosvodokanal 2013)
[14]	The cost based on the procurement plan of Moscow electricity distribution company (MOESK) for 2013 (MOESK 2013)

Apart from the Basic, Improved and Advanced cases, two additional alternatives were explored. The additional alternatives called **Advanced+** and **Advanced++ renovation packages** both represent an extension of the advanced district renovation package, and envisage that residential heating demand is provided by geothermal heat pumps, while the electricity demand is partly covered by solar photovoltaic panels. In the Advanced++ case, heating energy was produced by solar thermal collectors mounted on the roofs of buildings. The cost estimate of implementation these advanced packages was first calculated for the II-18 building and then further projected onto the whole district. At the same time, the need for renewal of the district heating infrastructure was excluded in both the Advanced+ and Advanced++ solutions since the heating energy would then be locally produced. Table 11 shows the additional costs of the on-site energy production solutions in total and floor area-specific terms for the II-18 building. The district renovation packages are summarized in Table 13. The sources used for cost estimates are listed Table 12.

Table 11. Renewable energy system costs of advanced district renovation solutions for the II-18 building.

Energy production system	Installed amount	Unit	Price [€/unit]	Total cost of system [€]	Cost per living area [€/m^2]
Solar PV peak capacity [15]	29	kWp	2,500	73,155	14.90
Solar collector peak capacity [16]	84	kWth	800	67,264	13.70
Ground source heat pump capacity [17]	151	kW	775	116,970	23.82

Table 12. List of used data sources for Table 11.

[Number]	Source
[15]	The price of solar PV systems was estimated to be €1.5 per installed Watt peak, based on prices of PV panels published by from solarbuzz and solar PV system cost by European Photovoltaic Industry Association (2011)
[16]	As installation costs for solar heating a price of €0.8 per installed Watt thermal was used. This number has been taken from the document by European Solar Thermal Technology Platform (2013).
[17]	Prices for ground source heat pump capacity are based on interpolating prices of different solution providers in Russia (Rovira ECO GROUP 2013 & SK Elbrus 2013)

Table 13. Table of measures included in the district renovation models presented in this study.

District renovation model measures					
District infrastructure and utility	**Basic**	**Improved**	**Advanced**	**Advanced+**	**Advanced ++**
District heating distribution pipe replacement	x	x	x	-	-
District heating main pipe replacement	x	x	x	-	-
District heating substation	x	x	x	-	-
Light bulbs for street lighting	-	x	x	x	x
Water distribution pipe	x	x	x	x	x
Water distribution main pipe	x	x	x	x	x
Water sewage distribution pipe	x	x	x	x	x
Water sewage main pipe	x	x	x	x	x
Electricity grid renewal	x	x	x	x	x
Main grid renewal	x	x	x	x	x
Transformer substation 10–0,4 kV	x	x	x	x	x
Energy systems	**Basic**	**Improved**	**Advanced**	**Advanced+**	**Advanced ++**
GSHP	-	-	-	x	x
SPV	-	-	-	x	x
STH	-	-	-	-	x

Similarly, the estimated costs of on-site energy production systems for building II-18 were extended to the residential district using specific costs per floor area. The estimated specific renovation costs of all the building and district renovation packages along with resulting annual energy and water savings are summarized in Table 14. The prices used were for heating €36.5/MWh (1700 RUR/Gcal), for electricity €0.10/kWh (4 RUR/kWh), for water and wastewater €1.21/m^3 (48.55 RUR/m^3). The prices in euro are based on estimates in rubles that were converted using an exchange rate of 40 (€1=40 RUR).

Table 14. Cost and energy and water savings comparison of the renovation solutions on the building and the district levels.

Building level (II-18)							
Model	Heating savings vs. Basic model [%]	Electricity savings vs. Basic model [%]	Water savings vs. Basic model [%]	Total Renovation cost [k€]	Total Cost vs. Basic model [k€]	Tariff savings (2013) [k€/a]	Tariff savings vs. Basic model * [k€]
Current	-63.5 %	-26.2 %	-70.0 %	0	-567	0.00	-29.33
Basic	0.0 %	0.0 %	0.0 %	567	0	29.33	0.00
Improved	22.3 %	6.3 %	25.0 %	716	149	39.79	10.46
Advanced	47.2 %	-3.8 %	37.5 %	946	379	47.29	17.96

District level							
Model	Heating savings vs. Basic model [%]	Electricity savings vs. Basic model [%]	Water savings vs. Basic model [%]	Total Renovation cost [M€]	Cost vs. Basic model [M€]	Tariff savings (2013) [M€/a]	Tariff savings vs. Basic model [M€]
Current	-73.6 %	-33.0 %	-70.0 %	0	-46	0	-2.5
Basic	0.0 %	0.0 %	0.0 %	46.4	0	2.47	0.0
Improved	22.2 %	11.7 %	25.0 %	56.5	10	3.28	0.8
Advanced	51.6 %	13.2 %	37.5 %	71.9	26	3.94	1.5
Advanced+	99.6 %	-31.8 %	37.5 %	84.1	38	4.11	1.6
Advanced ++	99.6 %	-23.9 %	37.5 %	91.9	46	4.23	1.8

3.6 Profitability of the renovation solutions

Investigation of Table 14 reveals that the simple payback time of additional investments into implementing renovations going beyond basic exceeds 12–14 years. With such long payback periods, the cost of capital plays a significant role, and in order to assess the long-term feasibility net present values (NPV) over the period of 20 years were calculated and a sensitivity analysis performed. As expected, the long-term viability varied significantly depending on the scenario of assumed discounting rates and rates of energy price growth. Despite the annual energy price rises in Russia have been over 10 percent in recent years, the long-term economic forecasts envisage that growth will be slowing down beyond 2020. The development of water supply and wastewater treatment tariff growth was assumed to be stable at a level of 5% annually. The results of the NPV calculations are summarized in Table 12. The results suggest that renovation of a district may be more feasible than renovation of individual buildings.

The Advanced+ and Advanced++ solutions are unlikely to be feasible unless a rapid growth of energy prices in combination of low capital cost is assumed. At the same time, implementation of such renovations may substantially reduce emissions (see Section 2.4).

The non-monetary benefits that could further improve the attractiveness and value of the area were not evaluated in the results. Such component of operational costs as maintenance was not included into the calculations due to a lack of reliable data.

Table 15. Renovation packages having the highest net present value over period of 20 years in various scenarios.

Most feasible renovation solutions (packages), based net present value calculations for various discounting rates and energy price growth

Building renovation

Interest rate, %	Annual energy price growth rate, %: 3	4	5	6	7	8	9	10	11	12	13	14	15
3	I	I	I	I	I	I	I	I	A	A	A	A	A
4	I	I	I	I	I	I	I	I	I	A	A	A	A
5	I	I	I	I	I	I	I	I	I	I	A	A	A
6	I	I	I	I	I	I	I	I	I	I	I	I	A
7	I	I	I	I	I	I	I	I	I	I	I	I	I
8	B	B	I	I	I	I	I	I	I	I	I	I	I
9	B	B	B	I	I	I	I	I	I	I	I	I	I
10	B	B	B	B	B	I	I	I	I	I	I	I	I
11	B	B	B	B	B	B	I	I	I	I	I	I	I
12	B	B	B	B	B	B	B	B	I	I	I	I	I
13	B	B	B	B	B	B	B	B	B	I	I	I	I
14	B	B	B	B	B	B	B	B	B	B	I	I	I
15	B	B	B	B	B	B	B	B	B	B	B	I	I

Basic = B
Improved = I
Advanced = A

20 year period, constant water tariff growth at 5 %

District renovation

Interest rate, %	Annual energy price growth rate, %: 3	4	5	6	7	8	9	10	11	12	13	14	15
3	I	A	A	A	A	A	A	A	A	A+	A+	A++	A++
4	I	I	A	A	A	A	A	A	A	A	A+	A+	A++
5	I	I	I	I	A	A	A	A	A	A	A	A+	A+
6	I	I	I	I	I	A	A	A	A	A	A	A	A+
7	I	I	I	I	I	I	A	A	A	A	A	A	A
8	I	I	I	I	I	I	I	A	A	A	A	A	A
9	I	I	I	I	I	I	I	I	A	A	A	A	A
10	B	B	I	I	I	I	I	I	I	A	A	A	A
11	B	B	B	I	I	I	I	I	I	I	A	A	A
12	B	B	B	B	I	I	I	I	I	I	I	A	A
13	B	B	B	B	B	I	I	I	I	I	I	I	I
14	B	B	B	B	B	B	B	I	I	I	I	I	I
15	B	B	B	B	B	B	B	B	B	I	I	I	I

Basic = B
Improved = I
Advanced = A
Advanced+ = A+
Advanced++ = A++

20 year period, constant water tariff growth at 5 %

4. Financing renovations

4.1 Background

Lack of adequate capital and lack of energy efficiency motivation block the implementation of the energy savings potential. At least 60% of energy efficiency potential in residential buildings lies with collective use systems, while 40% is achievable in flats (Bashmakov 2009). There are institutional options (for example, development of ESCO business, see Section 5.5.1), which might help identify a beneficiary for residential energy efficiency improvements and harmonize households' interests. Moreover, monetary savings achieved through reduced utility bills may become an important source of funds for financing capital repairs of residential buildings.

When discussing modernizing the district heating network, the biggest obstacle has been the tariff system, which has not encouraged energy efficiency. To modernize the heating sector, investors need to rely on tariff methodologies and structures that enable them to recover the capital costs of the investments with profit. To respond to this challenge, the new federal heat law was developed. The new tariff system that was taken into use on 1.1.2013 aims to provide better circumstances for energy efficiency investments in the heat network systems, including both transmission network and heat- and CHP plants (Boute 2012). The new tariff system has not been in force very long, and no deeper analyses of its functionality can yet be done.

Renovation of apartment buildings is a fairly expensive undertaking. According to the Russian Statistics Service (Rosstat 2012a), the average cost of capital repair in 2012 across Russia amounted to 4,500 RUR/m^2 (€110/m^2). The total expenditure on capital repairs in Moscow in 2008 and 2009 amounted to approx. 42,320 and 20,970 million rubles respectively which resulted in repair of 6,285 and 3,483 thousand square metres of total area in apartment buildings (Rosstat 2013), i.e. the specific cost was at the level of 6,000–6,700 RUR/m^2 (€140–165/m^2). According to cost examinations presented in Chapter 3, the costs at the building' level could range from €125 to 200/m^2 of total floor area, depending on the renovation package selected.

Only a part of renovation costs could be covered by way of introducing monthly mandatory payments to be made by residents (under the new financing mechanism, outlined in Section 4.4). On the assumption that the amount of financing by governments at all levels is declining, and amid limited possibilities of financing the capital repairs via ESCO, the role of loans is becoming a determinant one (IUE 2011a).

The technical condition of housing stock and amenities in Moscow is generally better compared to other regions. Moscow is the richest Russian region by income per capita, with average monthly wages of employees of €1,218 (Rosstat 2012b) compared to the national average of €670 (Rosstat 2013) in 2012. At the same time, while the monthly value of housing services and utilities services was €50.6 per person in 2009, only €26.4 per person was billed to the population, yielding the cost recovery ratio of 63%, one of the lowest among Russian regions (Rosstat 2010). Apparently, the relatively high subsidies and personal incomes have contributed to preserving the weight of housing services and utilities in the total spending of households at the level of only 5.6% (Rosstat 2010) in 2009 (lowest since 2005).

The payments for housing services and utilities are only intended to recover the costs of current maintenance, cleaning, waste removal and provision of communal resources (energy, water supply and sewage). Despite the fact that in 2009, 74.4% of Moscow housing stock was privately owned (72.2% by individuals) (Rosstat 2010) and the Russian Housing Code declares the responsibility of owners for building's technical condition, no sustainable form of self-financing the renovations of apartment buildings has existed.

In general, all the major decisions in an apartment building are taken collectively by voting at a general meeting of residents. The general meeting selects one of the three forms of common property management (relative share of building stock for Moscow given in brackets[1]):

1. self-management without legal identity, which may suit relatively small buildings but prevents from receiving capital repair subsidies (0.1%);
2. housing association or cooperative[2] (9%);
3. subcontracting a building management company (26% private, 65% municipal).

Besides high cost of borrowed capital[3] (AHML 2012), the most notable specific barriers may be summarized as follows. The first barrier most likely has to do with the law on privatization of apartment buildings of 1992, which stipulates an obligation

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1 Moscow department for capital repairs (b) http://www.moskr.ru/dkr/ru/inf/n_253 (slide 54) (accessed on Feb 5th, 2014).

2 The purpose of housing cooperatives and construction and housing cooperatives may be to build, buy or buy and renovate an apartment building in order to provide housing for the members of the cooperative. As soon as a member of a cooperative pays their share entirely (which in practice equals the value of an apartment), they gain the ownership of a particular apartment. After the first share has been paid, the decisions are made by general meeting by voting, where votes are distributed according to ownership.

3 For example, the weighted average interest rate on rouble mortgage loans issued in 2011–2012 has been in the range of 11–13% (The Agency for Housing Mortgage Lending 2012).

of the former lessors of residential units (the Soviet state and municipalities) to carry out capital repairs. Residents are poorly informed, get confused by the mass media and often believe that the responsibility for carrying out capital repairs in apartment buildings rests with the local authorities. The residents, except the minority associated in housing associations, are disunited and largely do not participate in common property management. (The Institute of Urban Economics for the EBRD 2011b.)

The housing associations are deemed by the banks to be unreliable, since the housing associations may be liquidated by a general meeting without extension of liabilities onto the buildings' residents.

In the last case, when the common property is managed by a building management company, an instability of relationships exists, since the maximum term of a management contract is limited to 5 years and the contract may even be terminated earlier unilaterally by a general meeting of residents, which impedes raising of major long-term renovation loans by management companies. (The Institute of Urban Economics for the EBRD 2011b.)

The barriers outlined above limit the possibilities of the Energy Service Companies (ESCOs) on the renovation market, since the ESCO has to conclude the energy performance contract with a legal entity (either a housing association or a building management company), – an entity whose relationships with the building's general meeting are unstable in the long-term. (The Institute of Urban Economics for the EBRD 2011b.)

4.2 The Housing and Utilities Reform Fund

Most capital repairs on apartment buildings in Russia are currently co-funded by "Housing and Utilities Reform Fund", a state-owned corporation mandated, for the period up until the end of 2017, to support capital repairs of apartment buildings, while encouraging market transformations in the housing sector. The corporation disperses the funding to regions to co-fund implementation of their regional "address-list" programs. The average co-funding rate is 70 percent (Housing and Utilities Sector Reform Fund 2013a), but the rate may vary substantially by region as it depends on self-sufficiency of regional budgets. Promotion of the sector reform is reflected in the requirements for co-funding.

The major requirement (Federal Law 185) is for regional/municipal authorities to reduce public ownership to a minority (e.g. to less than 25%) in at least 80 percent[4] of utility companies and apartment buildings' management companies, operating on their incumbent territories. Additional requirements include facilitation of housing associations and building management companies as forms of management (the former should be established in 10% of apartment buildings, the latter

[4] The requirement does not apply to provision of utilities where Federal ownership is involved but has not been leased or transferred to a concessionaire.

should manage over 80% of apartment buildings) and demonstration of progress in implementation of certain Federal legislation, for example:

- registrations of land ownership for plots of apartment buildings,
- energy and water consumption submetering on a building level,
- launch the new capital repair financing mechanism based on capital repair contributions (see Chapter 3).

Moscow seems to be the only region of Russia that does not apply for the co-funding from the Fund because Moscow does not fulfill the co-funding requirements (City of Moscow 2011).

The low average cost (approx. €20/m^2) of modernization implemented under the auspices of the "Housing and Utilities Reform Fund" suggests the conduct of selective repairs only, limited to the repair of lifts, roofing and facades (EBRD & IFC 2012). The same trend was noted in Moscow (City of Moscow 2011).

4.3 Current practice of financing capital repair of apartment buildings in Moscow

Until 2012 apartment building renovations in Moscow were almost fully funded from the city's budget under the city's capital repair programs. Only at the end of 2011 was the mechanism of co-financing launched, which envisaged that up to 95% of renovation costs is subsidized by the city and at least 5% contributed by apartment owners. The mechanism is reported to have attracted twice as many co-funding applications than it was budgeted for. (City of Moscow 2011.)

The city's current capital repair program aims, by the year 2017, to renovate 23.5 mln. m^2 of apartment buildings, thus bringing their average wear to 45% and the share of 30-year-old buildings (still requiring capital repair) to 78%. Another goal is to improve the safety of internal gas networks and elevators, as further operation of old elevators which is deemed socially unacceptable may be prohibited by state technical inspection; it is planned to replace up to a quarter of elevators (24,000 items), bringing the share of elevators that are more than 25 years old from 85% down to 30%. It is notable that over one quarter of the program's budget funding is allocated to replacement of elevators.

The budget-funding of the program is intended to cover 100% of costs for buildings that are in very poor technical condition (3.5–4 mln. m^2 yearly), and subsidize renovation of "active" apartment buildings, following an application process (0.8–0.9 mln. m^2 yearly). The works are implemented by privately owned organizations acting in a competitive market. (City of Moscow 2011.)

In the former case, implementation of capital repairs is centralized and address lists of the buildings are prepared. The city's local administrations work with apartment owners to get renovation decisions from general assemblies of the buildings as required by the Housing Code. Consequently the city conducts tenders following its own technical requirements[5] and public procurement procedures to subcontract design and implementation. (City of Moscow, 2014.) The scope of such tenders is not necessarily limited to the entire renovation of one building at a time; on the contrary, the scope would often include implementation of only certain components/systems in one or several buildings.

In the latter case, the subsidy is granted either to a building management company or to a housing association (whichever form of management was selected by the general assembly of the building's apartment owners). These entities organize and conduct the capital repair on their own, although the city still checks the technical design documentation. The criteria used to rate the applications for subsidy include: share of self-funding, age of the building, comprehensiveness of the repair (number of building components/systems covered by application), commitment of apartment owners (votes for the renovation decision on the building's general assembly), energy-efficiency measures and readiness of technical design documentation. The maximum amount of subsidy is determined from the allowed costs of building components/systems set in specific terms (e.g., per square meter of building, façade, windows, etc.) and differ for regular and "historical" buildings. (City of Moscow, 2014.)

4.4 New financing mechanism based on mandatory and voluntary capital repair contributions

A new financing mechanism, introduced by recent Russian federal legislation, envisages collection of capital repair contributions from apartment owners monthly to fill capital repair funds, which may only be used to finance implementation of capital repairs. The scheme is regional and covers the repair of at least the basic elements of jointly shared property in apartment buildings, such as foundations, cellars, walls and roofs, as well as elevators and internal services systems such as electricity, heating, gas, water supply and sewage. When setting the amounts of mandatory capital repair contributions, the regional authorities may further extend the scope of the scheme and include other measures, e.g. improvement of thermal insulation, etc. The mandatory capital repair contributions may be collected only after an approved regional capital repair program, containing a list of all apartment buildings and indicating years of implementation, has been published (Russian Housing Code). The regional capital repair program covers the period until all the apartment buildings have been repaired. The program is updated yearly and supported with more detailed 3-year implementation plans. The priority is given to buildings where no capital repair had been carried out before the privatization of 1992 – in practice, this means that the buildings constructed before 1962 are due to be renovated first.

5 For example, target level of thermal insulation of windows or walls, requirements for pumps, thermostats, pipes, heating system automatic regulation units, etc.

In several regions, the scheme has been launched and the amount of contributions varies between €0.1–0.2 /m^2 per month, which is hardly enough to cover the basic costs. For example in Tatarstan, where a centralized scheme of capital repairs has been co-financed by residents (€0.12/m^2 per month), only 30–45 percent of costs were covered in 2011–2013 with the rest financed by regional and local budgets and co-funded by the Housing and Utilities Sector Reform Fund (Faizullin 2013). The process of setting the amounts of capital repair contributions is likely to be politically driven: federal guidelines recommend that the ability of residents to pay (the Housing and Utilities Sector Reform Fund 2013b) and availability of subsidies are considered.

The key element of the new financing scheme is the possibility of pooling the collected capital repair contributions on a regional or territorial level (Figure 11) to finance implementation of a certain annual volume of the repair program by non-profit implementing organizations set up by regional authorities. The non-profit implementing organizations may not spend the proceeds from the capital repair contributions on their own administrative expenses. Apart from implementation in the centralized way, the general meeting of residents of an apartment building may decide that the capital repair contributions may not be pooled, but instead accumulated in the building's special-purpose bank account. The deposit interest (5.3–6.1% in 2011–2013) paid by the bank also belongs to the capital repair fund, which protects the capital repair funds against inflation to some extent. In 2011–2013, the average deposit interest rate was between 5.3 and 6.1%, and average inflation between 6.1 and 6.6% (BOFIT Russia Statistics 2013).

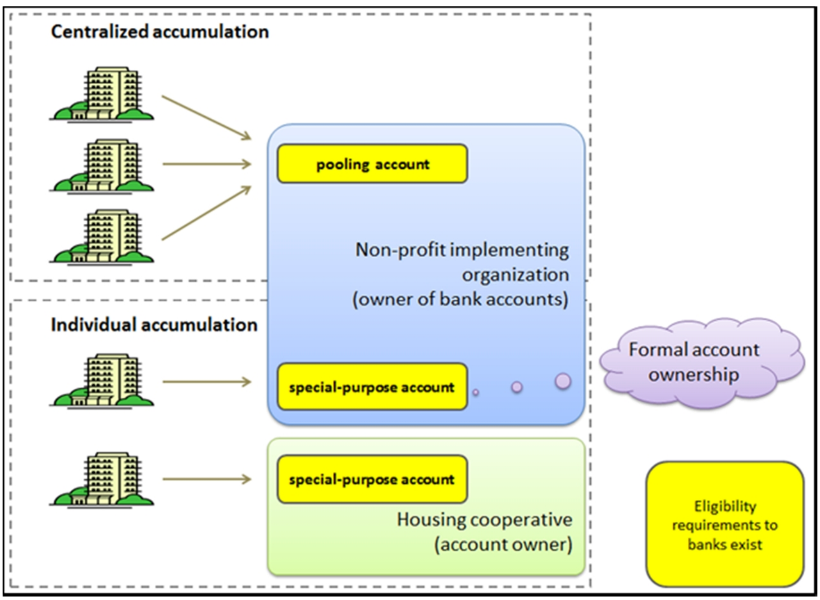

Figure 11. Pooling the collected capital repair contributions on a regional or territorial level.

In the case of such an individual accumulation, the general meeting decides who shall own the bank account and defines:

- the amount of monthly capital repair contributions (not less than the mandatory under the centralized scheme);
- scope of capital repair (not smaller than covered by the centralized scheme);
- year of implementation (not later than stated by regional capital repair program).

In case the general meeting decides that the amount of contributions should be increased, the additional “voluntary” part of the accumulated funds may be used to finance, for example, additional improvements in their building beyond the scope of regional scheme. In addition, when a building’s contributions are accumulated on a special-purpose account, they may be used to repay bank loans taken (by the decision of the general meeting) to implement repair works covered by region’s mandatory scheme earlier than scheduled by the regional capital repair program.

However, in case either a decision on separate accumulation is not taken, or the scope of regional scheme is not implemented in a timely manner, local authorities have the power to decide that the centralized scheme for the building applies and the funds from the special-purpose account are transferred to the account of the non-profit implementing organization. Similarly, if a decision on capital repair is not taken in a timely manner by the general meeting, the local authorities can decide that capital repairs are carried out according to the plan proposed by the non-profit implementing organization.

When an apartment building is repaired under the centralized scheme, the residents continue to pay capital repair contributions, thus paying their building’s debt back to the non-profit implementing organization, until all the repair costs have been repaid. If some of the repair works are implemented in the building earlier (e.g. paid off by a bank loan), the debt to the implementing organization is reduced accordingly. The debt of a building to the implementing organization may be increased if the cost of capital repair (e.g. additional measures) proves to be higher than a certain boundary set by regional authorities.

The general meeting of residents in apartment building may at any moment decide to change the form of accumulation of repair funds, if no debt exists. However, it takes up to two years for the decision on returning the money from the pool to the individual special-purpose account to take effect and only one month if the decision is to join the centralized scheme.

The capital repair subsidies from regional and local budgets may be granted to the non-profit implementing organization, housing associations and cooperatives as well as building management companies.

It may be estimated that, in order to ensure implementation of capital repairs once in 30 years in all apartment buildings of Moscow (214 mln. m^2), about 7.1 mln. square metres would need to be repaired yearly. To implement the improved scenario with the cost level of €145.8/m^2, the annual financing need would exceed 1.04 billion euros. Without subsidies, the lowest amount of monthly capital repair contributions may be estimated as €0.41 per square meter of total area.

4.5 Public private partnership (PPP)

OECD (2008) defines a public-private partnership (PPP) as “an agreement between the government and one or more private partners (which may include the operators and the financers) according to which the private partners deliver the service in such a manner that the service delivery objectives of the government are aligned with the profit objectives of the private partners, and where the effectiveness of the alignment depends on a sufficient transfer of risk to the private partners.”

Governments introduce PPPs for various reasons: to improve the value for money in public service delivery projects, or because PPPs have the potential of bringing private finance to public service delivery. In public-private partnerships the private sector is given the right to operate a service that is traditionally the responsibility of the public actor. PPPs range from short-term management contracts to concessions and joint ventures, where there is a sharing of ownership. Generally, PPPs fill a space between traditional procurement and full privatization; with privatization the government no longer has a direct role in on-going operations, whereas with a PPP the government retains ultimate responsibility. The benefits of PPP solutions are the combination of efficient private operation with public or hybrid financing – reducing both investment and operating costs. Public authorities are able to borrow money more cheaply than private companies, but the private sector has better operating efficiency. (e.g. OECD 2008, Ke et al. 2008, Grimsey & Lewis 2005.)

The investment and operational costs vary depending on the financing method. As PPP arrangements are commonly chosen through a bidding process, the alternative bids can be compared to each other by making value for money (VFM) analyses of the alternative solutions. Value for money is the best price for a given standard of service, measured in terms of relative financial benefit; The VFM analysis is a comparison of the costs of providing the service under traditional procurement and under a PPP scheme. The PPP model should only be implemented if the project is able to provide VFM. (E.g. European Commission 2003, Ke et al. 2008, Grimsey & Lewis 2005.)

There are various PPP models varying mainly by the ownership of assets, responsibility for investment, level of risk and duration of the contract. According to European Commission (2003) PPPs range between traditional public sector procurement and private ownership, as illustrated in Figure 12.

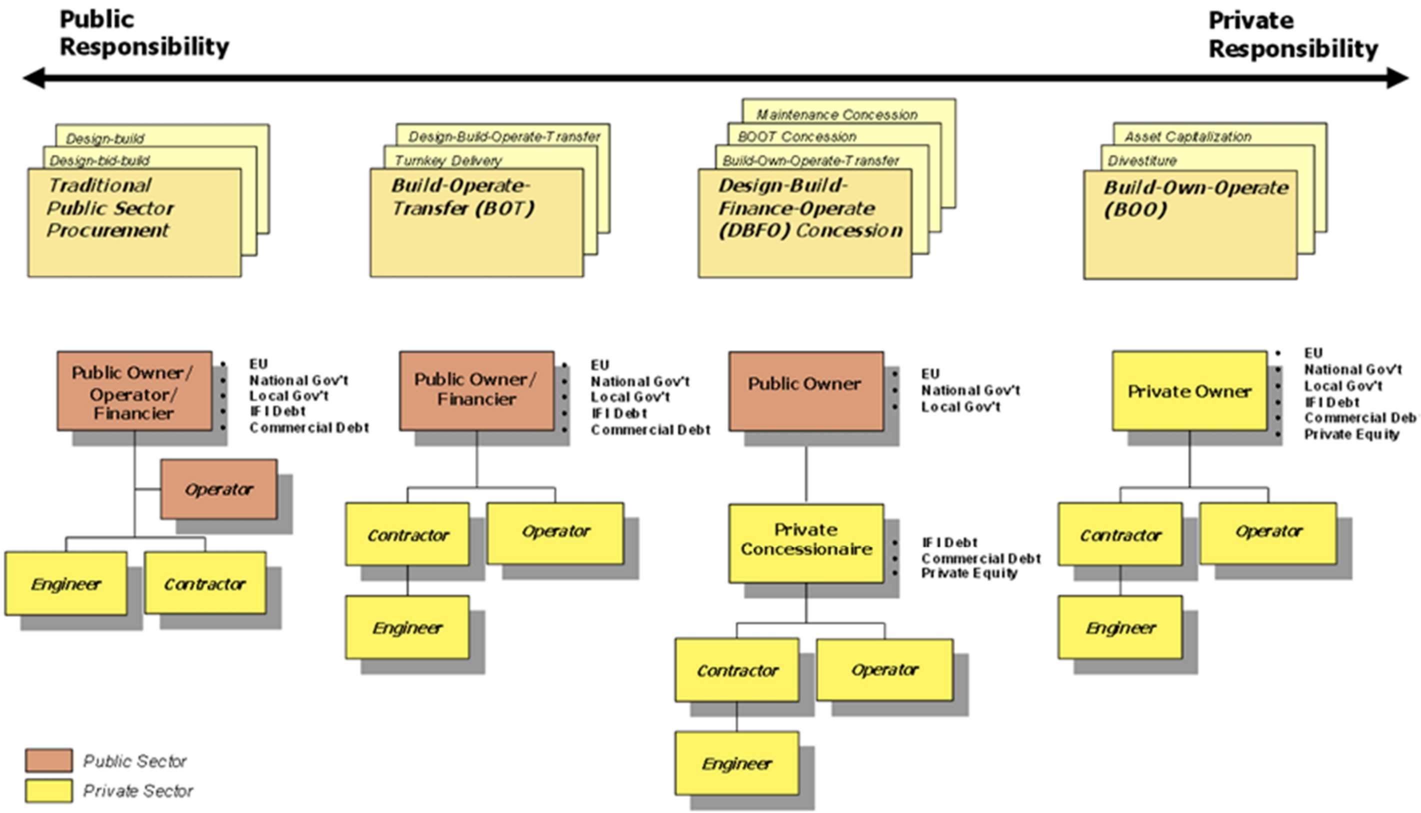

Figure 12. The diversity of PPPs (European Commission 2003).

4.5.1 PPPs in Russia

Russia's need to improve its infrastructure has raised the country's interest in PPPs. The Russian government has announced plans to spend about $1 trillion before 2020 on improving infrastructure, of which a significant part will be in the form of PPPs. However, a number of practical, legal and financial challenges generate obstacles for the implementation of PPP projects. (Schwartz & Ivano 2008.)

Currently, PPP projects are mainly based on concession agreements. Concession agreements stipulate the joint financing by the state and a private investor, and the operation of the concession facility by the investor for a certain period. Concession agreements are entered into on the basis of a tender. The concessionaire is granted rights to state-owned or municipally owned property for the purpose of the creation or reconstruction of a concession facility and its further operation. However, PPP models under the Concession Law are rather unattractive to private business, due to the complexity of the legal procedures and restrictions regarding ownership of assets. (Beiten Burkhardt 2013.)

4.5.2 Russian PPP legislation

There are no federal laws regulating PPPs envisaging private ownership; at federal level PPPs are regulated by the Law on Concession Agreements, the Land Law Code and laws regulating land issues, as well as the City Planning Code and laws regulating construction activity. In some territories there are local laws regulating PPPs as well. St. Petersburg's PPP law is seen as a pioneer in PPP legislation is Russia, and a number of projects have been procured by the St. Petersburg government. In Moscow there is no specific law on PPPs. (CMS 2010, Schwartz & Ivano 2008, Kotova-Smolenskaya & Cherlenyak 2013.)

The Federal Russian Law on Concession Agreements, adopted in 2005, specifies the utilization of PPPs in the public sector, e.g. for transportation, energy, education, health care and utilities. The Federal Concession Law restricts ownership of assets by private actors. This reduces the range of alternative PPP models to be implemented. Unlike the Federal Concession Law, the St. Petersburg Law on PPP, passed in 2005, does not include such restrictions and seems to offer a relatively flexible framework for structuring, tendering and supporting PPPs. Although the regional PPP laws may be more suitable than the Federal Concession Law, there is a risk when using such laws as they do not correlate with the federal law. (Schwartz & Ivano 2008.)

Examples of PPP projects based on the Federal Concession Law are, for example, the Western High-Speed Diameter (WHSD) or the Orlovsky Tunnel. Projects based on the St Petersburg PPP Law are, for example, the Pulkovo Airport. (Schwartz & Ivano 2008.)

A draft Federal Law "On Basic Principles of Private Public Partnerships in the Russian Federation", prepared by the Russian Government, is, as of January

2014, under consideration in the State Duma. The main purpose of the law is to establish a legal framework for PPPs on a federal level and to enable more advanced (compared to concession agreements) PPP models envisaging private ownership (State Duma Committee on Property[6]). If this law is adopted, regional legislation will have to be amended accordingly. The draft law establishes the concept of PPP agreements, sets forth principles and criteria for determining a project as PPP, specifies the scope of the federal, regional and municipal authorities, and determines the general procedure for a tender to select a private investor. (Beiken Burthardt 2013, Kotova-Smolenskaya & Cherlenyak 2013.)

4.5.3 Russian PPP markets

The Russian PPP market has enormous potential. Schwartz and Ivano (2008) state that the value of one of the smallest on-going PPP projects concerning roads in Russia, the Orlovsky Tunnel in St. Petersburg, is estimated at around $1billion, which is substantially bigger than the largest road PPP in relatively mature markets such as Germany – the A1 project valued at $672 mln. Currently, transport PPP projects are mainly being developed, but Schwartz and Ivano (2008) predict a future demand for PPP projects in other sectors as well.

The current legislative framework for Russia has a number of drawbacks, elimination of which is essential to attracting investors to PPP projects. According to the OECD (2008), the government must define clear legal and policy frameworks if it is aiming to engage in PPP projects. Currently, federal PPP legislation is being developed, aimed at reducing the obstacles to the implementation of PPP projects.

The public sector needs to establish itself as a credible partner in order to enable successful implementation of PPP projects. This also includes creating appropriate regulatory and oversight mechanisms as transparency and public oversight for both the development and procurement stage, as well as implementation of the project.

Critics say that lack of transparency and public oversight in public-private partnerships is an important problem, citing the example of the motorway connecting Moscow and St. Petersburg. One section of the motorway was laid through the Khimki forest, which originally had the status of a forest park in land use documents that would prohibit the construction. But, the status of the territory was changed to being for ‘industry and other special purposes’, thus allowing the construction of the motorway. This procedure has been called illegal by critics, as other suitable routes were available. Construction of this segment is being carried out by a company accused of being linked to several Russian investors belonging to President Putin’s inner circle. (Moscow Times 2013, Bankwatch 2013, OECD 2008.)

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[6] The draft federal law on PPPs (in Russian) retrievable online at http://asozd2.duma.gov.ru/main.nsf/(Spravka)?OpenAgent&RN=238827-6 (accessed 30.01.2014).

The Russian state has started investing money into waste management, and thus private investors' interest in this market is increasing. The market provides vast potential for investment and is attracting more attention from international financing bodies, operators and project developers. Public Private Partnerships (PPPs) are becoming the most popular topic and market entry model. According to the experts from Gazprombank, who are interested in financing such projects and looking for applicants, full cycle waste management projects are most attractive in a long-term perspective. (Finpro BRUC 2013.)

4.5.4 Current PPP projects in Russia

The Western High Speed Diameter motorway (WHSD) is a 47 km high-speed motorway linking St Petersburg's trade seaports with the national road network. It connects the northwestern, central and southern parts of St. Petersburg and plays a vital role in the city's development as a major world transport hub. The whole of the WHSD is scheduled for completion in 2016. The total project contract value was estimated at around $9bn, with approximately 50% of construction costs contributed by the Federal government. Construction started in September 2005. The WHSD is important for the Russian Federal government, and is used as a flagship for implementing PPPs. (Schwartz & Ivano 2008, WHSD 2013.)

The first 58 km section of the toll motorway linking Moscow and St. Petersburg (a total of 650 kms) aims to relieve congestion on one of the busiest highways in Russia. The total project contract value was estimated at $2.1bn, with approximately 50% of funding expected to come from the Federal government. The first section is aimed to be finished in 2014. (Schwartz & Ivano 2008, MSP-highway 2011.)

The Orlovsky Tunnel is a 1 km-long tunnel under the River Neva in St Petersburg which will open inland shipping to international transport and will also significantly improve the traffic situation in adjacent areas of the city. The city had planned to select a partner in mid-2008 but the project fell victim to the global economic recession, and in early 2009 a decision was made to suspend the project due to the financing issues. (Schwartz & Ivano 2008.)

The Pulkovo Airport in St Petersburg is arguably the most important part of the transport infrastructure in northwestern Russia and it is developing fast. $1.5bn was invested to upgrade the airport. The new terminal was opened in December 2013. The concession agreement covers some hotels and business premises which are still under construction. The concession agreement is likely to last for 30 years. (Schwartz & Ivano 2008.)

Finished Russian PPP projects (CMS 2010):

- the Moscow – St. Petersburg Highway (section 15–58 kms)
- the new link road between the Moscow ring road and the federal motorway "Belarus" Moscow–Minsk (the M1 highway)
- the development, reconstruction and operation of facilities at Pulkovo airport (St. Petersburg)

Development or procurement stage (CMS 2010):

- the Yanino domestic waste management plant near St. Petersburg
- the Volgograd toll road
- the Moscow region central ring road
- the Moscow – St. Petersburg toll road (section 58–684 kms)
- several municipal water treatment projects, including the cities of Sochi, Rostov-on-Don and Yaroslavl
- the operation and maintenance of facilities at Sheremetevo Airport (Moscow).

4.6 Financing examples of realized modernization projects from Russia

As mentioned earlier, a huge number of apartment building renovations across Russia are publicly funded through the Utilities and Housing Sector Reform Fund and as part of regional programs. Following the public procurement procedures, the tender announcements are placed on the Russian national procurement portal and private-sector contractors are then selected based on the lowest bid.

Hundreds of apartment buildings have been renovated in Moscow since 2011 under the city's housing programs coordinated by the Department for Capital Repairs (see Figure 13). The Department reports that between 2011 and 2013 comprehensive repairs were implemented in 104 apartment buildings, subsidized capital repairs took place in 428 apartment buildings, and ventilated façade systems were installed in 820 apartment buildings. In addition, over 2,600 apartment buildings had their elevators replaced. In terms of energy efficiency, the Department for Capital Repair (City of Moscow 2014) requires thermal performance of building envelopes in repaired buildings to correspond to the minimum standard for new construction.

Figure 13. Apartment buildings in Zelenograd (Moscow) after capital repair in 2012 type II-18 (left) and II-49 (right).

Some co-funding from the state corporation “Housing and Utilities Sector Reform Fund (2013c)” to regional resettlement programs, under which the residents of run-down buildings are relocated to new buildings, has been used to pilot energy-efficient and renewable energy solutions in some 40 new “economy-class” apartment buildings erected in various regions of Russia. The solutions included, apart from use of improved thermal insulation materials and four-pane windows, the use of larger windows on southern facades, ground-source heat pumps, ventilation heat recovery, recovery of wastewater heat, LED lighting, use of roof-top solar energy (PV and thermal), individual heat and water consumption metering, the collection and reuse of rainwater for watering (some examples shown in Figure 14).

Figure 14. Examples of completed energy-efficiency projects in Russia (Housing and Utilities Sector Reform Fund 2013c).

Russian banks, such as Gazprombank and Sberbank, are engaging in energy efficiency financing, though there are still concerns as to whether the financial sector has developed sound energy efficiency financing tailored to the Russian context. (Caprio 2012.) The EBRD (European Bank for Reconstruction and Development), NIB (Nordic Investment Bank) and the IFC (International Finance Corporation) fund implementation of projects focusing on energy-efficiency in Russia through local banks. The interest rates of loans in these projects are typically not subsidized; rather the aim is to develop the capacity of the banking sector in energy efficiency financing. The EBRD’s Russian sustainable energy finance facility (RuSEFF[7]) also aims at a market transformation and employs a set of criteria for products and materials that may be financed.

[7] RuSEFF – Russian Sustainable Energy Finance Facility: http://www.ruseff-r.ru/en (residential) & http://www.ruseff.com/ (industrial).

The EBRD was also involved in financing railway station modernization pro-grams[8]. The modernized railway station in Anapa features 560 PV modules with a total capacity of 70 kW, ensuring self-sufficiency during the day (Russian Railways 2012).

The Investment Fund of the Russian Federation, established in 2006, is one of the drivers of construction activity in the country (Interfax-Can 2013). The fund is a part of the Russian federal budget allocated to finance PPP projects and the creation of key infrastructure to make implementation of selected investment projects possible. Following an initial selection within the fund, the selected projects are approved by Government resolutions. The financial, budgetary and economic effectiveness is checked by Vneshekonombank (VEB), which acts as a financial consultant to the Russian Government. The register of the selected investment projects lists over 50 projects and, apart from roads and railways, includes development of heat and power supply, construction of the infrastructure for a port, regional industrial parks, housing projects, and new production facilities in agriculture, metallurgy, container-glass, wood processing, gypsum, sandwich-panels, mineral wool, antibiotics and other. The register also includes several projects focusing on water (in Rostov-on-Don, Perm, Petrozavodsk) and waste (Novokuznetsk, Cheboksari) (Investment Fund of Russian Federation 2013).

Vnesheconombank (VEB) funds major investment projects aimed at removing infrastructure restrictions to economic growth. VEB does not compete with commercial credit institutions and participates only in those projects that are not capable of receiving financing from private investors. Under the Memorandum of the Bank's Financial Policies, Vnesheconombank is to extend credits and guarantees for projects payback periods which exceed 5 years and where the total value is more than 2 billion rubles. The sectoral priorities of the bank embrace the space and aircraft industry, shipbuilding, electronics and nuclear, timber processing, defense, etc. (VEB) At the same time, the bank provides target financing of energy-efficiency and resource-saving projects in cooperation with the International Bank for Reconstruction and Development (the IBRD). The interest rates for end borrowers might be substantially reduced due to a relatively low cost of raising funds from the IBRD (VEB[9]).

Nordic Environment Finance Corporation (NEFCO) also has several financing instruments and may provide an energy-efficiency loan to municipalities or municipal owned companies for a period of up to five years to implement energy-saving measures in municipal buildings such as schools, day care centers, hospitals and sport facilities. It is required that annual savings amount to approximately 25% of the investment cost. Similar requirements exist for NEFCO's cleaner production loans. The loans and investments of NEFCO are supposed to generate positive

[8] Information available at: http://www.ebrd.com/pages/project/psd/2011/41905.shtml (accesssed Feb. 5th, 2014).

[9] See more information on http://veb.ru/en/strategy/pmfi/vebmbrd1/ & http://veb.ru/en/strategy/prj_rev/ (accessed Feb. 5th, 2014).

environmental effects of interest to the Nordic region. The majority of the projects implemented in Russia are located in the North-West of the country.

In addition, regional modernization projects were implemented in conjunction with preparations to hosting APEC summit in 2012, Universiade in Kazan 2013 and winter Olympic Games of 2014 in Sotchi. The next major event is the 2018 FIFA World Cup, which is to take place in 11 Russian cities (FIFA 2014).

5. Mapping of business concepts

The challenge in energy-efficient renovations of Moscow residential districts at the moment is the decision-making in residential buildings, partly because the income levels of households vary largely. It seems that housing associations, which often have central role as managing apartment buildings on behalf of the housing owners, do not act openly in creating trust and “greater responsibility” (Caprio 2012, p. 3). Based on several sources (Caprio 2012, Paiho et al. 2013), the greatest challenges lie elsewhere than in the willingness to conduct actions. At the moment, the technologies used originate outside Russia, which results in a lack of knowledge of these systems among building authorities, and increases the costs of the systems.

Access to the right technologies or products alone does not solve the problem. Without sophisticated service networks, the benefits are lost as well. The city can benefit from developed services as well. The most significant factors in economic growth in the largest cities are business services (Gritsai 1997). Face-to-face contact is the usual way of delivering these services, which means that the service provider and customer need to be based in close proximity (ibid.). New business models (Würtenberger et al. 2012) may help to lower the barriers to energy-efficiency investment together with other sources of motivation to invest, such as comfort, aesthetics, reliability, convenience or status.

5.1 Obstacles and challenges in doing business in Russia

Russia possesses many opportunities for foreign companies, having one of the world’s fastest growing GDPs and less competition than many other countries. However, Russia also has a challenging business environment, causing problems for companies unaware of what to expect and how to prepare. Russia is different from Finland, with specific rules and manners, and Finnish players may need to become accustomed to these. Corruption is very much present in the Russian business environment.

Fluency of business

The fluency of business is greatly affected by permits and governmental practice, which is seldom similar to Finnish practice. Business is highly regulated in Russia, and the generation of adequate permits may include significant bureaucracy. The number of permits needed for different activities differs significantly between Russia and Finland: business start-up 39–111 (Finland–Russia), construction permits 45–178, electricity connection 25–183, and registering of ownership of real estate 25–45. The difference in the bureaucracy of, for example, construction permits is significant; in Finland it requires 16 actions and takes approx. 66 days, while in Russia it requires 55 actions and takes approx. 423 days. In addition to the differing bureaucracy, refusal to take part in corruption may also slow down the process even further. (Kosonen 2011.) Globally, the Russian Federation stands at 178 in the ranking of 189 economies on the ease of dealing with construction permits (The International Bank for Reconstruction and Development & the World Bank 2013).

Corruption

All players active in Russian markets must inevitably deal with corruption. Especially when dealing with the Russian authorities, the risk for corruption is always present. Corruption originates mainly in the shortcomings in and disregard for the legislation in combination with the low salaries of the public administration. Refusing to take part in this will probably lead to failing on the Russian market. If one refuses to be involved in corruption, it is always possible to outsource the activities related to corruption, such as bidding processes and dealing with the authorities. (Fey & Shekshnia 2011.)

The most common terms of corruption are kickbacks for getting contracts and speeding up the bureaucracy, as well as fines due to unclear flaws spotted in authority inspections. In Russia the practice of kickbacks is very common. Authorities, decision-makers and different kind of deal facilitators working for the decision-makers require kickbacks in order to get things done. The kickbacks can be paid in the form of “voluntary” contributions to different funds or as traditional bribery to specific people. Receiving all the necessary permits for starting doing business in Russia may take a very long time, and kickbacks may speed up the process. This functions in the opposite way as well; if one is unwilling to pay kickbacks, the process may be further slowed down. (Kosonen 2011, Fey & Shekshnia 2011, Grishankova 2010.)

Corruption is identified as significantly preventing the development of Russia and is therefore combatted at a federal level. President Yeltsin was the first to define corruption as a national threat, and since then presidents Putin and Medvedev have continued the battle against corruption through laws and decrees. In the 2000s, anti-corruption work groups have been established in different levels of the federal administration. In 2006 Russia ratified both the UN and Council of Europe’s (CE) anti-corruption conventions. In 2007, Russia also became a member of the CE’s Group of States against corruption (GRECO). (Kosonen 2011.)

Business safety

Business safety in Russia is connected both to the general safety situation in the country, as well as internal and external threats to business (white-collar crimes). After the fall of the Soviet Union, the main threat was organized crime, which is now on the decline. Today, the main threat is within companies, such as employee misbehavior: unauthorized utilization of assets and selling of information to rivals. The greatest whiter-collar threat is the hijacking of a business by the local executive, either through establishing a parallel company and directing all the business to this company, or by running the company into bankruptcy and taking over the assets. (Kosonen 2011.)

Compliance with the requirements of business regulation requires a lot of work, and the authorities have the right to interrupt the business operation if violations are suspected. This may pose a risk for the business if operations are delayed or interrupted. Risks related to the public administration are most easily mitigated through complying with rules and legislation, which often requires the expertise of a lawyer. Risks are also commonly reduced through networking and the creation of good personal relations to the authorities, for example, by remembering birthdays as well as supporting local charity projects and sports clubs. (Kosonen 2011, Fey & Shekshnia 2011, Grishankova 2010.)

Due to the lack of transparency in Russian business, it is hard to know whether business partners are legitimate or whether they are involved in illegal business. It is hard to get reliable information about backgrounds and ownerships. Finns tend to trust their business partners and expect them to play by the rules and to be honest. Finns are commonly accustomed to sealing deals merely with a handshake, but in Russia the importance of signed contracts is significant. Finnish companies with experience of Russia state that a translated and signed contract is a must even when dealing with old business partners. The consequences of inadequate contracts are, for example, billing for undone jobs, billing too much, or not paying appropriately for goods/services. (Kosonen 2011.)

Competition legislation is quite undeveloped in Russia in comparison to Finland, and dishonest means are common when competition is hard. Companies bribe the authorities and pay salaries under the table, and may also force customers to boycott rivals in order to improve their competitiveness. Confidential information can also easily end up in the wrong hands, either through the misconduct of one's own staff, or by a rival's espionage or espionage by the federal intelligence service. (Kosonen 2011.)

5.2 Stakeholders

A stakeholder analysis clarifies which stakeholders there are, how they are connected to each other and what benefits they could achieve through renovation concepts. The scope of the analysis has been chosen to cover the whole energy chain including energy production facilities, heat and electricity networks, building blocks, individual buildings and users of the buildings who influence the energy demand profiles. The different building stakeholders can play an important role in determining how, why, and whether retrofit measures will be implemented and the development of methodologies that enhance the interaction amongst these stakeholders (Menessa & Baer 2014).

The residents. The residents are the people living in the apartments. In Russia, about 76% of housing units in apartment buildings are reported to be in private ownership (IUE 2011a). Typically, the resident and the apartment owner are the same, but on the other hand apartment owners may lend their apartments to tenants. In principle, there are two prevailing kinds of tenancy agreements: (i) social housing, whereby publicly-owned apartments are rented out to low-income population groups, and (ii) the traditional rental market, where "grey" schemes are common, meaning there are no valid[10] rental agreements. In both the cases, the tenants are probably the least motivated to directly finance energy efficiency or other improvements to buildings and districts, because they do not own the property and it is only the right of apartment owners to make renovation decisions.

Residents are the energy end-users in the apartments. They are also customers of energy and water companies in the case where they pay the costs based on the usage. The heating and water utilities are supplied to the building management companies (Paiho et al. 2013), who then distribute the costs to the apartment owners according to the rules set forth by law, taking into account possible submetering of consumption at the level of individual apartments. According to an action plan from December 2009 for the Federal Law N261 of Governmental Order N1830-9, apartment-specific sub-metering is required in all buildings for electricity and hot and cold water as well as heating step by step from January 1st 2012, although these requirements have not always been fulfilled. According to the Ministry of Regional Development, 40% of public buildings and only 25% of private houses/flats even have building-specific heat metering (Korppoo & Korobova 2012).

Residential consumers are charged for communal services such as heat, water, sewage, and waste disposal in one bill (Korppoo & Korobova 2012), where heat is the dominant item, with regional variations of 47% to 65% of the total. Electricity costs as a proportion of household income remain relatively low, at around 1.2% of average household income (Porohova 2010). During the last decade (2000–2009), heating tariffs have increased many times in Russia, and the rise in the price of heating has been steeper compared to other utilities (Nekrasov et al. 2012).

As for the financing of waste management operations, Muscovites pay 50% of waste disposal price and the other 50% is supported by municipalities. There is no

[10] Rental agreements, which are initially concluded typically cover the first 364 days so as to avoid cumbersome state registration, which is mandatory for long-term contracts. (http://www.evans.ru/rent/legal.html) Thereafter, either a new 364-day agreement is again concluded, or tenancy continues without agreements on paper. There is also a fraction of the market, where all the necessary agreements are in place.

available data on how much exactly Moscow residents pay for waste disposal, since it is included in an aggregate “Maintenance and repair of premises” tariff. (Finpro BRUC 2013.)

Households who do not receive housing subsidies pay at least one-third more for housing and communal services than those households who receive subsidies (Hamilton et al. 2008). Heat supply services account for the most part (60–80%) of household subsidies in the regions, and the total regional expenses on subsidizing households in the field of heat supply are several times greater than the budgetary expenses at all government levels on reconstruction and new construction of municipal heat supply systems (Antonov & Tatevosova 2006).

According to a housing survey in St. Petersburg (Herfert et al. 2013), only a small proportion of the residents living in large-scale housing estates have considered their satisfaction with living conditions, since to a large extent alternative options in the form of affordable residential offers are not available and the large majority of city dwellers still live in non-refurbished and traditional older buildings. Probably especially in the case of Moscow, most of the inhabitants do not have the opportunity to move somewhere else.

The resident benefits from technical renovations when acquiring better indoor comfort. The temperature might become more even and easier to regulate. Draft problems also disappear when renovating, which increases the comfort level. If the resident pays the energy costs, they benefit from decreased running costs.

Owner of the apartment. In Russia the owner of an apartment owns the apartment itself and also the windows and the balconies. The staircases and other common areas are not owned even partly by the apartment owners. The owner of the apartment has the incentive to keep the apartment in good shape so that the value does not decrease. Technical renovations compete with upgrading renovations such as kitchen renovations. For the apartment’s technical value, technical renovations make more sense. But when determining the market value of an apartment, upgrading renovations might have a bigger impact, like kitchen renovations. Often when remodeling the apartments, the owners introduce significant changes to the technical systems of buildings’ (Paiho et al. 2013). These often illegal changes affect the proper functioning of systems during the building’s operational phase.

Apartment buildings in Moscow (as well as in other Russian cities) are usually rather big, with several hundreds of apartments (owners), where the residents are rarely familiar with each other and may often have substantially different income levels, which complicates the common decision-making process. (Paiho et al. 2013.)

The recent version of the Housing Code established the obligation for the residents of apartment buildings to pay renovation fees to a renovation fund, which can be used either by the building association itself, provided two-thirds of the residents agreed, or by default by a regional operator (Housing Code of Russian Federation 2013).

Price is an important purchasing criterion, and Russian consumers are likely to opt for cheaper products (Lychuk et al. 2012).

Owner of the building. The owner of the building owns the building except for the apartments. In Finland, multi-family apartment buildings form a housing cooperative owning the building. The apartment owners have shares in the housing cooperative which is in charge of operating and maintaining the building. The housing cooperative typically hires a house management agency and a maintenance company for daily economic and technical functions.

In Russia, privatization of the common areas of buildings has yet to occur. Additional protections in the Russian Civil Code and Housing Code state that the owners of the premises in a multifamily building also own an equity in the common property (stairways, roofs, basements, the land plot, etc.). However, there is no formal description of the common property for specific buildings. Even land underneath buildings can be subject to dispute. The local authorities seek to charge apartment owners for the cost of establishing the boundaries, even though the law stipulates this is to be done free of charge. (Lipman 2012.)

The stairwells, the hallways, the roof, the heating and electrical systems, the lifts – all the common elements that affect the building's comfort, convenience, and value – are still often controlled and maintained by local government (or former government) entities. (Lipman 2012.)

Homeowners' associations. The housing reform that came into force in 2005 obligates all homeowners to organize the management of their building privately (Vihavainen 2009). One alternative to this, the establishment of a homeowners' association, has since become increasingly common. The other two alternatives are direct management by the homeowners without an association or management by a private company. A homeowners' association is, by definition, a non-profit organization, established for the management and maintenance of common property in a multifamily building.

City administration and other public authorities. The local public sector is involved in the renovation and management of old residential building stock (Paiho et al. 2013), firstly, because of an obligation to implement renovations and supervise the condition of buildings, secondly, because the scope of renovation is enormous and public funds are not sufficient – maintenance is the only way to keep social stability. The housing sector, in Moscow as well as in other cities of Russia, has a poor reputation due to its non-transparency, inefficiency and corruption.

The city plans the district and has the overall responsibility for providing comfortable and sustainable living surroundings. The city can influence what is being built and how it is being done. The city can also demand renovations or demand that buildings be demolished if they are in a very bad shape.

The city has the incentive to support energy-efficient renovations to achieve overall political energy efficiency targets for the city. The city can also be a building owner and an apartment owner. As in Moscow, the city can also own the energy utility and network utility.

Energy companies operate the energy producing facilities. The main interest of energy companies is in selling energy. It can, therefore, seem difficult to find interests in the energy companies in investing in energy efficiency measures.

Russian electricity prices are still relatively low by international standards. Average electricity prices for Russian residential consumers were just over USD 66 per MWh, or around 38% of the OECD average of nearly USD 175 per MWh, and around 27% of the OECD Europe average of nearly USD 245 per MWh in 2011 (OECD/IEA 2013). Russia raised electricity and gas prices by 15% on average in July 2013, and plans to increase them further in July 2015 (IEA 2013).

The majority of the CHP (Combined Heat and Power) plants are now over 30 years old and are nearing the end of their useful lives. Under the current electricity market liberalization plans, most of the CHP plants will be packaged in 14 Territorial Generating Companies and privatized. The economic fundamentals of CHP provide a favourable base for this. This includes the high and steady demand for heat, the good availability of cheap natural gas, and power prices that are currently among the world's lowest but are set to increase substantially in the medium to long term. (Masokin 2007.)

Most CHP installations are controlled by Territorial Generation Companies ("TGKs"). The TGKs are regional electricity production companies that have been created based on the regional production assets of the former Russian unified energy system, the quasi-monopolist RAO UES. The TGKs are the largest heat producers in Russia. (Boute 2012.)

The increasing demand and the ageing of the existing power plants will at some point lead to a need to invest in new power plant capacity. If the energy company can prolong these investments by increasing energy efficiency on the demand side and by managing energy loads better, it might have great value for the company.

The approval of utility companies is required when dimensioning new systems, for example, space heating systems (Paiho et al. 2013). Coordination is needed during the implementation phase of energy-efficient building modernization.

Energy network companies. The energy network utility owns the energy network comprising the district heating distribution system and the electricity transmission lines. There can be different actors operating the district heating network and the electricity grid. TGKs (Territorial Generation Companies) generally control district heating networks (Boute 2012). In Moscow, the district heating network is in poor condition and transmission losses are high (IEA 2008). The network utility is forced to do renovations to the network in order to keep the system working. Energy efficiency is an additional bonus of these actions. It is in the network utilities' interest to have an even and predictable demand curve. This is achieved with more energy-efficient buildings on the demand side.

There has been little investment in networks, especially distribution networks, over the last two to three decades in Russia. Ageing network infrastructure is beginning to deliver deteriorating network performance, including above-average network losses, reduced transfer capability and increasing service disruptions. Timely and efficient network investment will be needed to strengthen and improve transmission and distribution network performance so as to support the development of well-functioning electricity markets. (Cooke et al. 2012.)

Water and wastewater utility company. The freshwater of the City of Moscow is mainly supplied by surface water from the Moskvoretsky-Vazuza and Volga systems (Paiho et al. 2013). Currently, the fresh water distribution network of Moscow is in poor condition, and the tap water not always safe to drink. About 45–70% of the Muscovite sewage collection pipes have exceeded their service life. The water and wastewater utilities and networks are publicly owned.

Waste management company. Of the Muscovite municipal solid waste (MSW), the majority is collected and treated as mixed MSW. The majority of this waste is landfilled (63%), about 27% is incinerated (Rianovosti 2009), and 10% is recycled (Russian Heat Engineering Institute 2008). In 2008 the Russian Heat Engineering Institute estimated the number of landfills in the Moscow area at 58 legal and 109 illegal sites.

Regional waste markets are consolidated by large local waste companies which owns waste landfills and have own transport for waste transportation. EkoTechProm, a state unitary enterprise, (http://www.eco-pro.ru/) is one of the major participants in the MSW market in Moscow region, providing collection, sorting, transportation, and disposal services. (Finpro BRUC 2013.)

The MSW market is nowadays enjoying strong governmental support. The executive body responsible for the management of municipal solid waste In Moscow is the Department of Housing, Utilities and Amenities of Moscow Government (http://www.dgkh.ru). (Finpro BRUC 2013.)

Building operations and maintenance companies. Management companies may take care of the daily management and operation of apartment buildings (Paiho et al. 2013), so they may have a view of the most urgent renovation needs and the general condition of a building. In the case where the homeowners have hired a building management agency or a management company to manage the building, this agency or company still needs the authorization of the general residents' meeting to select the renovation contractor(s). The privately-owned building management companies are likely to have close ties with local administrations.

Construction companies. Many construction companies have been involved in designing and implementing apartment building renovation projects (Paiho et al. 2013). However, the vast majority of these projects have been facilitated by the public authorities in terms of financing, supervision of quality of the design documentation and the construction works implemented, working with the residents, etc. Nevertheless, the sector is technically ready to implement renovations. Typically, the companies implementing renovations are smaller than those involved in new construction. The qualification of employees is generally at a sufficient level, however, though some errors in the final product are possible (e.g. differences from the design documentation), which appears to be connected with poor quality control of the work.

The construction industry of the Russian Federation comprises over 130,000 organizations and enterprises (Panibratov 2009). Approximately 90% of all organizations operating in the sector are small businesses (up to 50 employees).Two major Russian construction companies operating in the residential sector are (Interfax-CAN 2013): LSR Group (http://www.lsrgroup.ru/en/) and Etalon Group (http://www.etalongroup.com/).

Product manufacturers. There are numerous products that are needed in energy renovations. In typical Russian apartment buildings, they may include but are not limited to windows, doors, insulations, control devices, radiators, heat exchangers for district heating systems, pipes, ducts, networks, ventilation units, water taps, toilet bowls, waste management devices, and light bulbs. In addition, elevators are often dilapidated and could be updated to more energy-efficient ones. Some Finnish window and door manufacturers have already entered the Russian markets (Grishankova 2010). When renovating residential districts, products such as water supply and drainage pipes, district heating pipes, electricity networks, valves, street lighting devices, control devices and monitoring systems could be needed. Russian companies tend to prefer to purchase from Western manufacturers when quality is essential (Lychuk et al. 2012).

European companies in the Russian construction industry deal mostly in markets for construction materials and construction instruments. Some companies export their production, others establish their own production facilities. German firms are among the most active foreign investors in the Russian economy. (Panibratov 2009.)

The share of energy-efficient lighting products in the total market remains negligible. Domestic manufacturing is limited to two factories producing compact fluorescent bulbs: LISMA Lighting and Smolensk-Svet. Manufacturers have indicated an interest in supplying more efficient lighting products, provided there is enough demand. This supply is possible from domestic production, joint-ventures, or imports. Lighting systems and products are not subject to any mandatory tests or certification to verify their energy performance or even luminous qualities. (UNDP & GEF 2010.)

System providers. In renovation projects, there are numerous systems that can be delivered as complete systems rather than merely separate products. In buildings, for example, the heat distribution system can be delivered in this way, including all the necessary components, such as radiators, pipes, valves, thermostats, etc.

Designers. Different designers are needed in building renovation projects, including heating, ventilation and air-conditioning (HVAC), structural, automation and electrical design. Also on the district scale, designers are needed for dimensioning exact systems.

Banks. The role of banks is significant for sustainable housing renovations (Paiho et al. 2013). Housing associations are a rather new phenomenon, and are regarded by the banks as being unreliable borrowers. The impact of mortgage lending on residential construction in Russia is still undermined by several important factors (Interfax-Can 2013): a relatively low level of the population income in Russia (only about 15% on the population has access to mortgage loans), high mortgage rates (the weighted average interest rate on ruble mortgage loans allocated in December 2012 was 12.7% per annum), and limited access to big mortgage loans.

Banks are not yet technical experts in the field of energy efficiency and need to see a track record of performance of energy efficiency retrofits in order to become comfortable with and lend against the retrofit asset's energy savings value-stream (Sweatman & Managan 2010). Russian commercial banks are not willing to provide the loans for investments in energy-efficiency and carbon mitigation projects, as these are classified as highly risky (Garbuzova & Madlener 2012). In addition, Russians do not trust their banks (Lipman 2012).

Investors. Investors in energy efficiency improvement measures need to recover the capital costs of their investments. To modernize the Russian heating sector, investors need to rely on tariff methodologies and structures that enable them to recover the capital costs of their energy efficiency investments and to earn a reasonable return on capital. (Boute 2012.)

Investments on renewable energy technologies are often considered as a high-risk investment because of high technology risk or regulatory risk (Aslani & Mohaghar 2013). This can reduce the investors' willingness to invest in the suggested district renewable energy production. Loock (2012) found that a "customer intimacy'' business model that proposes best services is much preferred by investors to business models that propose lowest price or best technology.

Funds. Generally speaking, funds are established to collect investors' money to be invested in specific businesses according to a specific investment strategy of the fund. A fund is typically managed by a specialized fund manager who is an expert in the target business and therefore is believed to be able to make profitable investments. A typical fund investing in energy assets is, for example, a private equity fund. (Lumijärvi & Ollikainen 2011.)

The third party equity funder is interested in maximizing returns on equity at a known risk with a pathway to exit or repayment within a determined horizon, say 5–15 years. External equity has been hard to attract for building retrofits because there is limited experience in the asset class, there is little performance track record in retrofit investments and deal size can be very small (requiring aggregation to create an interesting investment). (Sweatman & Managan 2010.)

Insurance companies. Banks continued to be the fastest growing insurance distribution channel in 2013 (KPMG 2013). Typically, people do not have home insurance in Russia. As regards insurance penetration, Russia has dropped to 55th place, with an insurance market accounting for 2.3% of its GDP in 2010 (Kalinin 2012). However, home insurance may become mandatory in the near future in Russia.

Real estate agents. In Finland, a natural person can manage simple housing deals by themself. The significance and professional expertise of a real estate agent is emphasized in real estate deals. A public notary is needed to confirm the deal in the real estate business. The estate agent has different responsibilities and duties towards both the buyer and the seller. The most important duties are the duty of disclosure and the duty to investigate. The estate agent can be made liable if they give the buyer wrong information. From the buyer's point of view, it will be safer to buy an apartment with the estate agent. (Peltonen 2009.)

In Russia, apartments are also sold in a fairly similar way to Finland. To purchase or sell an apartment, an individual would typically contact a real estate agency, as they can assist in searching, consult on procedures and take most of the risks. The duties of agents, however, are defined case-by-case in agreements concluded by real estate agencies and their customers (there are no standard sectoral agreements that all agencies follow). Another distinction of purchasing an apartment in Russia is that often no detailed information on the technical state of the building is known; similarly, energy efficiency certificates are not used. It may be important to check the apartment's floor plans, which are kept by local building inventory bureaus, in order to see whether any illegal modifications from the original design have been made.

5.3 General contents of business models

The essence of a business model is in defining the manner by which the enterprise delivers value to its customers, entices its customers to pay for value, and converts those payments into profit (Teece 2010). According to Osterwalder (2004), a business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams. The key components of a business model are shown in Figure 15 and are briefly introduced in the following text from Osterwalder and Pigneur (2010).

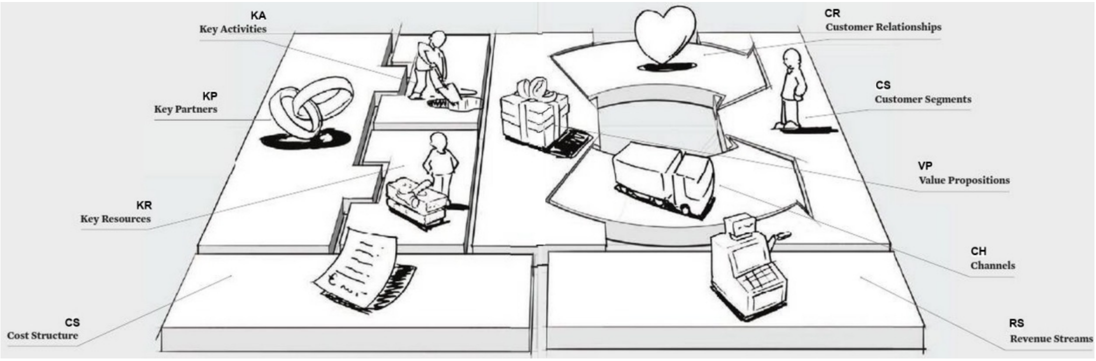

Figure 15. General business model canvas (Osterwalder & Pigneur 2010).

Customer Segments. The Customer Segments define the different groups of people or organizations that an enterprise aims to reach or serve.

Value Propositions. The Value Propositions describe the bundle of products and services that create value for a specific Customer Segment.

Channels. The Channels describe how a company communicates with and reaches its Customer Segments so as to deliver a Value Proposition.

Customer Relationships. The Customer Relationships describe the types of relationships that a company establishes with specific Customer Segments.

Revenue Streams. The Revenue Streams represent the cash that a company generates from each Customer Segment (costs must be subtracted from revenues to create earnings).

Key Resources. The Key Resources describe the most important assets that are required to make a business model work.

Key Activities. The Key Activities describe the most important things that a company must do in order to make its business model work.

Key Partnerships. The Key Partnerships describe the network of suppliers and partners that make the business model work.

Cost Structure. The Cost Structure describes all costs incurred in operating a business model.

There are also other ways to structure business model components. For example, the U.S. Department of Energy (2012) divides these elements into: governance, financial model or structure, assists and infrastructure, service offering, and customers and customer acquisition. Hedman and Kalling (2003) propose a generic business model that includes the following causally related components: (1) customers, (2) competitors, (3) offering, (4) activities and organization, (5) resources, (6) supply of factor and production inputs and (7) a longitudinal process component. Morris et al. (2005) divide the components as follows: factors related to the offering, market factors, internal capability factors, competitive strategy factors, economic factors, and personal/investor factors. However, the canvass by Osterwalder and Pigneur (2010) was considered the most suitable for this study.

5.4 Business model components for Russian district renovations

The sections that follow are based on the business model canvass developed by Osterwalder and Pineur (2010) and include some considerations of what kind of issues a service-oriented company should consider in order to be able to access energy-efficient renovation market in Russia.

Customer segments. The greatest benefits may be obtained when the whole apartment building or district is being developed so as to be more energy efficient. Even if the improved energy-efficiency benefits end users, the optimal customers for services are mainly, for example, housing associations, management companies and municipalities. Energy-efficient renovation services require knowledgeable customers.

Value proposition. Energy-efficiency itself is rarely enough to justify more expensive investments attached to renovation. Legislation can compel some actions, but laws and norms are always behind the technological development. Savings in future energy costs, secure cash flows, reduced technical risks or increased value of the asset (in this case an apartment or building) are some of the possible benefits to improve energy efficiency when there are renovation needs.

For a single resident in an apartment building, the improved energy efficiency can bring, for example, savings in energy costs or more comfortable indoor conditions. Apartment or utility owners can benefit from reduced risk levels, secure cash flows and perhaps increased rents or value of the asset (in this case an apartment or building).

Channels. As marketing channels, organized events for professionals play a central role in creating awareness. In addition, the creation of awareness among end-users helps to raise the demand for such services. These cannot replace personal contacts. Actions at a municipality level are required too.

Customer relationships. Customer relationship with institutional customers also differ from direct consumer relationships, even where different legislation is applied.

Here the institutional customers are considered more potential customers for energy-efficient renovation services due to unified decision making. Similar building stock provides the opportunity for mass customization. However, entering into the different sub-markets and features of clients requires personalized service, but on the other hand creates a fruitful basis for co-creation. In Russia, as in many other countries, the creation of trust plays an important role in business relationships.

Revenue streams. Existing services often try to tie pricing mechanisms to energy prices. There are well-founded reasons for this, but predicting price development is very risky. Instead, value propositions other than saving money could be included into services.

Key resources. Renovation activities are often labor-intensive. Finding knowledgeable people and managing a multicultural workforce creates its own challenges. Economies of scale can bring another challenge, namely that the production capacity is not extensive enough. The size of projects in Russia can be very large compared, for example, to Nordic residential areas.

Key activities. There might be a need to include several different activities in the service, for example marketing, energy audits, detailed planning of renovation, financing, installation, after sales, etc. The customer is easily buying only technical devices, but the service is not comprehensive if, for example, the delivery time and quality are not considered.

Key partners. Knowing customers or customer segments is not enough, but defining and finding key partners creates an essential basis for business. Transferring production near to the market may be required. These activities might require a creation of joint ventures with local actors. Marketing activities and creation of business relationships might also require “a partner, who opens doors.”

Cost structure. Energy-efficient renovation services are value-driven rather than cost-driven. There are possibilities for a leaner cost structure after services have been established in the market. Currently studied pre-fabrication methods, and the use of building information modelling during the design, planning and production phases can shorten delivery times in the future. The use of a local workforce makes a great difference in cost structure, but requires time and money so that the required people are trained. Russia’s residential energy-efficient renovation market provides a unique opportunity for Finnish companies to offer renovation services.

5.5 Possibly suitable business models from the literature

There are several ways to categorize business models. Richter (2012) and Richter (2013) divide utilities’ business models for renewable energy into: customer-side renewable energy business models and utility-side renewable energy business models. Frantzis et al. (2008) divide photovoltaic (PV) business models based on ownerships of the photovoltaics systems into end-user owned, 3rd party owned and utility owned. Frantzis et al. (2008) also show examples of end-user owners in residential retrofit. In the Netherlands Huijben and Verbong (2013) found three main types of business models related to photovoltaics: Customer-Owned, Community Shares and Third Party. Würtenberger et al. (2012) divide business models for an increased deployment of Renewable Energy Technologies (RET) in the built environment into: product-service-system business models, business models based on new revenue models, and business models based on new financing schemes. Lumijärvi and Ollikainen (2011) analyzed business models for carbon neutral energy supply in Finland and categorized the business models as: Energy company ownership models, End-user ownership models, Models based on leasing arrangements, and Special purpose vehicles. Okkonen and Suhonen (2010) divide business model concepts for heat entrepreneurships into public companies/utilities, public–private partnerships, private companies and cooperatives, Energy Service Company (ESCO), network model of large enterprise, and franchising.

Large-scale adoption of renewable energies requires utilities to think about their business model and how to adjust it to make the most out of the energy transition (Richter 2012). In what follows, we introduce some business models which may in some sense be suitable for energy renovations of Russian residential districts. In addition, we assess the relevance of each model described for parts of or a holistic sustainable renovation of Russian residential districts.

5.5.1 The ESCO model

Two basic ESCO (Energy Service Company) business models can be distinguished, which provide either useful energy (Energy Supply Contracting – ESC) or energy savings (Energy Performance Contracting – EPC) to the end-user. In addition to the two basic models, a hybrid model, labelled as Integrated Energy-Contracting (IEC), aims to combine useful energy supply, preferably from renewable sources, with energy conservation measures throughout the building. (Würtenberger et al. 2012.)

Bleyl et al. (2008) propose three different models for the implementation of Comprehensive Refurbishment in conjunction with Energy-Contracting: a General Contractor-, a General Planner- and a CR-Light EPC-Model. These three EPC-models allow combining (comprehensive) refurbishment measures of buildings with the advantages and long-term guarantees of Energy Contracting models.

Customer Segments. Companies providing energy services to final energy users, including the supply and installation of energy-efficient equipment and/or building refurbishment, maintenance and operation, facility management, and the supply of energy (including heat), are called Energy Service Provider Companies (ESPCs). They provide a service for a fee and take no risk. ESCOs also offer these same services with the difference that they guarantee the energy savings (as reflected in the contract) they can finance, or via energy savings guarantee assistance in arranging financing for the operation of an energy system, and their remuneration is directly tied to the energy savings achieved. (Bertoldi et al. 2006.)

The most common energy efficiency measure is the modernization and refurbishment of public buildings involving heating, ventilation and air conditioning (HVAC), control system installations and new boiler houses. Street-lighting and district heating using the ESCO concept are developed by municipalities. Cogeneration and refurbishment is common in commercial centers and industrial facilities. Improvement of industrial processes, heat recovery and replacement of motor and driver systems are implemented in industrial facilities. (Marino et al. 2011.)

The ESCO model has also been suggested as a business model for local heat entrepreneurship in Finland (see Section 5.5.5). The results indicate that in the Finnish area the ESCO model is challenging. Low profit levels and the assumed customer's preference for achieving cost savings from the beginning of energy renovation can result in long contract periods tying up capital. The ESCO model is unattractive in the current business climate, requiring modifications or integration with other maintenance services of housing associations. (Suhonen & Okkonen 2013.)

Value Propositions. An important difference between in-house ('do-it-yourself') implementation and outsourcing to an ESCO root is the functional, performance and price *guarantees* provided by the ESCO and the assumption of technical and economic risks by the ESCO (Würtenberger et al. 2012). Sometimes it is difficult to define how these guarantees are measured and verified. Investment in such projects must be facilitated, and ESCOs must clearly demonstrate the measureable and observable benefits of their projects (Pätäri & Sinkkonen 2013).

Channels. ESCOs may need to gain further experience and improve their technical, financial, management, and marketing abilities in order to develop the market (Marino et al. 2010).

Customer Relationships. Mutual trust and confidence between clients, Escos and banking institutions is a key to further market growth (Ramesohl & Dudda 2001). The high level of collaboration required between the client and the provider can be perceived as resource-consuming, while the commitment issues are largely related to the long contractual terms and low flexibility that characterize the ESCO model (Marino et al. 2011).

Revenue Streams. ESCOs accept some degree of risk for the achievement of improved energy efficiency in a user's facility, and have their payment for the services delivered based (either in whole or at least in part) on the achievement of those energy efficiency improvements (Bertoldi et al. 2006). The main share of revenue of an ESCO business model comes from the reduction achieved either in energy costs, energy usage, or carbon emissions (Garbuzova & Madlener 2012).

Key Resources. ESCO projects can be financed through either ESCO financing or Third Party Financing (TPF). ESCO financing refers to financing with the internal funds of the ESCO and may involve own capital or equipment lease. Third-party financing (TPF) refers solely to debt financing. These are two conceptually different TPF arrangements; the key difference between them is which party borrows the money: the ESCO or the client? In the first arrangement, an ESCO may borrow the money needed for realizing the investment. In the second arrangement, the customer takes a loan from a finance institution backed by an energy savings guarantee agreement with the ESCO; the purpose of the savings guarantee is to demonstrate to the bank that the project for which the customer borrows will generate a positive cash flow, i.e. that the savings achieved will certainly cover the debt repayment. (Bertoldi et al. 2006.)

Key Activities. Typically, an ESCO serves as a general contractor and is responsible for coordination and management of the individual components and interfaces of the service package towards the customer. It has to deliver the commissioned energy service (Megawatt hours of useful energy or energy savings, 'Negawatt hours') to the customer at 'all inclusive' prices. (Würtenberger et al. 2012.)

Key Partnerships. The engagement of financial institutions is crucial for the establishment of a successful ESCO market (Martini et al. 2011). Partnering with the selected technology providers and energy suppliers is also essential.

Cost Structure. The ESCO uses the income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the cost of the investment. The ESCO takes the technical risks of the investment and derives financial benefits from that risk-taking. In, payment is based on performance; a measure of performance is the level of saved energy. (Bertoldi et al. 2006.)

Typical EPC contract terms are for 10 years. Investments for comprehensive refurbishments of buildings, depending on their magnitude, can be refinanced only partially from future energy cost savings. The building owner has to pay part of the investment directly, for example, with a building cost allowance. Another option is extended contract periods of 15–25 years. Also, leasing finance can be an option and should be considered. After termination of the contract, the entire savings will benefit the client. (Bleyl et al. 2008.)

In Russia, ESCO activities are still in a nascent stage, at least when referred to a "Western-ESCO". Energy Performance Contracting (EPC) is not used in the Russian ESCO model. According to Russian legislation, leasing schemes seem to be very promising for the Russian ESCOs. They offer considerable benefits to the clients and provide important means of control over the measures implemented on the financing attracted by ESCO companies from their own sources or, rather rarely, from the financial institutions. Further sources of revenues of the Russian ESCOs are based on the energy audit and technical services for the implemented equipment during the project and not on the energy savings as in Western-ESCOs. (Garbuzova & Madlener 2012.)

Lack of appropriate forms of finance, public procurement rules, unstable customers, and a perceived high business and technological risk are seen as strong overarching obstacles that hinder ESCO market development in Russia. Companies operating as providers of energy services are of quite a small size; some offer ESCO-type contracts as an added value to their core business, such as energy equipment manufactures integrating the ESCO concept into the energy supply business. (Marino et al. 2010.)

Serious constraints on the development of ESCOs in the Russian Federation are mainly associated with the lack of stability for operations of small and medium business and with the traditional economic system of centralized planning. Other constraints relate to low energy tariffs which fail to provide incentives for energy saving. At the same time, end-user prices are fairly high as compared to the average income level. (United Nations 2010.)

An important aspect of ESCO projects' implementation relates to ensuring payback guarantees, as risk control would be problematic at all phases of project implementation. Such guarantees may be ensured by financial institutions or Russian government authorities. ESCO operations in the Russian Federation need to be supported by a corresponding clearly-defined legislation and predictable taxes. Improving public awareness of the energy saving issue and ESCOs as an energy saving tool is to become a priority task. (United Nations 2010.)

5.5.2 Customer-side renewable energy business model

In this business model, renewable energy systems are located on the property of the customer (Richter 2012). The systems can also be owned by the customer (Huijben & Verbong 2013, Frantzis et al. 2008). In small-scale business, the dominant sources or renewable energy are typically wood pellet stoves, small wind turbines, small-scale combined heat and power systems (CHP), solar thermal collectors, solar photovoltaic systems, geothermal, and heat pumps (Aslani & Mohaghar 2013). The size of the systems usually ranges between a few kilowatts and about 1 MW (Richter 2012). For the district renovations, energy production units serving only one building would be within this size limit.

Customer Segments. In principle, the customer segments for the energy utilities remain the same as before and are the energy end-users. However, since parts of the production will happen at the customers' sites, these customers will buy less energy and the utility needs to buy energy from several producers. Service packages, including for example consulting, installation, financing, operation, maintenance and warranties, could be formulated for new customers (Richter 2012). For example, a number of energy companies in the Netherlands are selling PV panels to their customers and providing additional services such as installation and monitoring (Huijben & Verbong 2013).

Value Propositions. The value proposition for the customer-side renewable energy business model has yet to be defined, and utilities are still uncertain as to what can be profitable in the long run (Richter 2012). In Germany, even the utilities that see distributed generation as a potential market really struggle to develop value propositions for this field (Richter 2013). Successful micro-CHP business models minimize the trouble for final consumers and feature technologies with low maintenance requirements, a single contact for all issues, moderate initial investments, etc. (Boehnke 2007).

Channels. New service-oriented business models require a better exchange of information between the utility and the customer (Richter 2012).

Customer Relationships. Customer relationships turn out to be more relevant as the value creation tends to be closer to the customer (Richter 2012). From the utilities' side, the customer-side energy production is more like a business-to-business relationship. In Germany, new products and services have been invented but mainly for the creation of political goodwill and customer relationship (Richter 2013).

Revenue Streams. To date, utilities' revenues are usually based on a fixed price per kilowatt hour, meaning that the more energy is consumed the better it is for the utility. Creating new revenue streams, based for example on feed-in remuneration and provision of additional services, or new value propositions is the essential task for utilities to maintain profitability in the future energy landscape. (Richter 2012.)

Feed-in remuneration can be a tariff, which like a preferential price covers the full generating costs, or it can be a premium, which provides a 'bonus' for the producer to cover the financial gap between the generation costs of using renewable energy versus using conventional (fossil) energy. A feed-in scheme guarantees access to a predictable and long-term revenue stream, which can serve as a stable basis for a business model. (Würtenberger et al. 2012.)

For micro-CHP businesses in Germany, simply selling units to final consumers is not a very valuable option for generating revenues, since only consumers with a large income can afford to pay the high initial capital costs. A much better way to market micro-cogeneration is to offer the units in combination with financing services that relieve consumers from the initial investment and require a regular payment of small rates instead. (Boehnke 2007.)

Key Resources. Key resources in the energy sector are the generation units. In the customer-side business model, the generation assets are, for example, photovoltaic solar systems installed on the customer's roof. Owning and operating a large number of decentralized renewable energy systems would lead to a fundamentally different structure of the key resources than in the traditional utility business model. (Richter 2012.)

Key Activities. With a large number of small, decentralized generation assets on the customer-side, utilities need to develop new approaches in the field of asset management and operation (Richter 2012).

Key Partnerships. Utilities might enter into partnerships with manufacturers of renewable energy systems so as to provide customers with cheap systems and the benefit from economies of scale. They could partner with installation companies like local service technicians if they do not want to hire their own staff in this field. Partnership formation can be a valuable entry strategy into new markets. (Richter 2012.)

In the case of micro-CHP, additional value for the final consumer can, for instance, be created by teaming up with banks or other financial institutions in order to provide financing services that reduce initial costs for the final consumer (Boehnke 2007).

Cost Structure. The cost structure becomes more complex due to many small instead of a few large investments. The installation and operation of a large number of energy systems in dispersed locations leads to higher transaction costs per megawatt of installed capacity. (Richter 2012.)

Typically, the feed-in tariff (FIT) payment is sized to cover both installation and operating costs, but the tariff is only paid for actual energy production (Gifford et al. 2011). This makes it most suitable for technologies that are available off-the-shelf (Würtenberger et al. 2012). Feed-in tariffs for heat are evolving (REN21 2013).

In this business concept, there are two key actors both producing energy, namely the energy utility and the distributed renewable energy producers at customer locations. In Russia, the energy utility, also owning the energy networks, is most often a public body (see Section 5.2). The energy production facilities and the energy distribution equipment are old and in need of renewal. In case, whole residential districts would be renovated the energy demands of these districts would be smaller as well as the required energy production capacities. This smaller energy need could be produced at the customer-side by renewable energy. The energy would have ecological value and at the same time result in smaller transfer losses compared to the current situation. The business for the energy producers could be, in this case, to maintain and “rent” the distribution capacity and offer maintenance services (maintenance, balancing, storage capacity etc.) regarding the customer-owned energy systems.

Feed-in policies are widely used around the world, but Russia has not adopted them yet (REN21, 2013). Because of the flexibility in choosing categories and tariffs, government can use a feed-in scheme to stimulate private sector investments into specific technologies or niche markets (Würtenberger et al. 2012).

5.5.3 Utility-side renewable business model

In this model, the projects are larger than customer-side projects and range from one to some hundred megawatts (Richter 2012). In large-scale business, the dominant sources of renewable energy are typically biomass and biogas plants (or CHP plants), on/offshore wind energy, large-scale photovoltaic systems and solar thermal energy like concentrated solar power (Aslani & Mohaghar 2013). For the district renovations, the energy production units serving the whole district would be within this size limit.

Customer Segments. Customer segmentation allows to increase the customer base and earn "eco" price premium (Richter 2012). For the utility management, clean energy and energy efficiency are often a lower priority than reliability and cost (U.S. Department of Energy 2012).

Value Propositions. The classical value proposition of the utility, i.e. the product or service offered to the customer, is generation and delivery of electricity for a fixed price per unit. The production of electricity from utility-side renewable sources does not force utilities to change their value propositions fundamentally, but it offers possibilities to enhance the value proposition by underlining the additional environmental value and creating ways to capture this value. (Richter 2012.)

Channels. The channel towards the end-customer is not affected for energy producers (Richter 2012). Utilities have a number of marketing channels already in place, such as customer referrals, internet search engine optimization, public relations, advertising and direct mailing (U.S. Department of Energy 2012).

Customer Relationships. There is no need for utilities to significantly change or improve the relationship towards the end customer to make the business model work (Richter 2012).

Revenue Streams. Traditionally, utilities have a disincentive to reduce energy consumption, as their revenues have been tied to kWh sales (U.S. Department of Energy 2012). Revenue models for the utility-side business model exist and can easily be adapted by utilities (Richter 2012).

Decoupling and cost-recovery mechanisms allow utilities to recover some of the revenues lost from demand-side management (DSM) or other energy efficiency programs. Decoupling refers to a situation where a utility's profits do not depend on the quantity of energy it sells to customers. Cost-recovery mechanisms allow an organization to wait to recognize revenues from an investment until the organization has completely recovered the up-front cost of the investment. The goal of DSM is to meet the demand for electricity during peak hours without activating more expensive peak generators. (U.S. Department of Energy 2012.)

Key Resources. The most important assets are the renewable energy projects (Richter 2012). The basic model and a starting point of supplying and purchasing energy is based on generation and distribution assets owned and operated by municipal and state energy companies (Lumijärvi & Ollikainen 2011). The energy products are sold to end users who pay for consumed energy (electricity, heat, and/or cool).

Key Activities. Utilities' key activities regarding large-scale renewable energy projects depend on the size and competencies of the individual utility. One possible approach for utilities would be to cover the whole project value chain. This approach allows the highest return on investment, because the utility is involved in every step of the value creation process. (Richter 2012.)

Key Partnerships. Key partnerships play an important role for utilities in the field of renewable energies, because utilities are often inexperienced in this new field. Key partnerships provide a possibility to acquire knowledge and experience that is not available in the own organization. (Richter 2012.)

Cost Structure. Cost structures are in favor of utilities' experiences with large-scale infrastructure financing. There are economies of scale from large projects and project portfolios. (Richter 2012.)

In a competitive market, the electricity bill that a customer has to pay can be reduced significantly by shifting part of the demand to low price periods. Demand response services may reduce the electricity bill of a final customer with distributed generation capacity by over 15%. (Gordijn & Akkermans 2007.)

Energy companies play a central role in the sector, largely defining when, where and what kind of capacity will be constructed. Municipal and state-owned companies play a major role in the energy business, even if it is becoming more privatized and opened up for competition in Russia. Since 2003, the Russian electricity market has gradually opened up to competition, and the end of 2010 marks the final stage of this transition (Boute 2012). The heat market is still regulated (Boute 2012). Due to the dominating role of the traditional energy companies, any substantial change in the energy generation mix will include the involvement of the municipal and state (and industry's) energy companies. On the other hand, experiences indicate that the energy companies are not typical early adopters of new technologies and business models (Lumijärvi & Ollikainen 2011). Often technology companies, new business models and private equity are required to initiate and finance the market penetration of a new technology.

If residential districts in Russia were to be renovated to become more energy-efficient, their energy demand would fall. The energy needed could thereby be produced locally from renewable energy sources. From the utilities point of view, the business would change in the way that they would sell less energy, but the energy that they generated would contain ecological value, and at the same time result in smaller losses and infrastructure costs (instead of long-distance transfer and maintenance of the distribution network).

For the district renovations, the new energy production units created would serve the whole district and not be building-specific solutions. They could be owned by the homeowner's associations in the area, by the building operations and maintenance companies, by the municipalities or by the energy utility. In the Netherlands, there are examples of community-shared projects where apartment complexes own the PV production facilities (Huijben & Verbong 2013). If there is periodically or always more electricity produced than is needed in the area, this can be sold to the grid for profit. If the heating energy is locally produced from renewable energy sources, only the local district heating network will be in need of renewal.

5.5.4 Mankala company

In a Mankala arrangement (see **Figure 16**) the shareholders establish a limited liability project company (a "Mankala company", one form of an energy company ownership business model), the purpose of which is to operate like a zero-profit cooperative to supply electricity to shareholders at cost price (Lumijärvi & Ollikainen 2011).

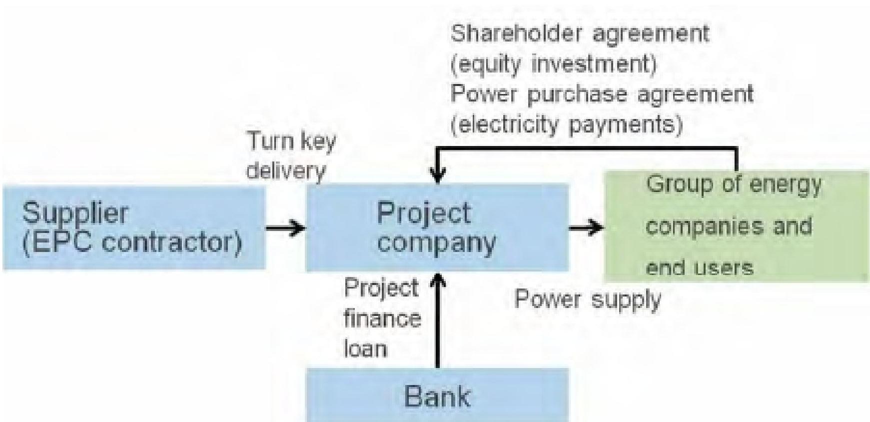

Figure 16. The Mankala company principle (Lumijärvi & Ollikainen 2011).

Customer Segments. The purpose of the Mankala companies is to produce electricity for the joint owners at the lowest possible cost. The owners acquire electricity in proportion to their ownership at a cost price. The owners can use the electricity in their own production or sell it on through the exchange or bilaterally. (Puikkonen 2010.)

Value Propositions. Typically, the owners have the right to acquire a share of the electricity corresponding to their share of ownership, and at the same time they commit themselves to cover also their pro rata share of the actual costs of the Mankala company. In this way, the Mankala company is not exposed to market risks, as these are taken by the end users. (Lumijärvi & Ollikainen 2011.)

The profit distribution is organized reversely compared to dividend. The joint owners get the profit through low procurement costs. This profit can be called other earning from the company. This other earning is tax free, which is one of the main benefits of the model. (Puikkonen 2010.)

Channels. Marketing of services is not needed in its traditional sense, since the buyers of the produced electricity are also owners of the company. In case, the electricity is sold forward typical communication channels with the customers are required. In Finland, the Market Court has claimed that cooperation in a Mankala-company does not give the joint owners any specific information about other owners, and that the cooperation does not lead to a possibility of interacting with other companies' activity on the markets (Puikkonen 2010).

Customer Relationships. As Mankala companies have both energy companies and end users as owners, they could be considered to be both an energy company and an end-user ownership model (Lumijärvi & Ollikainen 2011). The owners of Mankala companies consist mostly of wholesalers and retailers and, on the other hand, of companies with a large energy consumption such as large industrial companies (Puikkonen 2010). So, customer relationships are mainly handled by business-to-business.

Revenue Streams. The purpose of the Mankala companies is to produce affordable energy for their owners. Since the owners of the companies answer respectively for the production costs of the produced energy, they have not been considered to gain taxable profit, although the companies produce electricity at a price lower than the market price. (Puikkonen 2010.)

Key Resources. As for energy companies in general, the key resources are the energy production equipment.

Key Activities. In Finland, the use of the Mankala structure is restricted to larger investments, and most of the investors participating in the structures are large companies. On the other hand, gathering a large number of companies may enable small or mid-sized companies to participate in the Mankala structure. However, as the structure is suitable for larger investments only, even a large number of very small investors may not be able to collectively secure the cash flows and debt service by the project company from the banks' perspective. So far, the Mankala principle has been applied in several energy investments in Finland, including, for example, wind, hydro and nuclear power. (Lumijärvi & Ollikainen 2011.)

Key Partnerships. The lenders do not have recourse to the shareholders' balance sheets, although in the case in which the Mankala company goes bankrupt the shareholders typically commit themselves to take over the debt. The structure is, therefore, attractive for banks, as several creditworthy owners or end users will ensure the long-term cash flow, and as a result the project company can be heavily leveraged. (Lumijärvi & Ollikainen 2011.)

In Finland, The Mankala model can be described as a long, and in principle an ever-lasting contract, in which the companies bind themselves to the obligations of the joint owners, which in turn leads to the fact that new companies' entry into the partnership is prevented (Puikkonen 2010).

Cost Structure. The structure is heavy, entails extensive legal and financial arrangements and documentation, and therefore high transaction costs (Lumijärvi & Ollikainen 2011). The price of other earnings from the company is defined in the shareholder and other agreements, and is the same for all owners within the different production forms (Puikkonen 2010).

In Finland, the Mankala model has been used in very large energy investment projects quite different to those needed in Russian residential districts. The model is complicated and it contains questionable features, such as competition issues (Puikkonen 2010). However, in some lighter and revised form it could perhaps be adapted to energy-efficient renovations of Russian residential districts. This would require several bodies or stakeholders to have a common vision and will towards energy-efficiency improvements of residential districts. Then, the model could perhaps be utilized in other similar cases as well.

5.5.5 Heat entrepreneurship model

"Heat entrepreneurship" refers to a business model which is to some extent similar to traditional energy companies' district heating business but on a small scale (Lumijärvi & Ollikainen 2011). A heat entrepreneur or enterprise can be a single entrepreneur, entrepreneur consortium, company or cooperative providing heating for a community (Okkonen & Suhonen 2010).

Customer Segments. In Finland, municipalities have played a key role in the establishment of enterprises that have taken the responsibility for heating public buildings, such as hospitals, schools, offices and libraries, as well as private houses and industrial estates (Okkonen & Suhonen 2010).

Value Propositions. The heat entrepreneur model has become a popular form of providing heat produced with bioenergy, often wood chips in Finland. In Finland, it is often used in smaller scale cases. An entrepreneur sells the heat as a service product to the end customer. Often the scale of the heating units is small, at maximum a few megawatts. (Motiva 2013.)

Channels. Heat entrepreneurship is a very local form of activity. Most obvious is to utilize local media and direct contacts for marketing it.

Customer Relationships. In Finland, the heat entrepreneurs are often small companies, even run by just a single person such as a farmer. They do not have great resources for developing customer relationships. Mainly relationships are handled when accidentally meeting customers.

Revenue Streams. The heat plant can be owned either by the client or by the entrepreneur. The entrepreneur has the responsibility for the operation and maintenance of the plant. The entrepreneur can either sell the heat directly to a building, or they can sell the heat to the local heating network. (Motiva 2013.)

Key Resources. The heat production and distribution systems are essential for the model.

Key Activities. The basic model is a so called "BOOT" business model (Build, Own, Operate, Transfer). The heat entrepreneur develops designs, constructs and invests in the heating system (Lumijärvi & Ollikainen 2011). It could also be possible to include other services, such as property management and guarding, to the offering (Pakkanen & Tuuri 2012).

Key Partnerships. The heat entrepreneur requires a constant fuel supply. For example, low quality forest fuel could cause unscheduled stoppages and reduce the profitability of cost-sensitive heat production (Laihanen et al. 2013).

Cost Structure. Long-term heat sales and purchase agreements with the local end customer(s) are signed, and the heat entrepreneur takes full responsibility for operation and maintenance of the system. The customer pays for energy consumed in a similar way to the case of district heating. At the expiry of the heat supply contract, the energy system may be transferred to the customer, or ownership may be retained by the heat entrepreneur and the heat supply contract may be renewed. In the basic model, the heat entrepreneur owns and finances the investment. (Lumijärvi & Ollikainen 2011.)

The prices (€/MWh) of heating business services made by Finnish municipalities are typically tied to a specific index or to a "price basket" (e.g. 1/3 light fuel oil, 1/3 peat and 1/3 electricity), and are reviewed at agreed intervals (typically once a year). Municipalities think that the price is right, when it is not more than 80% compared to oil heating. (Pakkanen & Tuuri 2012.)

In Russia, this model may have a certain potential. In general, private industrial enterprises (especially large-scale) have been involved in the provision of district heating services to communities (Solanko 2006). In Moscow, third-party investors own two heating plants, one on the territory of the former ZIL truck plant and another a heating plant converted from using coal to gas and supplying heat to an area of high-rise office buildings known as “Moscow-City”. The size of these plants is typically over 100 MW (City of Moscow 2009b).

5.5.6 On-bill financing

In this business model, utilities provide financing (i.e. a loan) for renewable energy and energy efficiency measures. The building owner (or building user) repays this loan by means of a surcharge on its utility bill. Preferably the overall utility bill should still be lowered, because of the associated energy cost savings. (Würtenberger et al. 2012.)

Customer Segments. This model is originally targeted to owner-occupied single-family houses and small commercial buildings (Würtenberger et al. 2012), but it could be extended to apartment buildings at least if energy is billed based on building-level metering only. There are examples from the United States where this model has been applied to large multi-family buildings (ACEEE 2012). In case of billing based on apartment level submetering the model is more challenging.

Value Propositions. On-bill tariffs are a mechanism for charging customers for energy efficiency investments or upgrades provided as a service by the utility (Bell et al. 2011). If set up well, the program can be very simple for the building owner or user (Würtenberger et al. 2012).

Channels. On-bill financing can leverage utility’s unique relationship with energy customers to provide convenient access to funding for energy efficiency investments (Bell et al. 2011). Johnson et al. (2012) documented on contractor-driven and customer-driven marketing approaches.

Customer Relationships. An on-bill financing program may be a way to increase customer retention in liberalized markets (Würtenberger et al. 2012). By offering standard information and programs to customers, the Utility Fixed Repayment Model (basically the same as the on-bill financing) helps get the owner and occupant on the same page and can help avoid some agent problems (Sweatman & Managan 2010).

Revenue Streams. On-bill financing allows utility customers to invest in energy efficiency improvements and repay the funds through additional charges on their utility bills (ACEEE 2012). A utility can perceive an on-bill financing program not as an obligation, but as an opportunity to generate returns (Würtenberger et al. 2012).

Key Resources. In on-bill tariff programs, utilities have the ability to disconnect customers from utility services in case of default on the loans (Würtenberger et al. 2012). The job categories that act as service providers for these programs are typically HVAC contractors, lighting and electrical contractors and installers, and those in the remodeling business (Brown 2009).

Key Activities. Linking payments to utility bills offers a relatively secure way of recovering the loan. As a consequence, it may be possible to offer attractive interest rates due to the lower default risk. (Würtenberger et al. 2012.)

Key Partnerships. On-bill financing generally needs to be complemented with other approaches such as technical assistance, contractor training, and cash incentives to reduce the amount of loan needed or buy down interest rates (Bell et al. 2011). The utility may rely on additional partners for financing, such as banks or government bodies (Würtenberger et al. 2012). These programs are most successful when the application process is simple and straightforward and the contractors receive prompt payment for their services (Johnson et al. 2012). Installers of renewable energy equipment may become involved by partnering with the utility (Würtenberger et al. 2012).

Cost Structure. In the US, on-bill financing mechanisms can typically be divided into two categories: loans and tariffs (Bell et al. 2011). On-bill tariffs assign a financial obligation to a property (often by tying the service to the building's meter) allowing the receivables incurred from the investment or upgrade to transfer to subsequent owners or renters (Bell et al. 2011). In contrast to a tariff-based system, loans assign financing to an individual customer and the financing is non-transferable (ACEEE 2012). On bill-financing programs are often combined with grants so as to enable a wider range of measures to be cost-effective (Würtenberger et al. 2012).

It is common that neither generation nor consumption of heat is metered in Russia, but the Law on Energy Efficiency N261 from November 2009 requires that renovated buildings must be equipped with heat meters to the extent this is technologically possible. The whole heating energy chain from generation to end-use suffers from inefficiency through high costs and low quality of service. In addition, heating tariffs fail to cover the costs of production, distribution, and the massive need for modernization. (Korppoo & Korobova 2012.)

The cost-plus tariff methodology used in Russia discourages heating suppliers from investing in any measures that save on operating and maintenance costs (which include energy costs). With the cost-plus method used currently, the greater the cost base, the greater the profit margin earned by heat suppliers. As such, the producers' goal of maximizing profit contradicts with the objective of improving their efficiency. Tariff reform is the best way to improve energy efficiency in the heating sector. (World Bank & IFC 2008.)

The question of regional tariff autonomy in Russia is of particular importance from an energy efficiency perspective. Regions in the Russian Federation are directly confronted with the challenges of ensuring reliability of heat supply and securing primary energy fuels for heat production. They are directly facing the social and economic consequences of primary energy fuel scarcity and local environmental pollution. Energy efficiency measures improve the reliability of heat supply and reduce the dependency on primary energy fuels for regions that do not produce energy and are dependent on energy imports from other regions in the Russian Federation. (Boute 2012.)

Regulated residential consumers currently receive a subsidy of around RUB 1.5 per kWh electricity consumed, or €0.037 per kWh (OECD/IEA 2013). It is likely that most regulated residential prices would need to increase by between 50% and 70% to reach cost-reflective levels. Some estimates suggest that residential electricity prices may need to nearly double in order to reach cost-reflective levels (Cooke et al. 2012). At the federal level, short-term (heat) price increases are a very sensitive issue and a serious obstacle to the implementation of energy efficiency and renewable energy initiatives (Boute 2012).

In accordance with the Federal Heat Law and the Federal Energy Efficiency Law, heat tariffs must reflect the costs that are approved in the investment programs, including energy efficiency and renewable energy projects. The regional authorities can thus require heat companies to implement ambitious energy efficiency improvement measures and guarantee the financial viability of these measures by adopting appropriate tariffs. As the investment costs of these energy efficiency measures are included in the investment programs of the companies concerned, they must be considered eligible costs that can be recovered through the regulated tariffs. What is more, Article 25, paragraph 7 of the Federal Energy Efficiency Law provides that the costs related to mandatory energy efficiency improvements (including energy efficiency projects in investment programs) must be taken into account for the determination of tariffs. (Boute 2012.)

At the moment, the consumer payments for energy are subsidized, but they have been under pressure to rise. The local authorities have a vital role in boosting energy efficiency. So, on-bill financing could be one suitable model. However, Russian tariff law strictly regulates the type and proportion of costs that investors can recoup through tariffs (Boute 2012).

5.5.7 Energy leasing

Energy leasing enables a building owner to use an energy installation without having to buy it. There are two main types of leases: operational lease and financial lease. Leasing can be a central component of the business model of an Energy Service Company (see Section 5.5.1). Leasing can also be a central component of the business model of a company that introduces a specific new technology onto the market via a leasing arrangement, including a service and maintenance package. (Würtenberger et al. 2012.)

Customer Segments. Leasing could be applicable to all types of buildings when a specific service is offered through the item or equipment leased. It is not suitable for renovating certain vital building parts or components such as windows, façades or ceilings, which cannot be removed after the end of the lease term.

Value Propositions. Leasing of equipment provides a building owner or occupier with the opportunity to use this equipment without initial investments, thus helping to overcome the barrier of high up-front costs. However, leasing is generally more expensive than taking a loan or financing the equipment in other ways. (Würtenberger et al. 2012.)

Channels. Leasing is not commonly used for renewable energy projects for reasons of suitability of renewable energy technology for leasing and due to its lacking attractiveness to market parties (Würtenberger et al. 2012). If the model becomes more general, the channels for companies to reach the potential clients will also develop.

Customer Relationships. Since the model is not that common, there are not many examples of customer relationships. They will form after longer experience.

Revenue Streams. In a leasing arrangement, the leasing company ("lessor") owns the equipment and makes an agreement with the customer ("lessee") on the use of the equipment. The latter pays a monthly fee to the former for the right to use the equipment. As part of the agreement, the lessor or a third party may provide operation and maintenance services, if needed. In the end of the leasing period the lessee has the option to purchase the equipment. (Lumijärvi & Ollikainen 2011.)

Key Resources. The lessor has a bit different resources depending on the model structure used. Partially they can be the same as in the ESCO model (see Section 5.5.1). Installers of the equipment leased and the financial institution are always somehow involved. In addition, the leasing may include additional services such as operation and maintenance.

Key Activities. The equipment provided for clients to produce or save energy constitutes the main service offered. In addition, the leasing also covers the funding of these investments. By leasing via an energy service contractor, the building owners may profit from additional services such as specific financial, legal, fiscal and administrative consultancy, and operation and maintenance services (Würtenberger et al. 2012).

Key Partnerships. Usually an ESCO or a building owner takes a lease while a financial institution or bank provides it. Also, a company aiming to introduce a new technology to the market may offer leasing of these technologies to a building owner or user. (Würtenberger et al. 2012.)

Cost Structure. Leasing is suited to situations where physical assets form the greater bulk of the expenditure rather than labor services, and where in the event of default continued use of the asset may be denied to the ultimate owner. The transaction costs involved in leasing on a small scale would be high, relative to consumer credit, and there would be a greater risk for the lender, and cost to the borrower, in projects with a low component of physical assets. (OECD/IEA & AFD 2008.)

In Russia, implementation of leasing schemes is advisable in order to minimize the financial risks of ESCO in its relationships with the client and to obtain an additional mechanism of control over the client's operations within the frame of the energy-saving system and technologies (Efremov et al. 2004). Leasing is only suitable for equipment and different services systems. So, when renovating Russian residential districts leasing could be used, for example, for renewal of energy equipment but it could not be used for renovation of parts integrated in buildings.

5.6 Possible business concepts for district energy renovations

The energy renovation of Russian residential districts often requires improvements to the whole energy chain, while many building level renovations would only improve the energy-efficiency of the building itself. This means that, if the same amount of energy is supplied to the building through uncontrollable district heating, the building energy consumption and emissions do not fall. So, the whole district, instead of just single buildings, should be renovated. This led to analyzing business models from a holistic district renovation point of view. **Table 16** lists the main advantages and disadvantages of the business models presented in Section 5.5 when adapting them in renovations of Russian residential districts.

Table 16. Pros and cons of different business models in Russian residential district renovations.

Business model	**Advantages**	**Disadvantages**
ESCO model	• One actor takes responsibility for all renovations	• "Western-ESCO" not common in Russia • Current ESCO companies are small • Requires tangible guarantees of the benefits • Existing low-energy tariffs limit revenues
Customer-side renewable energy business model	• Final consumers less dependent on municipal energy production	• Suitable only for energy production units serving just one building • Another model needed for other renovations • Feed-in tariffs not adopted in Russia
Utility-side renewable business model	• Same energy utility serves the whole district • Optimization and balancing of production	• Covers only modernization of district energy production
Mankala company	• Joint ownership between end users and energy companies • In a modified form could be applied to all district renovation aspects	• Complicated heavy structure
Heat entrepreneurship	• Local actors specialized in local conditions involved	• Basic model aimed solely at heat production
On-bill financing	• Local authorities can require heat companies to implement energy-efficiency measures • Simple financing mechanism	• Consumer payments for energy are subsidized • Russian laws regulate tariffs • Heat consumption is not currently metered, however heat metering installations are mandatory in renovations
Energy leasing	• No need to buy the energy production units • Russian legislation supports leasing schemes	• Not suitable for renovations of systems integrated in the district • Leasing contracts could involve long-term agreements and several stake-holder, which could make it complicated to reach an agreement

As can be seen from Table 16, the business models found from the literature are mainly meant for energy production or for limited energy-efficiency improvements. None of the models is suitable as such for holistic energy-efficient renovation of Russian residential districts. If one actor takes responsibility of all the renovation needs, the business concept should also include all the construction renovations or modernizations in the district, such as building structures and systems, heating distribution networks, electrical systems, street lighting systems, water and waste water systems, and waste management systems.

In order to exhaust the opportunities for the reduction of energy and carbon intensity, Russia requires new business models to attract and secure extensive investment funds, and to reduce transactional barriers and risks (Garbuzova & Madlener 2012). Renovation of whole districts could also offer business opportunities for new actors providing full service concepts such as the one-stop-shop business model (Mahapatra et al. 2013) introduced for single-family houses in Nordic countries. In addition, all the possible business models somehow include energy-saving obligations (Würtenberger et al. 2012) which are one form of policy instruments.

In district renovations, there are several stakeholders involved (see Section 5.2). Value networks could be utilized to show the relationships and the value transferred between key stakeholders, as was done by Frantzis et al. (2008) when analyzing photovoltaics business models. Therefore, analyzing the value networks of different possible business models could be of help in finding the most relevant business concepts.

6. Conclusions

In a previous related study, Paiho et al. (2013) described three different renovation concepts for improved energy efficiency for both a typical Moscow apartment building and a typical residential district. The building renovation concepts, named Basic, Improved and Advanced, were adjusted in such a way that each of them becomes an improvement on a previous one as regards the total annual energy demand. The building renovation concepts, named Basic, Improved and Advanced, were adjusted in such a way that each of them becomes an improvement on a previous one as regards the total annual energy demand. At the district level, different energy renovation scenarios were analyzed in terms of energy demand and emissions. The district scenarios were also called Current, Basic, Improved and Advanced. Considerable energy savings, of up to 34% of the electricity demand and up to 72% of the heating demand, could be achieved in the district considered using different district modernization scenarios.

This study continued the analyses from the economic, financial and business points of view. The economic attractiveness of the suggested energy-efficient renovation of districts was analyzed by comparing the additional improvements to the basic capital repairs that in any case need to be implemented in buildings. The cost analyses included the cost for improvements of external walls, windows and doors, upper ceiling, basement, ventilation, heating system, water and wastewater, electricity, gas, metering, and other improvements and costs. At the building level, the costs per floor area of the different renovation measures were €125/m^2 for the basic package, €155/m^2 for the improved package and €200/m^2 for the advanced package.

The district renovation concepts were aligned with the building renovation packages, and the costs of building renovations were included in the costs of improving district energy and water infrastructure in a pilot district. Apart from the Basic, Improved and Advanced cases, two additional alternatives were explored. The additional alternatives, called Advanced+ and Advanced++ renovation packages, both representing an extension of the advanced district renovation package, were also calculated. In the district level, the costs per inhabitant varied between €3,360, €4,090 and €5,200 for the Basic, Improved and Advanced renovation packages, respectively. The costs of the additional alternatives per inhabitant were over €6,090.

Simple payback time for the additional improvements beyond the basic renovations exceeds 12–14 years. In addition to the costs, also the net present values for different building and district level renovation packages for a 20-year period were calculated with different interest rates and annual energy price growth rates. Both at the building level and the district level, with most combinations of the interest rate and annual energy price growth rate, the Improved renovation package turned out to be the most profitable.

There are signs of emerging financing mechanisms for such basic capital repairs of apartment buildings in Russia. These and existing financing mechanisms, including public-private-partnership (PPP), are discussed in the publication. So far, budget money is still the main financing mechanism for renovations.

In energy-efficient district renovations, there are various stakeholders involved, such as residents, public authorities, utility and network companies, construction companies, product manufacturers, system providers, designers and financing organizations. The main stakeholders were analyzed in the Russian context. This analysis lead to business model considerations since the stakeholders must always be taken into account when thinking about the potential business. The widely used business model canvas was utilized first to evaluate the business model components for the energy-efficient renovation of Russian residential districts and then to analyse possibly suitable business models from the literature. None of the business models analyzed as such suit holistic district renovations, but they all have advantages and disadvantages. Perhaps, even a completely new actor is needed to take over. Because of their complexity and scope, district renovations require cooperation of a wide range of stakeholders.

Russia has extensive residential building stock built after World War II and needing modernization. This creates great potential also to improve energy-efficiency through economies of scale. By reducing domestic energy use, Russia can increase the export of, for example, gas and gain economic benefits as well. Despite the importance of the matter, energy issues are constantly handled as low priority among individual building owners.

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Title	**Business aspects of energy-efficient renovations of Soviet-era residential districts** **A case study from Moscow**
Author(s)	Satu Paiho, Rinat Abdurafikov, Ha Hoang, Malin zu Castell-Rüdenhausen, Åsa Hedman & Johanna Kuusisto

Abstract

The majority of Russian housing stock was built after World War II and needs modernization. About 60% of the Russian multi-family apartment buildings are in need of capital repairs. When attaching energy-efficiency improvements to the mandatory repairs, implementing these is cheaper than taking separate measures.

District heating is mainly used for space heating in Russian apartment buildings. Due to the technical structure of the district heating used in Russia, energy renovations of single buildings seldom lead to reduced energy production. Energy production demands are reduced only if the residential districts and their various utilities and networks are renovated holistically. This publication examines the business aspects for energy-efficient renovations of Russian residential districts. One Moscow district is used in part as a case example.

In a previous study, alternative energy renovation concepts, called Basic, Improved and Advanced, reducing the environmental impacts of the residential apartment buildings in the Moscow case district were developed and analyzed. In this study, the different renovation concepts were analyzed from an economic point of view. At the building level, the costs of different renovation packages varied between €125/m^2 and €200/m^2 depending on the extent of the selected renovation package. All the building level packages covered improvements of external walls, windows and doors, upper ceiling, basement, ventilation, heating system, water and wastewater, electricity, gas, metering, and other improvements and costs but the selected products and solutions varied from basic through improved to advanced ones.

The district renovation concepts were aligned with the building renovation packages, and the costs of building renovations were included in the costs of improving district energy and water infrastructure in the pilot Moscow district. At the district level, the cost analyses covered district heating distribution and main pipe replacements, district heating substations, water distribution and main pipes, sewage water distribution and main pipes, electricity and main grid renewals and transformer substations. In addition, light bulbs for street lighting were included in all the packages except the basic one. Also, some renewable heating production alternatives were included in the two most advanced packages, and then district heating solutions were excluded from the calculations. At the district level, the costs per inhabitant varied between €3,360, €4,090 and €5,200 for the Basic, Improved and Advanced renovation packages, respectively. The costs of the additional alternatives per inhabitant were over €6,090.

In addition to the costs, 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. Both at the individual building level and the district level with most combinations of the interest rate and annual energy price growth rate the Improved renovation package turned out to be the most profitable. At the building level, the Advanced renovation package was the most profitable with low interest rates and high annual energy price growth rates, and the Basic package with high interest rates and lower annual energy price growth rates. At the district level, the Basic renovation package is the most profitable only with low interest rates and low annual energy price growth rates. At the district level, the Advanced renovation package is the most profitable even with low annual energy price growth rates and moderate interest rates. The most advanced packages including renewable energy production solutions are profitable only with low interest rates and high annual energy price growth rates.

Financing renovations is often a major barrier in any country. This topic is also addressed in this publication. Most of the housing units in apartment buildings are privately owned due to the free privatization after the Soviet collapse. However, no sustainable form of self-financing apartment renovations has existed, and former lessors of residential units still have the obligation to carry out capital repairs. Existing and new financing mechanisms, including public-private-partnership (PPP), are introduced in the publication. Regional and local budgets are still the main financing mechanisms for capital repairs in Russia.

This publication also examines possible business models for energy-efficient renovations of residential districts in Russia. An important part of this is the stakeholder analysis carried out by the relevant actors involved in district renovations in Russia. None of the business models analyzed as such suit holistic district renovations. Perhaps, even a completely new actor is needed to take over. Because of their complexity and scope, district renovations require cooperation of a wide range of stakeholders.

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Nimeke	**Liiketoimintanäkökulmia neuvostoaikaisten asuin-alueiden energiatehokkaaseen korjaamiseen** **Tapaustutkimus Moskovasta**
Tekijä(t)	Satu Paiho, Rinat Abdurafikov, Ha Hoang, Malin zu Castell-Rüdenhausen, Åsa Hedman & Johanna Kuusisto
Tiivistelmä	Suurin osa Venäjän asuntokannasta on rakennettu toisen maailmansodan jälkeen ja tarvitsee uudistamista. Noin 60 % Venäjän asuinkerrostaloista on suurten peruskorjausten tarpeessa. Energiatehokkuuden parantaminen on halvempaa pakollisten korjausten yhteydessä kuin erillisinä toimenpiteinä. Venäjän asuinkerrostaloja lämmitetään pääasiassa kaukolämmityksellä. Venäjällä yksittäisten rakennusten energiakorjaaminen harvoin pienentää lämmitysenergian tuotantoa, koska kaukolämmitysratkaisut ja -kytkennät poikkeavat suomalaisista järjestelmistä. Energian tuotantotarve vähenee vain, jos samalla korjataan kokonaisvaltaisesti sekä asuinrakennukset että koko asuinalueet ja niiden energia-, vesi- ja jätehuoltoinfrastruktuuri. Tämä julkaisu tarkastelee liiketoimintanäkökulmia Venäjän asuinalueiden energiatehokkaaseen korjaamiseen. Moskovaa käytetään osittain esimerkkinä. Ympäristövaikutusten pienentämiseksi aikaisemmassa tutkimuksessa kehitettiin ja analysoitiin vaihtoehtoisia energiakorjauskonsepteja, nimeltään ”perus”, ”paranneltu” ja ”kehittynyt”, neuvostoaikaisille asuinkerrostaloille ja moskovalaiselle esimerkkiasuinalueelle. Tässä julkaisussa eri korjausvaihtoehtoja tarkastellaan taloudellisesta näkökulmasta. Rakennustasolla korjausvaihtoehtojen hinnat asuinneliötä kohden vaihtelivat 125 €/m^2 ja 200 €/m^2 välillä riippuen valitusta korjauspaketista. Kaikki rakennustason korjauspaketit sisälsivät ulkoseinien, ikkunoiden, ovien, yläpohjan, kellarin, ilmanvaihdon, lämmitysjärjestelmän, vesi- ja jätevesijärjestelmien, sähkölaitteiden ja -järjestelmien, kaasuverkoston, mittaroinnin ja yleisten tilojen parantamisen, mutta valitut tuotteet ja järjestelmät vaihtelivat eri paketeissa. Asuinaluetasolla tarkasteltiin moskovalaisen esimerkkialueen kaikkien asuinrakennusten ja alueen koko energia- ja vesi-infrastruktuurin korjausvaihtoehtojen kustannuksia. Aluetason järjestelmistä mukana olivat kaukolämpöputket, lämmönjakokeskukset, vesi- ja jätevesiputket, sähkö- ja kantaverkot sekä muuntamot. Lisäksi katulamput sisältyivät kaikkiin muihin paketteihin paitsi perusvaihtoehtoon. Edistyksellisimpiin vaihtoehtoihin sisällytettiin myös lämmöntuotantoa uusiutuvilla vaihtoehdoilla, jolloin kaukolämpöratkaisut jätettiin pois laskelmista. Aluetasolla kustannukset asukasta kohden olivat peruspaketille 3 360 €, parannellulle paketille 4 090 € ja kehittyneelle paketille 5 200 €. Edistyksellisimpien vaihtoehtojen kustannukset asukasta kohden olivat yli 6 090 €. Kustannusten lisäksi laskettiin eri rakennus- ja aluetason vaihtoehdoille 20 vuoden ajalle nettonykyarvot eri korkokannoilla ja vuosittaisella energianhinnan kasvuprosentilla. Sekä rakennus- että aluetasolla ”paranneltu” korjauspaketti osoittautui kannattavimmaksi useimmilla korkokannan ja energianhinnan kasvuprosentin yhdistelmillä. Rakennustasolla ”kehittynyt” vaihtoehto oli kannattavin alhaisella korkokannalla ja korkealla energianhinnan kasvuprosentilla ja perusratkaisu korkealla korkokannalla ja matalalla energianhinnan kasvuprosentilla. Aluetasolla ”kehittynyt” ratkaisu oli kannattavin jo matalalla energianhinnan kasvulla ja maltillisilla korkokannoilla. Kehittyneimmät uusiutuvaa energiantuotantoa sisältävät vaihtoehdot olivat kannattavia vain matalalla korkokannalla ja korkealla energianhinnan kasvulla. Korjausten rahoittaminen on usein suuri este missä tahansa maassa. Julkaisu käsittelee myös tätä aihetta. Venäjällä useimmat kerrostaloasunnot ovat asukkaiden omistuksessa, koska ne yksityistettiin ilmaiseksi Neuvostoliiton romahtamisen jälkeen. Kestävää mallia remonttien omarahoitukseen ei ole kuitenkaan ollut olemassa, ja entisillä vuokranantajilla on edelleen velvollisuus toteuttaa suuria korjauksia. Julkaisussa käsitellään kin uusia ja nykyisiä rahoitusmekanismeja, muun muassa julkista ja yksityistä kumppanuutta (PPP). Venäjällä julkinen rahoitus on edelleen tärkein rahoitusmekanismi suuriin korjauksiin. Julkaisussa tarkastellaan myös energiatehokkaan aluekorjaamisen mahdollisia liiketoimintamalleja Venäjällä. Tärkeä osa tätä on sidosryhmäanalyysi aluekorjaamisen toimijoista Venäjällä. Yksikään analysoitu liiketoimintamalli ei sellaisenaan sovellu kokonaisvaltaiseen aluekorjaamiseen. Ehkä tarvitaan jopa täysin uusia toimijoita. Joka tapauksessa aluekorjaamisessa tarvitaan toimijaverkostoja kokonaisuuden monimutkaisuuden takia.
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