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Sustainable Buildings for the High North. Strategic plan for the implementation of energy efficient renovation and construction in Northern parts of Russia

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Tiivistelmä: Buildings constitute remarkable share of the global energy consumption. Efforts to measure and standardize energy usage have been developed across countries. In 2010 Energy Performance of Building Directive (EPBD) was recast with added specifications regarding energy certification and building types by European Union. Energy consumption in Russian building sector is also acknowledged recently. Presidential decree given in 2008 states that energy intensity must be reduced by 40 % from the level of 2007 until 2020. The energy efficient construction and renovation markets are vast in Russia. Total investment value is evaluated to be 300 billion USD. Only 7 % of the value is budgeted for federal and regional parties, thus private sector investments are required. Especially low-cost and high impact technological methods are studied to improve energy performance of Russian and Scandinavian buildings.

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Russia is regarded as strongly developing green energy market area where construction and renovation markets are vast. Russian building stock represents unique architectural directions that have multiple options to improve energy efficiency. Information sharing among professionals and end-users increase awareness of energy efficient methods and the benefits. Although benchmarking and renovation concepts are needed to lower cost and manage the quality of renovations also case-by-case analysis and actions are needed. Here only building-related measures are discussed although major challenges relate more to surrounding infrastructure and cultural aspects. Recognizing underlying circumstances is essential when planning energy refurbishment for the buildings in the area.

1 Introduction

Buildings are in central roles in our lives. They provide shelter for the weather and climatic conditions and create comfortable indoor environment. Our homes, working places and many of the free time activities reside in buildings. Energy consumption and indoor air quality influence on economics and health circumstances.

Buildings constitute remarkable share of the global energy consumption as they consume roughly 40 % of total final energy use (e.g. [1] (#cite-text-0-0)). Energy use of buildings is relatively new issue, and first efforts to measure and standardize the energy performance were enacted in 2002 when Building Performance Energy Directive was confirmed by European Union. In the recast 2010 some specifications were added regarding energy certification and building types.

Energy consumption in Russian building sector is even newer topic than in Europe. Directives regarding the building energy use are acknowledged as a reference, guiding also Russian building sector. Presidential decree No 889 given in 2008 states that energy efficiency of buildings must be improved by 40 % from the level of 2007 until 2020. In 2009 Federal Law No. 261-FZ "On Energy conservation and increasing energy efficiency" and Government Program "Energy saving and energy efficiency up to 2020" were confirmed by Russian Duma in 2010 (see [2] (#cite-text-0-1)).

According to estimates done for Russia, 44 % of the aimed energy savings can be gained from buildings, 22 % from oil and gas sector, 19 % from enhanced power transmission to residential buildings and municipal institutions and the rest 15 % saving is due to industrial sector [3] (#cite-text-0-2) [2] (#cite-text-0-1).

The energy efficient construction and renovation markets are vast in Russia [2] (#cite-text-0-1). Total investment value of 9.5 trillion RUB, or 300 billion USD is evaluated and of this only 7 % is budgeted for federal and regional parties. Therefore, investments from private sector are required [3] (#cite-text-0-2) [2] (#cite-text-0-1).

Higher levels of energy efficiency reduce direct and indirect energy use when less primary energy sources and fuel for transform and transport of energy are required. When electricity use is decreased, nearly fivefold reduction occurs in overall energy consumption. Similarly lowering the heating energy consumption results in threefold reduction in overall energy sector consumption [4] (#cite-text-0-7).

Improvement of energy efficiency can be expressed as financial, economic or technical potential. The focus of this report is to discover strategically suitable low-cost and high impact technological methods to improve energy performance of Russian buildings particularly in Murmansk area. Renovation of apartment buildings in North-Western part provide conditions for cross-border trade in northern latitudes. Collaboration of research, education, companies, decision-makers and other related stake-holders is required as it promotes implementation of the objectives.

On the basis of earlier reports (1, 2 and 3) provided by Work Package 3 to Sustainable Buildings for the High North (SBHN) -project and other available publications, some main areas are selected as recommended measures in strategy to improve energy performance. The same procedures are at least partially applicable to Scandinavian houses. Main emphasis of the project is on residential sector and non-residential buildings are discussed only briefly.

1.1 Special features of residential sector

In Europe largest share, 75 %, of the building stock is comprised of residential buildings. These include single and multi-dwelling buildings and holiday resorts. Generally, two third are single family houses and one third apartment blocks [1] (#cite-text-0-0). Construction boom experience in the period 1960–1990 doubled the housing stock in almost all the countries.

As a shared character, single family houses have been major construction target across the decades. In units of building stock, a share of detached houses is 44–77 % in Scandinavia and 30 % in Russia. When inspected in floor areas, highest proportion of single-dwelling apartments is in Norway with 86 %. The values are 65 % and 55 % for Finland and Sweden [1] (#cite-text-0-0).

Construction of apartment houses has focused especially in 1960–1970 decade, except in Norway where majority have been constructed in 2000 century. One in six of all residences locate in high-rise buildings constructed in the period 1960–1980. In quantities, Finland and Norway have relatively low proportions of attached and apartment houses, 11 % and 23 % of residential buildings. Highest share of apartment houses are in Sweden and Russia, with 56 and 70 percentages. In floor areas, the proportion of attached-apartment houses in Norway is 14 %, Finland 35 %, Sweden 45 % [1] (#cite-text-0-0) and Russia 68 % of the building stock (2.2 billion m^2 of apartment floor area is divided by total floor space of all buildings 3.2 billion m^2).

As overall, forty percent of residential buildings are constructed before 1960 at the time when regulations regarding energy regulations of buildings were rather scarce [1] (#cite-text-0-0). The age of the buildings that have not undergone renovation, is largely associated with the energy consumption level. The older the buildings, the higher the energy consumption levels are. The main regions in Europe; North-West, East-Central and South show no strong variation in the age groups (oldBPIE. 2011. Europe´s Buildings under the microscope. A country by country review of the energy performance of buildings. Buildings Performance Institute in Europe. Hakupäivä 30.11.2015. www.bpie.eu/documents/BPIE/LR_%20CbC_study.pdf. However, between individual countries some variation may appear in structure and age of the building stock.

Residential sector consume majority of the energy end-use of buildings. In a year 2009, households consumed 68 % of the total final energy used by the sector [1] (#cite-text-0-0). According to various estimations, energy-efficient and cost effective refurbishment of the apartment buildings could result in 28 % energy saving potential in general. The most promising energy saving areas locate in Eastern Europe where regionally even up to 39 % energy saving is reachable [5] (#cite-text-0-13). In Russia, residential sector has the largest technical potential to reduce energy consumption by 53.4 mtoe which corresponds to 49 % energy saving. According to estimates, approximately 84 % of the potential is economically and 46 % financially viable [4] (#cite-text-0-7).

Differences in the usage of energy sources and consumption are detected in residential houses. Majority of the energy, around 82 %, is used for heating the space and water. In Norway, the electricity is the main heating energy source also in apartment houses. In Sweden and Finland, electricity heating prevails in detached houses, whereas district heating is the most popular among block of flats. In Russian apartment houses district heating is practically the only heating form. The heating energy per square meter is roughly 1.5 times higher in Russia than elsewhere. Lighting and appliance constitute 11 % of the energy consumption in residential sector (see [6] (#cite-text-0-15)).

In Norway, hydroelectricity is the main energy product. Generally, consumption of oil and solid fuels for heating purposes have decreased in Europe. This is also reflected in energy use of Sweden and Finland (Figure 6-5). Partly, this is due to replacement of oil-boilers with biofuel-boilers and connections made to district heating network.

1.2 Special features of non-residential sector

Non-residential buildings constitute 25 % of the building stock in Europe [1] (#cite-text-0-0). Until 2030 approximately 60 % of the floor area is estimated to locate in commercial buildings constructed in 2008 or earlier [7] (#cite-text-0-17). At that time, the highest energy and carbon saving potential is gained by retrofitting and renovating the building stock, the one that is constructed in the beginning of 2000 century [8] (#cite-text-0-18).

Non-residential building sector is even more complex and heterogeneous than the residential one. Diversity in form of building typologies is high (e.g. shops, schools, offices, hospitals, hotels, supermarkets, universities, sport centers and restaurants) when sizes, usage patterns and construction styles are considered [1] (#cite-text-0-0). Additional complexity is brought by between country differences.

In Russia, approximately 9 % of energy end-use is consumed by public buildings. Otherwise scarce data exist for the sector and detailed structure of the energy end-use [4] (#cite-text-0-7). Although no data is available of the total floor space and age of buildings, large technical energy saving potential is evaluated for public and commercial buildings. Space heating can provide 49 % technical energy saving potential out of total energy consumption of the sector in 2005 [4] (#cite-text-0-7).

In Europe the largest portion, 27 %, of the non-residential building stock is formed of wholesale and retail buildings. Usually these building types have large floor areas and spaces are frequently used for storing. Wholesale-retail is expected to differ from other categories regarding cooling and heating conditions.

Office buildings, as second largest category, form one quarter of the floor area. Similarities to residential buildings are observed in heating and cooling systems, although the use-times are shorter in offices. Educational buildings account for 17 % of commercial building stock and resemble office buildings in many aspects [4] (#cite-text-0-7).

In hospitals the usage pattern for building technology is continuous and can vary regarding to energy demand. For example consultation rooms have different energy need than surgery room in requirement for cooling, ventilation, lighting, air conditioner etc.

Proportion of building category "Other" is rather large in many EU countries and reflects further need to disperse floor area to the set categories [1] (#cite-text-0-0).

2 Strategy and sub-strategic plan

The long-term vision of SBHN-project is to promote cross-border trade in sustainable building sector and increase shared research and educational activities. Due to higher proportion of old buildings, renovation business is in particular interest (Figure 2-1).

A mission, the reason for existence, of the SBHN-project is to gather essential information about renovation business in neighboring countries and to establish virtual market arena called Building Evolution Portal. Due to unique nature of projects regarding the schedule, budget, topic and stakeholders to achieve the set goals (e.g. [9] (#cite-text-0-24)), data has been collected from different areas of building and commercial science. Also knowledge produced by previous projects have generated understanding about cultural differences, energy use and building stock in countries. In this respect projects, past and becoming, can be seen as actors in the value production chain where the added-value is the accumulation of information between neighboring countries. Consequently the results of SBHN-project create foundation for establishment of new related projects which promote the collaboration and trade between neighboring countries, the vision of the SBHN-project.

Strategy, the measures, to achieve the vision is to perform applied macro environmental analysis, PESTEL (e.g. [10] (#cite-text-0-25)), where components of Politics, Economics, Social, Technology, Environment and Legislation are inspected to provide measures to reach the goals (see Figure 2-1).

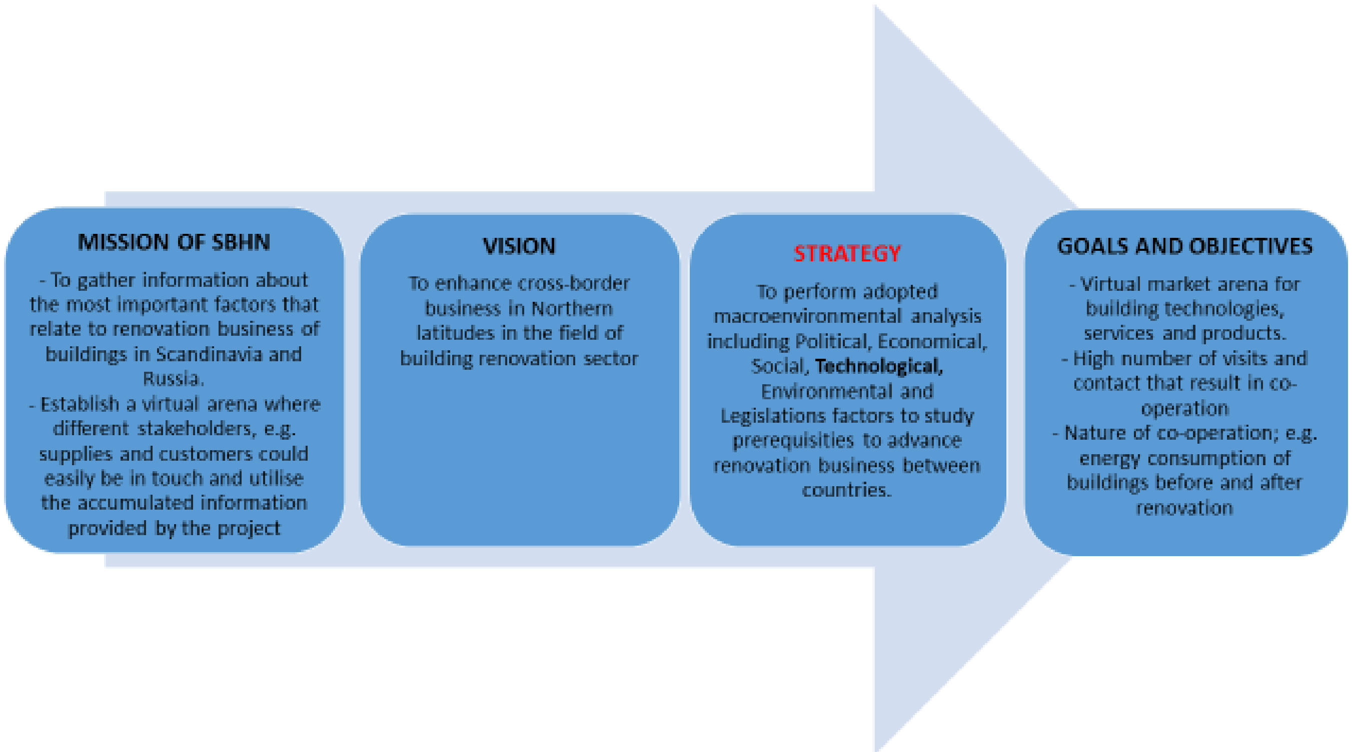

FIGURE 2-1. Overview of the purpose, future aspirations, methodologies and measures of the SBHN-project to evaluate the success. Here technological strategy is seen as one sub-strategy among others in achieving the vision

Sub-Strategy of WP 3

The strategic planning process of WP 3 is described in Figure 2-2. The mission and goals of the SBHN-project are iterated but emphasis is on building technological aspects. Internal issues of the project are knowledge, experience, portfolio of mature and new technological solutions, available statistical data and vast co-operation network. External issues are the ones that operate outside the project and are not that controllable such as politic-, economic-, legislation- and customer related external factors that can influence on the final outcome of the project.

SWOT-analysis is useful strategic planning tool to discover internal strengths and weaknesses along with external opportunities and threats (Figure 2-3). Here, the most essential internal strengths are multicultural knowledge, experience of the renovation projects, diversity of available technological measures, shared cold climate which aid in comprehending the circumstances and building technology requirements.

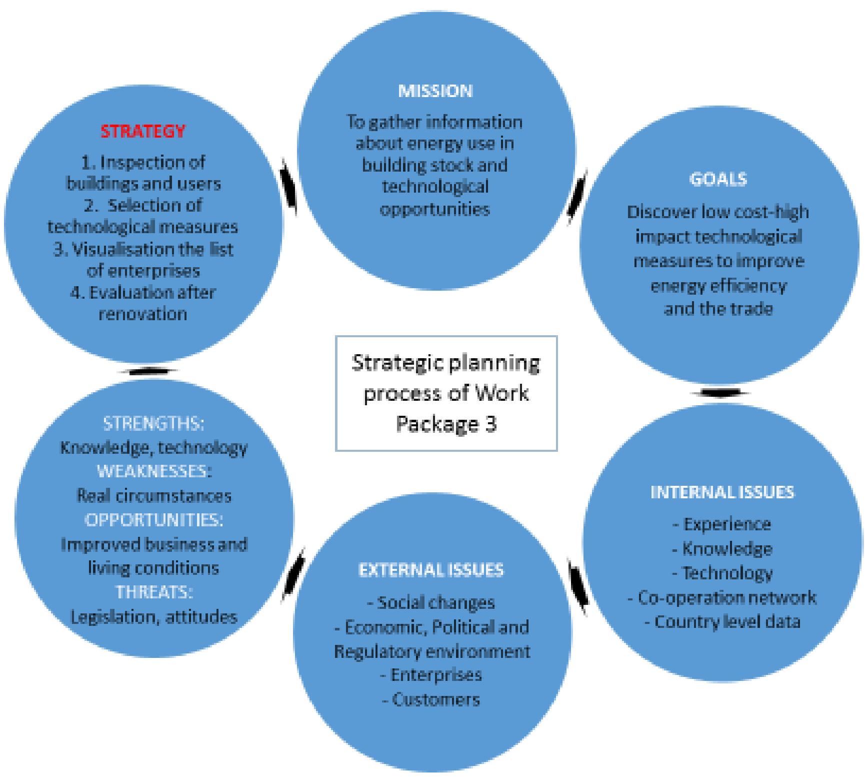

FIGURE 2-2. Scheme of strategic planning processes of Work Package 3

As categorized weakness could be the lack of knowledge based on seeing and feeling the existent buildings stock in Murmansk area. The received conception is solely formed by information given in published reports and scientific articles. Although this may bring some uncertainty to the suggested implementation plan, the main directions are believed to correspond to the real situation.

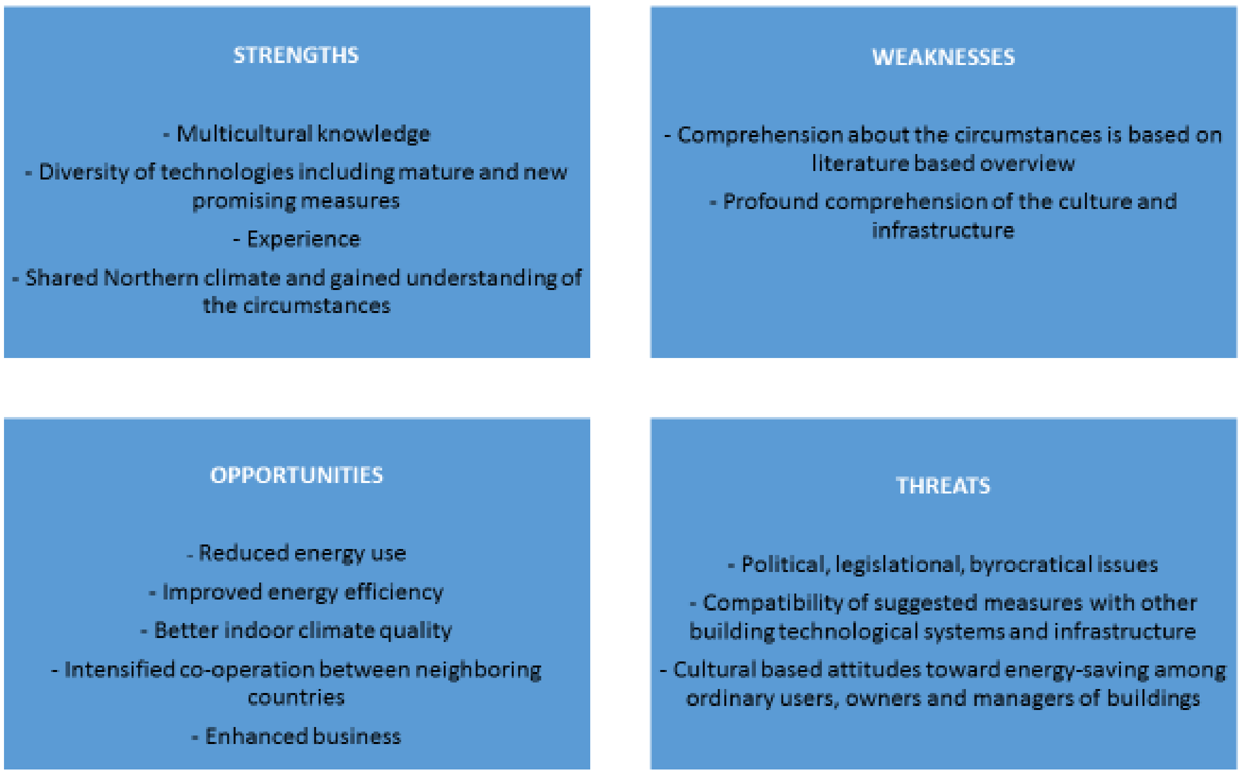

FIGURE 2-3. SWOT-analysis to obtain a conception of the critical issues in implementing technological solutions in liaison with renovation projects in Russia

Among external opportunities in the technology implementation plan are reduced energy use, increased energy efficiency, improved business opportunities and indoor climate.

Consequently, threats include incompatibility of suggested measures with existing building technology and surrounding infrastructure (e.g. [11] (#cite-text-0-26) [12] (#cite-text-0-27)). Also political, regulation, economy focused subjects can prevent the adaptation the technology and the overall business. Attitude of ordinary people such as occupants, building owners and managers toward energy saving effort can turn out to be challenging, as energy is historically regarded as free, or almost free, utility provided by government for citizens (e.g. [4] (#cite-text-0-7)).

Finally, strategy is generated as end -product of the process, although the processes can be considered continuous. The strategy is updated when needed to stay in the outline defined by vision and mission.

On the basis of three reports produced by Work Package 3 to SBHN-project and other available information we propose following technologically emphasized sub-strategic plan to enhance business in building sector between countries. In exploring opportunities we aimed to identify and evaluate most potential technological options to develop realistic framework to achieve the goals and the vision. The technological measures and plan are considered from point of view of Russian buildings and knowledge about technological solutions commonly used in Scandinavian building sector.

Simple and small-scale procedures of low cost can result in significant energy savings. For example, regularly performed maintenance in the form of adjustment of the heating system is estimated to bring 10–15 % energy saving and improve living comfort when between room temperatures are balanced [13] (#cite-text-0-29). Other potential targets include improvement of building envelope thermal properties by upgrading the insulation, sealing and windows, installing measurement devices, automated control of systems and adaptation of some passive house typical measures (see Figure 2-4).

Measures that represent new trends in producing energy in sustainable and de-centralized manner are also issued. Energy prices and aims for renewable energy-based self-sufficiency are increasing as fossil primary energy reservoirs are diminishing and insecurity in global economy and climate increasing.

Residential and non-residential sector have slightly different optimal energy saving targets and these are discussed under each sub-topic.

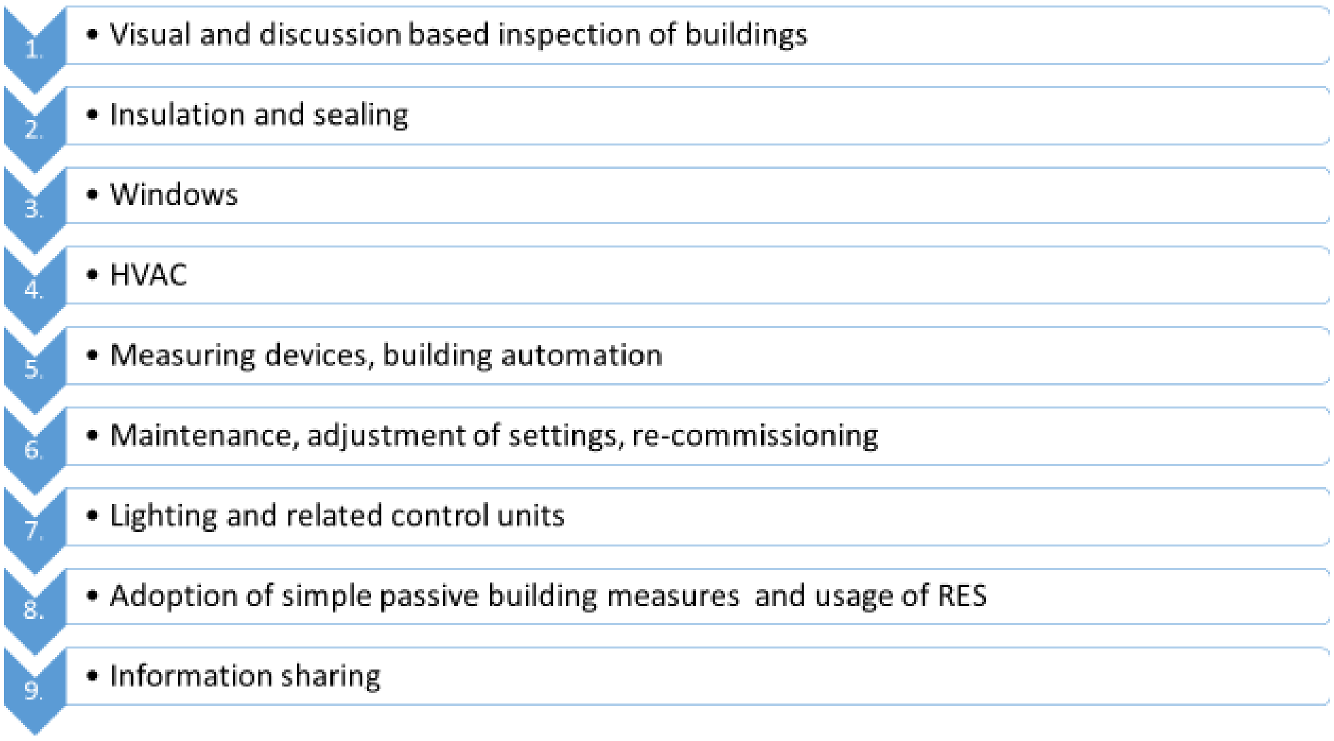

FIGURE 2-4. The developed strategy to improve energy efficiency of Russian buildings with low cost-high impact measures

2.1 Visual inspection

Benchmarking as such may not be the most functional solution, rather the case-focused analysis of the ideal measures are recommended. The frequent follow-up and reporting the energy use convey the information of the current status. Binding the energy-usage goals as part of the budget may aid to gain the goals. Visual inspection is needed to gain overview of each building´s condition as individual differences are expected to occur. Also the assumed lack of metering devices as is reported in many publications (e.g. [14] (#cite-text-0-30) [11] (#cite-text-0-26)) forces to use rather qualitative than quantitative approach in the evaluation of the needed renovation measures. Discussion moment or other information gathering manners are recommended to obtain opinions of different user levels; occupants, customers, owners and managers to gain comprehensive perception of the condition and occurring faults in buildings.

In literature are shown some examples in Russia where lack of monitoring energy efficiency, missing data and incomplete analysis have resulted in making investments in wrong buildings where unsuitable technologies and solutions have been used [4] (#cite-text-0-7). Capital repair investments made were mostly not effective.

2.2 Insulation and sealing

In majority of Russian buildings thickness of insulation layer is not adequate or it is completely missing (e.g. [14] (#cite-text-0-30) [15] (#cite-text-0-34) [2] (#cite-text-0-1) [4] (#cite-text-0-7)). This is due to long prevailed circumstances of cheap oil and natural gas which have not stimulated construction developers and managers to lower the heating costs by better insulation and energy efficiency (see [2] (#cite-text-0-1) [16] (#cite-text-0-38)). Currently the three domestic main players form 50 % of the market share with equal proportions. Other companies constitute the other half, including also foreign companies such as Paroc.

By adding insulation or improving the prevailing ones have the highest effect on energy saving as heating is the major energy consuming function in households (e.g. [1] (#cite-text-0-0)). Improving the insulation of outer walls declines the heating energy losses significantly as walls constitute the largest share of the envelope. Additional insulation can be done for outer or inner walls. Outdoor-based insulation is reasonable to perform in liaison with renovation or replacement of outer shell. In ideal circumstances insulation can be added to inside surfaces which fastens the renovation schedule and lowers the costs. The usage of breathable insulation material such as mineral wool and airing behind the outer boarding are one examples of optimal solutions [17] (#cite-text-0-40).

Estimations of payback times of renovations where insulation is upgraded on the level of passive house in Russia vary between 18-27 years, highly depending on various economic and technical factors [15] (#cite-text-0-34).

Sealing is regarded as one of the most cost-efficient measure in improvement of energy efficiency [18] (#cite-text-0-42). Quantity of lost energy can be reduced by enhancing the sealing of windows and doors which has positive consequences also on living comfort as draught is decreased. Due to better control of heat and draught, room temperatures can be lowered by one to three degrees without consequences on the indoor climate quality. Toward one degree lowering of the room temperature, the heating energy need is reduced by five percent. Saving of 8 % in heating energy consumption can be gained along the proper sealing of windows and doors.

After improving the sealing and insulation, adjustments on ventilations system may be required to prevent the heat loss and maintain the reached advantage via better insulation. Particularly in old buildings the inhibition of air flow through gaps in frames of windows and doors may induce low indoor air quality unless ventilation is updated [18] (#cite-text-0-42).

In studies, the installation of additional insulation on outer walls brought on average 11.68 % energy saving in the studied 78 buildings [19] (#cite-text-0-44). In the other research, heating energy consumption was reduced in half of the outer wall-insulated apartment buildings and was increased in the other half [20] (#cite-text-0-45).

In Russia, insulation and construction related standards were left volunteer-based along the Federal Law on Technical Regulation since year 2010. The law covers both new buildings and renovation of existent buildings. No requirements are set for constructors and developers to use energy efficiency improving technology [4] (#cite-text-0-7).

Preliminary phases of building project give foundation for later energy consumption. In new buildings, the shape of the building determines largely the energy efficiency and potential for heat losses. The more compact the building is the higher the energy performance is. When exterior walls are designed to have minimum possible area also costs for insulation are reduced. Also the essential design and construction rules of passive houses; the closed thermal outer insulation shell, avoidance of thermal bridges, usage of appropriate porous insulation material in places of thermal bridges, sealing the joints between elements and geometry where obtuse angles are more than 90° provide prerequisites for airtight outer shell.

2.3 Windows

Along tightening the Russian energy efficient regulations and building energy code, also the demand for high energy performance windows, doors and insulation have increased (e.g. [2] (#cite-text-0-1)).

Small investment can bring huge saving without massive façade renovation because windows and ventilation account for more than half of the heat loss in apartment buildings [21] (#cite-text-0-48). Windows deliver 33 % of the heat in detached houses [22] (#cite-text-0-49). Heating technological features (e.g. U-values) and permeability for solar radiation (e.g. G-values) are central properties of windows. Especially in summer time permeability has a significant effect on room temperature. Occupancy status of dwelling and working position; whether renovation is performed externally or internally, and window frame material, determine the price of renovation (see [23] (#cite-text-0-50)). When façade is refurbished the air tightness of upgraded windows and doors are ensured to confirm absence of leakage and adequate level of energy efficiency. Also properly operating air ventilation is confirmed.

In Russian window market three main segments prevail. In 2009, the shares of plastic, aluminum and wooden framed windows were 76 %, 13 % and 11 % of the market. Plastic framed panes has been popular since 2003 and the market segment has annually been growing by 30 % [2] (#cite-text-0-1).

Double glass-pane windows have increased their market proportion mainly resulting from the growth of personal income. These windows have been installed both in new and old buildings. Three pane windows are most desired and cheapest where two static panes are on sides and opening pane in the middle [24] (#cite-text-0-52). Installation of triple-pane windows and weatherization of buildings can produce heating energy saving of 40 % in Russia [4] (#cite-text-0-7).

By replacing windows to energy efficient versions the shell of the apartment house is improved which influence to balance between ventilation and heating. In window renovation, smart control and balance of ventilation are essential.

Although high number of local window manufacturers are in the market, only small number of them is producing high-efficiency windows. Foreign companies have entered the Russian market including German, Austrian, Turkish, Ukrainian, Belgian and Finnish firms and some of these have also local manufacturing units [2] (#cite-text-0-1).

Deep renovation of windows indicated that energy consumption was reduced on average by 6.2 %, from average value 52.5 kWh/m³ to 49.2 kWh/m³. In the studied 40 residential apartment buildings, double glazing were mainly updated to energy efficient panes (U-value=1.1-1.2 W/m²K). With minor portion changes were also made to ordinary triple-glazing windows (U=1.8 W/m²K) and the ones filled with air or argon (U=1.4-1.5 W/m²K. The largest savings, 16 %, were gained in buildings were double glasses were replaced with energy saving windows. Surprisingly also water consumption was reduced by 6 %. By adjusting the heating and ventilation systems after window renovation, the energy saving is expected to be even larger [25] (#cite-text-0-55).

In the other example, on average 14.7 % energy saving were induced when 23 apartment houses located in different part of Finland were renovated for energy efficient windows together with installation of smart exhaust ventilation system. Smart system monitors that ventilation is in balance in each dwelling to avoid excessive heat losses and inadequate supply air. Also incoming air windows are important factor in creating energy saving in addition to smart systems. Fresh supply air is passively warmed in interspace of glass panes due to own heat loss of windows and becoming solar radiation. Preheated supply air increases the comfort of occupants and influences energy use of dwellings [21] (#cite-text-0-48).

Calculation method to compare energy efficiency of buildings before and after window renovation was developed by Motiva Service Ltd. Normalized monitoring of energy use is important tool that is utilized in the context of smart window refurbishment. Currently many companies utilize the calculation method as part of their own ventilation service solutions.

2.4 HVAC

With the improvement of air tightness and energy efficiency of buildings the heating need is decreased simultaneously as cooling need is increased especially in summer time (e.g. [26] (#cite-text-0-57) [27] (#cite-text-0-58)).

Heating sector consumes one third of the primary energy usage in Russia. In 2008 the proportion of heat was 114 mtoe which corresponds to entire final energy consumption of some countries, e.g. Mexico (see [2] (#cite-text-0-1) [28] (#cite-text-0-60)). Majority of the heating, 78 %, is based on district heating system. Russian district heating infrastructure is world´s largest and also the oldest. Before 1990 were constructed 70 % of the water boilers and 66 % of district heating networks. Average heat boiler efficiency is approximately 73 % in Russia it is in Western European countries 85-95 % (see [2] (#cite-text-0-1)).

As a general point of view, inadequate maintenance and minor investments made in 1990´s have induced lower level of reliability of supply in district heating systems in Russia [29] (#cite-text-0-62). Significant energy savings can be reached by energy efficiency measures and enhanced efficiency of heating plants. According to IEA data and Russian energy experts, approximately 3 % and 20-30 % of the generated heat is lost in transmission and distribution processes. Major repair or replacement is needed for roughly 60 % of the district-heating network [29] (#cite-text-0-62). Poor insulation around heat pipes causes large heat losses.

District heating system is characterized by lack of metering devices in central units and within apartments. Vertical-stand pipe systems in old buildings link apartments of different floors. Within dwellings pipes are not connected to each other and thus temperature is not monitored [2] (#cite-text-0-1). Therefore building level meters can be regarded as reasonable solution as they are generally over- or under-heated depending on the location along the distribution pipe.

Vast energy saving potential is estimated to reside in Russian residential buildings. Technical potential to decrease energy consumption in space heating varies between 30-60 % of the final heat consumption level in 2005. Technical energy saving potential for water heating is 35 % of the usage 2005. Large share of this is due to improvement of water temperature regulation and hot water pipes surrounding insulation. Of the saving, more than one third becomes from investment performed in individual apartments, for example by implementation of hot water meters (Figure 2-5). Around 78 % of the investment on space and water heating are economically viable and 38 % financially viable when compared to heat prices of year 2007 [4] (#cite-text-0-7).

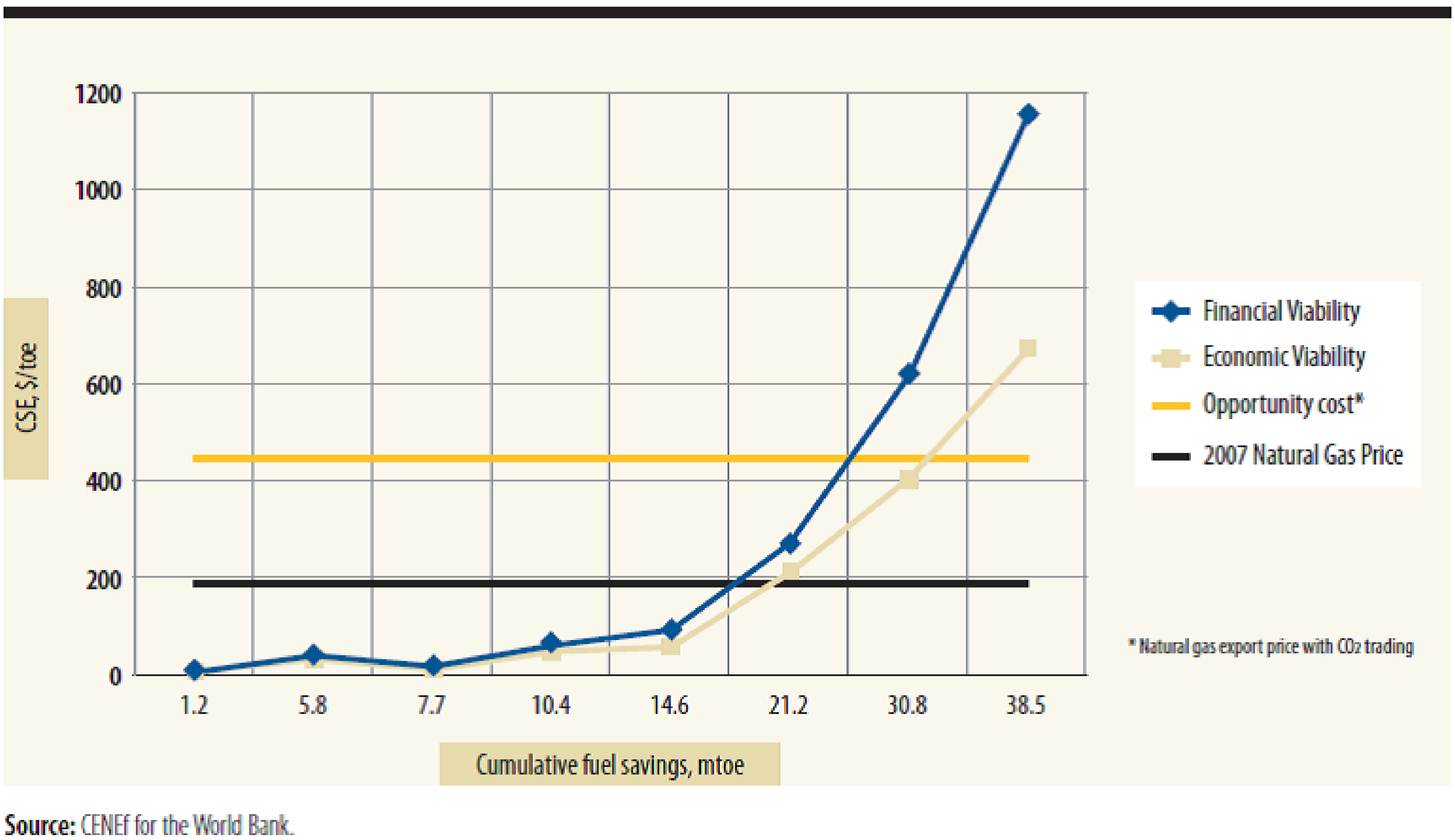

FIGURE 2-5. Space and water heating in residential buildings in Russia and the supply curve [1] (#cite-text-0-0)

Ekonor-heating guarder is one example of the advanced technology that recognizes the real temperature within the apartment and adjusts incoming district heat according to real indoor temperature instead of outdoor temperature

According to estimate, total value over 20 GWh/a heat energy saving in apartment buildings could be gained by heat recovery. For attached and detached houses around 3-5 GWh/a saving could be reached. Heat recovery is one of the most powerful methods to decrease the heat loss from ventilation, but is used at relatively low percentage in all the building types [22] (#cite-text-0-49).

Ventilation, as it consumes one third of the overall energy use, has large technical potential in effecting the thermal economy of building. As stated above, additional insulation and renovation of windows change the volumes of incoming and leakage air and consequently air pressures which alter also the need for ventilation. The operation and adequacy of ventilation must be confirmed after refurbishment.

In Scandinavian and other European countries space- and water heating/cooling is mainly provided by electricity, district heating/cooling and heat pumps.

Heat pumps extract renewable energy from the surrounding phase, e.g. ambient air, water or ground, and with the provided energy (electricity or gas) the temperature is adjusted to higher or lower level depending on the heating or cooling needs [28] (#cite-text-0-60). The technology is highly efficient and aid in producing energy and carbon dioxide savings. The ability to transfer primary energy to desired temperature is dependent on the used electricity production. In reversible heat pump systems heating and cooling can be alternated, and in hybrid systems heating and cooling occur simultaneously [28] (#cite-text-0-60).

Basic technologies for heat pumps in non-residential sector correspond to the equipment in residential sector. Often implementation is performed on larger scale. Essential issue is the integrated design of the building envelope and the HVAC system. In temperate climate, small offices usually utilize reversible-air-to-air systems. Large commercial buildings use ground-source heat pumps together with thermal storage technologies to heating and cooling purposes [28] (#cite-text-0-60). Although the technology is mature and heat pumps have been available for decades, the current proportion of heat pumps in the world-wide heating market is small. In residential sector, approximately 800 million heat pumps were installed in 2010 [28] (#cite-text-0-60).

In Russia, reversible heat pumps would be reasonable option only after installing the heat meters and upgrading the energy efficiency of outer shell e.g. by improving insulation. Along the growing incomes and the requirement for increased comfort during hot summers, demand have risen for air conditioning and ventilation especially in major cities [28] (#cite-text-0-60). Also recent energy-efficient legislation in Russia is expected to promote interest toward HVAC equipment. Currently, six out of 100 households own air-conditioner [28] (#cite-text-0-60).

Highest growth rate for air conditioning equipment has been observed in Russian sale when also European countries are included. Since 1998 ventilation equipment and central air conditioning systems have been favored along with room air conditioners, and 25 % increase in sales has been experienced in comparison to five previous years. Despite of the promising figures, the market segment is estimated to be only at early phase in the Rogers innovation adoption lifecycle curve [30] (#cite-text-0-73).

In an example case Housing Corporation that owned two residential apartment buildings built in 1975 changed the district heating system to geothermal heat. After installation, the heating energy saving was 20 000 € during the first year, resulting payback time of 13 years with front-end investment of 225 000 € [31] (#cite-text-0-74).

In the other example the energy cost was reduced to one fourth of the original value after the replacement of oil heating system with geothermal heat, giving payback time ten years or less depending on the growing development of oil price [32] (#cite-text-0-75). Also heating cost saving of 80 000 € per year has been reported for apartment houses along the adoption of geothermal heat [32] (#cite-text-0-75).

In an example case heat recovery system for exhaust air was installed in seven-floored and 35 dwelling consisting apartment building constructed in 1969. Before the installation, the quantity of purchasable heating energy was 338 500 kWh and after operation 190 330 kWh per year. By heat recovery system the amount of purchased heating energy decreased by 43 % and the investment payback time was eight years. Subsidies are granted for the 15 % of the total costs [33] (#cite-text-0-77).

Heating recovery system was installed into the other residential building of 60 apartments, constructed in 1971. Heating energy consumption decreased by 37 % in one year which produced savings of 17 000 € [34] (#cite-text-0-78).

2.5 Measuring devices, building automation

"If you cannot measure it, you cannot improve it" phrased by William Thomson, the famous mathematical physicist and engineer, conveys the core message of all the improvement processes. If the current condition is not known, the controlled and successful management of a change is not supported. Installing meters to monitor energy usage levels give starting point for comprehension of current situation, and discover methods to reduce the consumption. Ability to monitor and adjust heating energy and electricity use is essential for building owners and occupants to increase motivation to change energy usage habits (e.g. [4] (#cite-text-0-7)).

Metering the heating energy consumption is minor in Russian households. Usually no metering exist at municipal boilers or heat supply receiving buildings in district heating system. Because flow is not generally controlled or measured it induces uneven flow distribution between buildings. Depending on the position along the pipe, buildings are over- or under-heated. Thus in the middle of winter only option to ventilate is window opening to have comfortable temperature within dwellings [29] (#cite-text-0-62).

When meters are lacking for residential and commercial customers, charging is paid as part of the rent according to equation where either floor space or per apartment inhabitant are taken into account (e.g. [4] (#cite-text-0-7)). The real and normative consumptions generally differs thus leaving end-consumers unaware of their real energy-usage levels. Also inability to control heating energy supply is caused by the design of heating systems with vertical single pipe through the building [4] (#cite-text-0-7).

Installation of heat meters to households for example as subsidized action bring significant savings. In Rostov oblast, heat consumption become 12–37 % lower than consumption norms in 357 houses after meter installations [4] (#cite-text-0-7).

In the other example, more than 1600 meters were installed for heat, electricity and water in public buildings of Chelyabinskaya oblast. Roughly 170 million rubles were saved in communal costs during the period of eight years. This corresponds to 3 % of the communal service expenses in 2005 [4] (#cite-text-0-7). Average pay-back time after installation of meters can be 2-4 years, as was case in Rostovskaya oblast [4] (#cite-text-0-7). There public buildings were equipped with different kind of meters which produced average monthly saving of 20–40 %.

Installation of automated controls and sensors along with building commissioning provide additional potential to lower energy consumption in commercial buildings. Possibly with the usage of automation, additional 5 % to 20 % technical energy saving potential could be achieved in Europe (see [35] (#cite-text-0-86) [36] (#cite-text-0-87).

Online-technology and automatically adjusting systems enable the usage of multiple solutions in reducing energy consumption and preventing envelope and human-related damages (e.g. [37] (#cite-text-0-88) [38] (#cite-text-0-89) [39] (#cite-text-0-90). Indoor climate conditions, such as air exchange, microbes, moisture and temperature have high effect on sensing comfort by the user and on maintaining the building in good condition.

EPBD requires inspection schemes for heating boilers and/or air conditioning systems. Still variation appears between countries in the implementation, and also overall data is rather scarce [1] (#cite-text-0-0).

In non-residential buildings the share of smart energy management systems is expected to increase as the sector is using high share of the electricity. For example efficient lighting control system for office lighting, which is highest end-user in the sector (164 TWh in European countries in 2007), has substantial potential for energy saving. As single stand-alone measure, replacement of incandescent lamps with fluorescent lamps in offices and street lighting is estimated to have energy saving potential of 38 TWh per year until 2020 [1] (#cite-text-0-0).

2.6 Maintenance, adjustment of settings, re-commissioning

In the lifecycle of building initial design and construction phases last for relatively short period and form only 20 % of costs but most importantly have long-lasting effects on the energy performance levels of buildings. For example, when passive-house related knowledge where positioning of the building on the plot, number and location of windows, shape of the building and surrounding vegetation are taken into account the energy consumption levels can be significantly lowered during the lifespan. Well-designed house is expected to have less repair, renovation and maintenance needs. Majority of the expenses are induced by operation and maintenance where energy consumption and the related expenses form principal costs of lifecycle (see Figure 2-6).

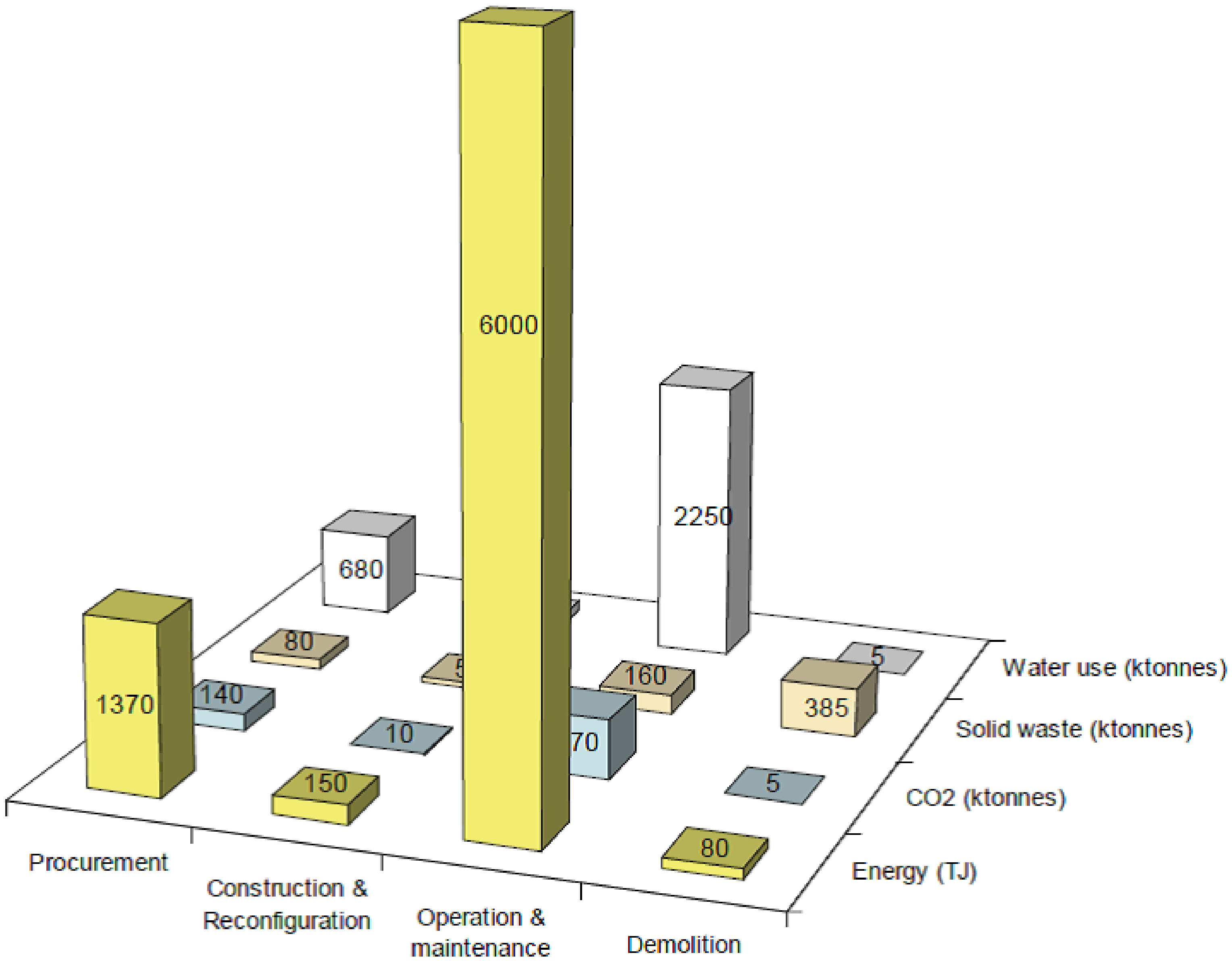

FIGURE 2-6. Life cycle analysis results for Stadium Australia [2] (#cite-text-0-1)

In Russia, majority of buildings have been poorly maintained for decades [2] (#cite-text-0-1). Among the most cost-effective measures are improvement of lighting and control. In many schools lighting systems represent 40-50 years old technique. Up to 74 % of the total electricity is consumed by lighting in one school of Moscow region [4] (#cite-text-0-7). The amount of light produced from a light source decreases along the aging which is expressed as lumen maintenance value. Luminaires calculated after usage hours are compared to new light value, e.g. lumen maintenance L70 indicates that of the output lighting 70 % of lumens are maintained (e.g. [40] (#cite-text-0-95)). Large differences between incandescent and LED lamps are observed. By replacing lamps according to maintenance plan, adequate illumination level is maintained and electricity bill lowered [41] (#cite-text-0-96).

Re-commissioning, or fine tuning, of existing building stock aid in saving energy costs. Re-commissioning (RCx) aims to re-optimize processes by increasing co-operation of separate and system-integrated equipment to reach higher energy performance levels. Generally updating the building automation and by installing frequency converters to air ventilation machine and by modifying control units of different systems produce savings. With remote service energy efficiencies of estates can be constantly monitored [38] (#cite-text-0-89).

With re-commissioning, building owners can restore the best possible operation level and save energy with small actions. During the lifecycle of building changes are often made to room spaces, equipment and systems as a consequence of technological advances and changes in intended use of the space. Also end-users are altering along the new employees or inhabitants of dwellings. Often different level construction, minor or major, are involved where new business or living supporting infrastructure are implemented. For example, data and power lines, phones, removal and addition of partitions are excluded or inserted when purpose of rooms, sections or floors are changed, e.g. from offices to storage- or assembly places [38] (#cite-text-0-89).

Changes can result in reduced building energy performance which is reflected as higher energy cost, increased maintenance expenses and lower employee productivity due to lessened indoor comfort caused by air-quality problems [38] (#cite-text-0-89). Generally overheating of one Celsius degree increases five percent increase in heating costs in households [13] (#cite-text-0-29). Problems that appeared already in design and construction phases are addressed simultaneously. Successful adjustment requires good co-operation from all parties including expert of the HVAC-field property managers and contractor. Measurement of energy consumption, indoor temperatures and water flow are required. Usually new radiator and line valves are installed to old buildings [13] (#cite-text-0-29). Operation and maintenance procedures are updated similarly as the users and personnel are educated to use adjusted equipment and systems in intended manner to improve building energy performance [38] (#cite-text-0-89). Living comfort is improved when under and overheating are avoided and between rooms temperature balanced which induce energy savings and reduced ventilation [13] (#cite-text-0-29). With re-commissioning energy savings between 5 % and 15 % can be reached with relatively short payback times, often approximating two years (see [38] (#cite-text-0-89) [42] (#cite-text-0-105)).

According to evaluations 75 % of the Finnish residential building stock basic adjustment is done in deficit manner. Temperature differences are estimated to be more than 3 °C between estates. By adjusting too high indoor temperatures back to the normal level in all the facilities can result in energy savings of several millions MWh [13] (#cite-text-0-29).

As an example case, Siilinjärvi town located in Finland has made ESCO-service agreement with YIT-company where energy saving of 9 % is aimed to be reached until 2017 according to energy efficiency agreement of Motiva. The costs of electricity and heating are aimed to be reduced as well as carbon dioxide emissions by 450 tons. For example in ice hockey halls with energy efficiency improvement and heat recovery can cut 30 % of the costs. Adjusting the control units of heating and air ventilation systems according to the usage in sport halls gives applied efficiency for given period which excludes unnecessary operation times. No additional money is needed to be invested by municipal party because the costs are covered by the savings accumulated from the energy savings [43] (#cite-text-0-107).

In one housing corporation the basic adjustment of district heating systems reduced heating energy consumption 14 % annually. In other example kinder garden and elementary school complex was adjusted for the heating systems which removed over- and under-heating of the spaces improving indoor air quality and working comfort of employees and children [13] (#cite-text-0-29).

In USA, re-commissioning of non-residential building could bring energy-saving potential of 30 million dollars annually until 2030 [35] (#cite-text-0-86).

2.7 Lighting and related control units

In Russia, yearly electricity consumption for lighting was 137 TWh in 2007, which corresponds to 14 % of the national energy consumption. Industrial and commercial building are responsible for more than half of the used quantity [44] (#cite-text-0-110) (see [2] (#cite-text-0-1)). Technical potential for energy saving is estimated to be 57 000 GWh/year and released capacity 26.2 GW for the entire lighting sector. In residential sector electricity consumption for lighting is 20 000 GWh/year which is 15 % of the total lighting electricity use. Potential annual energy saving is 13 000 GWh and released capacity 10 GW (see Figure 2-7).

In Russia, lighting control systems and electronic ballast for LFL are largely missing in the market. Energy efficient lighting products and technologies constituted relatively minor share of the total lighting sources in 2009. Over 50 % were old-fashioned incandescent lamps which produced inefficient energy use. Differences between sectors were observed, as much higher share were in residential sector (97 %) than in industrial-commercial sector (20 %) (see [2] (#cite-text-0-1) [44] (#cite-text-0-110)). Three times higher power demand for lighting exist in Russian public building than in public buildings of OECD countries.

Type of lighting equipment	Established capacity (GW)	Electric energy consumption (GWh/year)	Potential energy saving (GWh/year)	Released capacity (GW)
Industry and commercial buildings	28	85 000	30 000	10
Public, educational and state buildings	8	12 000	5 000	3
Street lighting	1.5	4 500	2 000	0.7
Residential sector	15	20 000	13 000	10
Agricultural sector, including rural population	5	16 000	7 000	2.5

Total	57.5	137 500	57 000	26.2

FIGURE 2-7. Energy use in Russian lighting sector and technical opportunities for the reduction of energy [3] (#cite-text-0-2) adapted from [44] (#cite-text-0-110) [45] (#cite-text-0-115)

Import of lighting products has been growing as domestic production is not strong due to past recession and economic restructuring. According to estimation, Russian lighting market can be valued as 1.92 billion USD [44] (#cite-text-0-110) [2] (#cite-text-0-1). New legislation of Russia inhibits sales of all incandescent lamps since 2014 which is assumed to promote the energy efficiency lighting business between countries.

2.8 Adoption of simple passive building measures

The usage of renewable energy sources will be increased in the near future as new RES-Directive becomes in force since 2020.

Heating and cooling can be promoted without additional energy by utilizing renewable energy sources, positioning of the building on the lot, by number and direction of windows. Other passive energy methods include cooling by using awning blinds, eaves, shades installed on outdoor, curtains and blind shades for the inner-side of windows. Also, sun protection glazing and thin films of low-emission for outer glasses are useful passive methods [4] (#cite-text-0-7).

As new technological solutions are becoming more popular, prices are reducing. This is case also with de-centralized energy production. Currently, the most common small-scale energy production technologies involve combustion of biomass, wind power and solar panels in Scandinavia.

For example, Finnish Voltera-company provides equipment that gasifies wood chips and burns the resulting carbon monoxide at high temperature. Particularly pure combustion produce both heat and electricity to distribution network where detached houses, farms and factories are linked. Local district heating network of low temperature (50 °C) operates in the region. In extreme cases entire village can become entirely self-sufficient and operate as off-grid close to city areas. Good example of this is in 2010 established Kempele Ecovillage located in the City of Oulu area where community of 10 detached houses inhabited by children families gain all the electricity and heat from renewable energy sources.

Next generation product Voltera 30 of the same company was placed in container to facilitate transfers. Besides of producing electricity and heat to detached house built in 1906 and other nearby buildings (such as leisure-time hall and storage house) it was also joined to the grid owned by local electric company. Idea here was to feed additional electricity to the grid and to test co-operation between de-centralized energy production plant and the energy company. Smart grid system follows the energy consumption and adjust the power according to desired operation plan. The plant produces 30 kW of electric power and 80 kW of heat energy. Also waste heat produced in the electricity generation is utilized in heating the space and service water and in removing moisture from the wood chips used for fuel [46] (#cite-text-0-119). The complex includes also new kind of local heat distribution network, connection to virtual realXtend world and recharging station for the electric cars [46] (#cite-text-0-119).

According to current electricity pricing, the front-end investment of equipment are paid back in five to ten years in the form of reduced energy bills [46] (#cite-text-0-119).

In Russia, decision of having de-centralized energy production is matter of whole cities rather than districts. As cultural derived attitude, energy is often regarded as free and obsolescence commodity. Although the supply of energy can be improved, challenges may occur in attempts of implementing distributed energy production system in Russia.

2.9 Information sharing

Worldwide, one of the listed barriers for implementing energy saving measures is the lack of information. Various programs and projects aid to recognize country-level requirements and discover solutions to improve energy performance and awareness among professionals and end-users. The same obstacle is met in Russia where also attitude-level problem is encountered. Energy is regarded as free utility provided by government that can be consumed and wasted without consequences (e.g. [4] (#cite-text-0-7)).

Formation of co-operative coalitions between stake-holders bring into discussion the practices organization have regarding energy efficiency which enable value sharing. Distributing the knowledge of the operating models may encourage also others to perform resembling energy efficiency procedures and aid in forming new contacts [47] (#cite-text-0-123).

Share of good practices between estates, for example regarding the replacement of traditional lighting with LED-energy saving lamps in parking lots. The utilization of smart systems energy is used only when needed to increase lighting, heating etc. For example, in smart ventilation systems change of the control unit aid direct the air flow according to the needs [47] (#cite-text-0-123).

By adopting different energy usage practices tremendous saving can be induced. Practical level examples about the amount of saved money, such a new car, travel or investments aid end-users to realize the saving potential. Along the energy reduction also rebound-effect may occur where saved money is consumed in other energy consuming manners. Metering the energy use give more practical example and possibility to control own energy use by occupants.

Energy inspections give information of the current energy use and costs, propose energy saving targets, and enable calculation of investment costs and payback times.

Information gained by re-commissioning should be spread to reach understanding and acceptance of recommended energy saving actions among owners and occupants.

Target setting regarding energy efficiency is a key in making improvement efforts. For example with set target commercial center Myyrmanni located in Helsinki region, saved totally 6 100 MWh of energy during a year due to selected measures. Within two years, heating costs were reduced by 8 % and electricity by 20 % [47] (#cite-text-0-123).

3 Discussion

Russia is regarded as strongly developing green energy market area [2] (#cite-text-0-1). Continuous growth of building mass and energy prices together with climate change create additional pressure to improve sustainability in buildings. Business opportunities are large for cross-border operations.

Building stock represents unique architectural directions that have multiple options to improve energy efficiency. Russia has relatively high share, 68 %, of apartment- and attached houses out of total building stock (2.2 billion m^2 of apartment floor area is divided by total floor space of all buildings 3.2 billion m^2). The corresponding proportions are 45 % in Sweden, 35 % Finland and 14 % Norway [1] (#cite-text-0-0).

Majority of the energy, generally around 60 %, is used for heating the space. In Norway, the electricity is main heating energy source also in apartment houses as majority of the electricity is produced from native hydropower. In Sweden and Finland, electricity heating prevails in detached houses, whereas district heating is the most popular among block of flats. In Russian apartment houses district heating is practically the only heating form. The heating energy per square meter is roughly 1.5 times higher in Russia than elsewhere [4] (#cite-text-0-7).

The country is regarded as among the coldest in the world. In other countries with corresponding average temperatures, such as Finland, Norway, Sweden, not as strong association to energy intensity are observed than in Russia. Long heating season, inefficient design and outdated technology are named to be factors behind energy intensiveness of Russian buildings. Relatively old facilities constructed in 1960–1970 decades consist technology which operate on fossil fuels and usually lack automation on boilers, -control and -air valve systems [4] (#cite-text-0-7). Due to poor maintenance, already minimal investments are cost-effective especially in northern part of Russia and have prerequisites to produce large energy savings in buildings (e.g. [2] (#cite-text-0-1)).

Deep renovations in Russia are rarely paid by energy savings alone thus smaller-scale measures might be more optimal to ordinary people. The purpose of this report and SBHN-project are to discover measures of low cost that have large impact on improving energy performance of Murmansk area buildings and enable business development in the field. On the basis of three earlier reports and other available literature and statistics information, we propose some technological solutions and also other approaches that promote achievement of the project goals. The measures are suitable also for older Scandinavian buildings constructed in 1960's. Generally operations have relatively short payback time and provide significant energy savings in the long-term. The cost can be reduced when energy improvements are implemented concurrently with ordinary renovation.

In Russia, inadequate maintenance and scarce repair funds are partly caused by incompatibility of tariffs with real heating energy costs which are cross-subsided with the funds gained from electricity [29] (#cite-text-0-62). Long-term viability of the systems should be based on updated pricing for energy as currently no real production-, distribution- and environment-related energy costs are charged. Accumulated knowledge have shown that higher energy prices provide also better indoor air quality as side-effect along the higher energy bills which has positive effects on the living comfort of occupants.

Lack of monitoring is one of the obstacles in improving energy efficiency in Russian residential sector. When offset level is not known, also evaluation of advantages gained by other measures is complicated [4] (#cite-text-0-7).

In ventilation systems inadequacy of total air flow in relation to the intended use of facilities and unequal dispersal of air flow within buildings are frequently discovered. In heating systems the majority of challenges are related to lack of thermostatic valves in batteries and the caused problems for room temperatures. In commercial centers particularly the lighting and halls are primary objects to reduce energy consumption

Beyond the suggested technical measures, the discovered major challenges relate more to the surrounding infrastructure and cultural aspects. Roughly 60 % of the district heating network requires the major repair [29] (#cite-text-0-62). Lower supply reliability levels are influenced by inadequate maintenance and investments performed in 1990's. Improvement of energy efficiency for example by additional layer of insulation around the pipes prevent heat losses or upgrading the heating plant itself will have long-term positive effects. Due to the typical network structure of city blocks and nature of the district heating network in Russia, where buildings are directly connected to system without own secondary circuit within buildings, the sole renovation of apartment buildings may not be regarded as long-term sustainable solution to improve energy efficiency [12] (#cite-text-0-27) [14] (#cite-text-0-30). Rather the whole districts should be treated at once [12] (#cite-text-0-27). For example district heating system distributes the heat and hot water to almost all urban populations and industry [29] (#cite-text-0-62). Water flow is not controlled or measured in transmission/distribution lines in majority of networks, and uneven distribution cause overheating building upstream and under-heating others in downstream [29] (#cite-text-0-62). Due to system design, heat limitations such as thermostats set to certain radiators restricts passage of flow also to other radiators in the same buildings, thus leaving some rooms cold. If energy efficiency of single building is enhanced, the other buildings in the block are consequently using more energy. This is mainly due to lack of appropriate measuring and controlling units in the receiver-end and also the lack of feedback system in the energy producer-side.

Approximately 13.4 Mtoe saving which equals to 35 % of the energy use in 2005 could be produced by improved technical efficiency of water heating. Upgrading the hot water delivery system e.g. by insulating the hot water pipes to enable better regulation of water temperature can produce 12 % of the saving. Within individual apartments, investments such as installation of hot water meters bring 38 % of the savings. Additional 30-40 % saving can be obtained by consumer behavior due to enabled monitoring of the water usage [4] (#cite-text-0-7).

The method and habits energy is used influence the consumption levels at home and work. Small actions, such as off-switching the lights in unoccupied rooms may also provide long term results along the replacement of old-generation bulbs with LED lights. Along the rise of economic circumstances, energy usage by housing tends to increase, e.g. as dwellings are heated to more comfortable levels, larger dwellings, more appliances and lighting points are acquired (e.g. [48] (#cite-text-0-140)).

Recognizing the underlying challenges is essential when planning energy refurbishment for the buildings in the area. Here only building-related measures are discussed although the requirement for larger scale renovation clearly exists. Although not large-scale energy saving could not always be gained with single measures, also the sensation of comfort is important to inhabitants as the majority of our lives occurs within various indoor climates. Work, home and many of the free-time activities occur in buildings which are associated to the health of the users. Sick-house syndrome include many symptoms such as head-ache, concentration problems, diseases which are accumulating as increased welfare and health cost in municipals. Also lessened productivity of employees may result which have consequences also on GDP of the nations.

Energy efficiency should not be regarded as a single project but rather like a chain of continuous improvement operations. Here, the current building stock and the available technology are in central role in determining energy improvement actions in frames given by legislation. Age of the building determines partly the cost of energy efficiency investment. Often most challenging targets are old and historically valuable buildings Motiva. 2014. Verratonta vertaistukea. Energiatehokkuussopimukset. Motiva 1. Splendid support from co-operation. Energy efficiency agreements. In Finnish. Hakupäivä 30.11.2015. www.motiva.fi/files/8932/M_1-2014.pdf. Energy-efficiency related incremental costs are not needed for new buildings. Rather number of floors, building orientation and geometry, labor and material cost influence on the expenses in new buildings [4] (#cite-text-0-7).

Recognized major obstacles that restrain implementation of energy investments in residential sector include lack of general awareness, lack of good-quality statistical data, high initial investment costs, minor appreciation of energy efficiency, shortage and too mild incentives, split incentive, environmental externalities, tariff methodologies and tariffs, high transaction costs, lack of competition, lack of monitoring energy consumption and -efficiency [4] (#cite-text-0-7).

In addition to lower energy consumption levels sustainable buildings are expected to have higher occupancy and turnover rates. Investment related risks that developers generally encounter are also decreased. In Russia and the other studied countries, upgrading the energy efficiency of building is most cost-effective when it is performed along the regular renovation [11] (#cite-text-0-26). For inhabitants air quality is improved in most convenient manner and globally current and future energy and eco-efficiency objectives will become attainable (e.g. [11] (#cite-text-0-26)). Worldwide, urbanization has increased the construction of apartment houses which has reduced per capita increase of square meters. Also milder climate since 1980 has flattened energy and electricity consumption per apartment area.

In larger extent, deep renovation of the whole city blocks are required to induce more efficient and sustainable energy savings in Russia. Smaller scale measure are also essential in improving the quality of indoor climate and giving occupants more knowledge and methods to adjust the energy consumption. Although bench-marking and concepts are needed to lower cost and manage the quality of renovations also case-by-case analysis and actions are needed for different aged and conditioned building types.

High energy intensity of major Russian economic sectors, measured in global categories has emphasized the need to improve energy performance. In buildings, enhanced energy efficiency is associated to indoor and outdoor climate conditions. Energy intensity reduction promotes nation-wide economic growth as saving gained from energy costs can be invested into the other targets and more energy could be exported to Europe and other continents (e.g [4] (#cite-text-0-7)). Renovation concepts that are tested both in laboratory and field conditions reduces the costs and shorten the length of the refurbishment period. In former area of Eastern Berlin, renovation concepts have been exploited successfully during several years where prefabricated elements and quality-inspections across the entire supply chain are performed regularly. Building stock resembles Russian buildings and partly the corresponding structures and building technology have been used. The gained knowledge and experience form one option to implement tailored concepts to Russian circumstances.

4 Conclusions

Russia is regarded as strongly developing green energy market area where construction and renovation markets are vast. Russian building stock represents unique architectural directions that have multiple options to improve energy efficiency. Apartment- and attached houses are district-heated, and they form relatively high share (68 %) of total building stock. The heating energy per square meter is roughly 1.5 times higher than elsewhere. Long heating season, inefficient design and outdated technology are prime reasons behind energy intensiveness. Relatively old facilities constructed in 1960–1970 decades consist technology which operate on fossil fuels and usually lack automation on boilers, -control and -air valve systems. Due to poor maintenance, already minimal investments are cost-effective and have prerequisites to produce large energy savings in buildings in Northern part of Russia.

In majority of buildings thickness of insulation layer is not adequate or it is completely missing. Sealing is regarded as one of the most cost-efficient measure in improvement of energy efficiency. Sealing of windows and doors have positive consequences also on living comfort as draught is decreased. With the improvement of air tightness and energy efficiency of buildings the heating need is decreased simultaneously as cooling need is increased in summer time. Installation of meters allow charging of energy according to real consumption which increase awareness of end-consumers of their real energy-usage levels.

Annually, electricity used for lighting corresponds to 14 % of the national energy consumption. Industrial and commercial building are responsible for more than half of the used quantity. Improvement of lighting and control systems form one of the most cost-effective measures. Re-commissioning, or fine tuning of existing building aims to re-optimize processes by increasing co-operation of separate and system-integrated equipment to reach higher energy performance levels. Heating and cooling can be promoted without additional energy by utilizing simple passive buildings methods. For example renewable energy sources, positioning of the building on the lot, number and direction of windows, awning blinds, eaves, shades installed on outdoor, curtains and blind shades for the inner-side of windows. Sun protection glazing and thin films of low-emission for outer glasses are also useful passive methods. Information sharing among professionals and end-users increase awareness of energy efficient methods and the benefits. Although bench-marking and renovation concepts are needed to lower cost and manage the quality of renovations also case-by-case analysis and actions are needed. Here only building-related measures are discussed although major challenges relate more to surrounding infrastructure and cultural aspects. Recognizing underlying circumstances is essential when planning energy refurbishment for the buildings in the area.

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