Energy savings potential for space heating in public buildings in Slovakia

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Abstract

Public buildings, being approximately 15,000 in number and largely neglected in terms of maintenance and major renovation, may provide a considerable energy savings and mitigation potential in Slovakia. Although several programmes have been providing funding for major renovation in public buildings in the last decade (through structural funds and other sources such as BIDSF and Munseff programme), and public sector is undergoing a reform aimed at its down-scaling, vast majority of the public buildings are still in a poor technical state. The paper shows the results of an analysis of energy savings potential in public buildings in Slovakia until 2030. The analysis is based on a bottom-up model used for a similar analysis in Hungary (Korytarova 2010). Both models use performance-based approach to modelling energy consumption. The model was updated and adjusted to national conditions. Scenario assumptions of the two models differ as well. The analysis utilises inter alia the results of a sample of approximately 250 energy audits. The analysis shows that increasing the annual retrofit rate to 3 % for the whole public building stock may not be economically effective, not even in the long run (2050). Due to currently high specific investment costs cost effectiveness can be reached only with lower rates. The research implies that first, suitable policies must be implemented, especially those ensuring quality of renovation projects as well as significantly higher share of buildings renovated to highly energy efficiency levels. These may include financial mechanisms providing support depending upon projected or achieved savings. Only then, rates of renovation can be increased, e.g. through provision of new funding. The analysis was conducted within the project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings", which was financed by structural funds and operated by Slovak Innovation and Energy Agency.

Introduction

There are approximately 15,000 public buildings in Slovakia according to the monitoring conducted in 1994–2003 (Sternova et al. 2010). The number of these buildings has decreased as many have been sold as unnecessary property or several buildings have been demolished in the meantime, however the precise up-to-date number of all public buildings is not available. Although several financial mechanisms have been focused on major renovation of public buildings, and the public sector is undergoing a reform aimed at its down-scaling (so-called ESO reform, i.e. Effective Trustworthy and Open Public Government[1]), the vast majority of buildings are operating without any major renovation since they have been built. Due to a long-term lack of proper repair of technical equipment and renovation of building envelope there is still a large energy savings potential.

Although it is assumed that the potential is large, there is no up-to-date assessment of the energy savings potential in the public buildings. Due to this reason, more than 250 energy audits were performed within the project "Support for instru-

1. ESO reform aims to make the public government more effective, increase quality of the provided services, increase its transparency and accessibility to the citizens (MoI SR 2015).

ments for the introduction and optimization of measures in the area of energy efficiency in public buildings", which is financed from the Operational Programme Competitiveness and Economic Growth (within financial framework of 2007–2013). Subsequently, an analysis utilising the findings of the energy audits was conducted with the aim of identifying energy savings potential under several scenarios.

The analysis utilizes a bottom-up performance-based model, which is based on the model PUBMIT_HU used for a similar analysis in Hungary (Korytarova 2010). The aim of the paper is to present the results of the analysis of energy savings potential and draw specific recommendations.

Methodology

The analysis of energy savings potential for space heating in public buildings in Slovakia utilizes a bottom-up performance-based model "PUBMIT_SK". This model is a follow-up model based on a so-called "PUBMIT_HU" model used to identify energy savings and mitigation potential in public buildings in Hungary (Korytarova 2010), which has been updated, adjusted to national circumstances and further developed.

Both models are bottom-up models utilizing a performance-based approach. Unlike component-based models, the performance-based models enable consideration of the building as a system and not as a sum of several components. Using this approach enables a more flexible modelling without the need for iterations of summing up energy savings potentials of the individual components after every change in the respective scenario. On the other, this flexibility of the performance-approach requires the architects and planners to optimize the use of different high-quality materials and techniques in terms of quality and costs through integrated building design. In the recent period, several studies aimed at energy savings or mitigation potential in buildings prefer performance-based approach (Novikova 2008, Korytarova 2010, Petrichenko 2009, BPIE 2011, Urge-Vorsatz et al 2010, 2011, 2012, 2015).

The main difference between the two models are due to differences in research questions, modelling time-frame, time of model development, national circumstances as well as differences in several modelling assumptions.

The main aim of the PUBMIT_SK is to identify energy savings potential for space heating in public buildings in Slovakia under three different sets of assumptions – scenarios: BAU, energy savings scenario I. (ES I.) and energy savings scenario II. (ES II.).

MODELING FRAMEWORK

The modelling framework for PUBMIT_SK is shown in Figure 1. First, the building stock is reproduced based on the available statistical data and further sources due to lack of detailed statistical information on public buildings in Slovakia. The buildings are aggregated into eight main categories: small educational buildings (kindergartens), large educational buildings (primary and secondary schools and universities), small health care buildings (medical centres), large health care buildings (hospitals), small administration buildings, large administration buildings, buildings for social care and cultural buildings. Second, the building stock is projected up to 2030 based on the historical trends, and/or projections of indicators influencing the development of the given public building category, such as projections of school entities based on projected number of students in different types of schools (UIPS 2015, Herich 2015), population growth for health care, trend in increase in population over 65 years for social care (Infostat 2013).

Then, the current average energy performance profile for existing buildings is created for each public building category based on the results of the energy audits (SIEA 2015b), as well as data from the "Pilot project Energy Efficiency in Public Buildings" (SIEA 2015a), data from municipalities and from

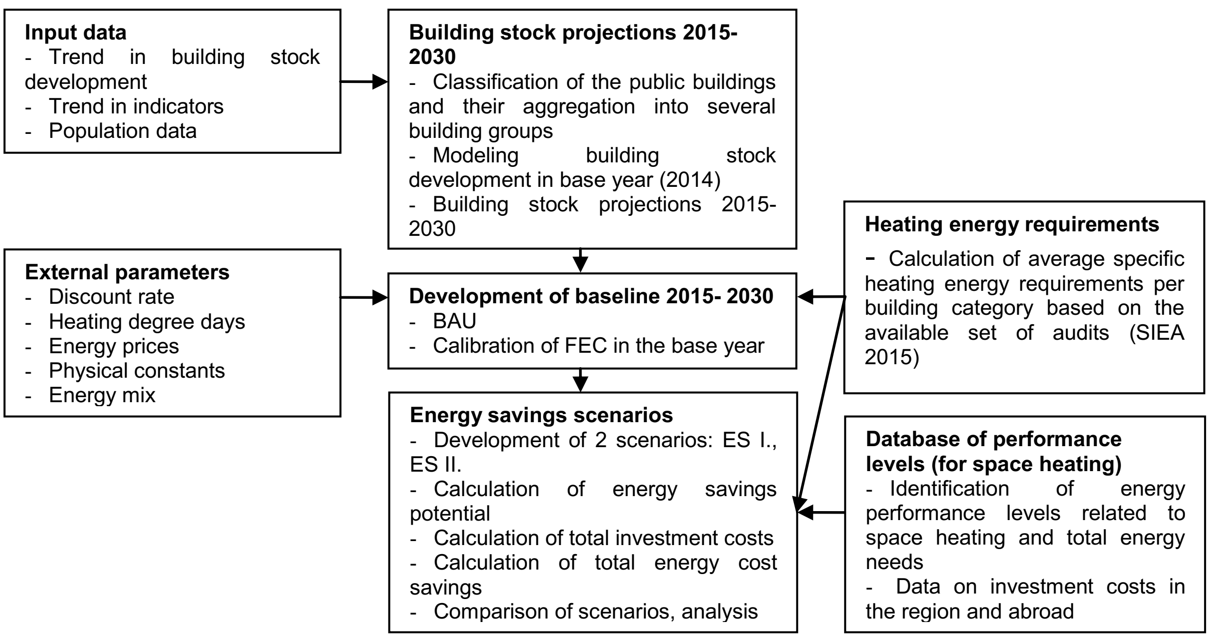

Figure 1. Modelling framework for PUBMIT_SK.

Table 1. Scenario assumptions.

Scenario assumptions	
BAU scenario	**New buildings:** Fulfilling minimum requirements: • From 1 January 2013: low-energy buildings, energy class B • From 1 January 2016: ultra low-energy buildings, energy class A1 • From 1 January 2019: nearly zero energy buildings, energy class A0
	Existing buildings: • retrofitted at natural rate of retrofit of 1,76 % p.a., which takes into account historical trend in 2010–2014, existing and planned financial mechanisms and annual renovation of 3 % of total floor area of buildings of central government, • major renovation: fulfillment of minimum requirements as for new construction (Act No. 555/2005 Coll.), while taking into account lower rate of fulfillment of the requirements for renovation as compared to new construction.
All mitigation scenarios (ES I., ES II.)	**New buildings:** Fulfilling minimum requirements: • From 1 January 2013: low-energy buildings, energy class B • From 1 January 2016: ultra low-energy buildings, energy class A1 • From 1 January 2019: nearly zero energy buildings, energy class A0 • Similar to BAU, except for more intensive transformation to the higher energy classes
Energy saving scenario I. (ES I.)	**Existing buildings:** • retrofitted at an estimated average rate of retrofit of 1,80 % p.a., which takes into account the financing from European structural and investment funds and annual renovation of 3% of total floor area of buildings of central government, • major renovation: fulfillment of minimum requirements as for new construction (Act No. 555/2005 Coll.), while taking into account lower rate of fulfillment of the requirements for renovation as compared to new construction. The rate of fulfilment of the requirements is higher than in BAU. • Out of the retrofitted buildings there are by 2030: • 32 % Energy class A0 • 34 % Energy class A1 • 30 % Energy class B • Partial retrofit and energy class C does still occur, however, in a decreased share (1 % and 3 % of retrofitted building stock, respectively by the end of the modeling period)
Energy saving scenario II. (ES II.)	**Existing buildings:** • Higher rate of retrofit: 3 % p.a. of existing buildings as of 2017 • major renovation: fulfillment of minimum requirements as for new construction (Act No. 555/2005 Coll.), while taking into account lower rate of fulfillment of the requirements for renovation as compared to new construction. The rate of fulfilment of the requirements is higher than in ES I. • Out of the retrofitted buildings there are by 2030: • 50 % Energy class A0 • 36 % Energy class A1 • 10 % Energy class B • Partial retrofit and energy class C does still occur, however, in a decreased share (1 % and 3 % of retrofitted building stock respectively by the end of the modeling period)

the Ministry of Health Care (MoHC SR 2013) collected during preparation of the Third National Energy Efficiency Action Plan (MoE SR 2014).

Further, values for different currently valid and planned energy performance levels are set based on the legislation and available data sources. Based on the building stock projections and the performance levels the baseline scenario, in this case business-as-usual (BAU) scenario, is developed. Finally, two energy savings scenarios are developed based on the assumptions regarding retrofit rate and level of compliance with the minimum requirements for energy performance of buildings. Subsequently, the cost benefit analysis is conducted for the two scenarios.

MODELLING ASSUMPTIONS

The main modelling assumptions include assumptions on projection of building stock (mentioned above), assumptions on scenario development and cost assumptions. Table 1 shows the scenario assumptions. The scenario assumptions are mainly based on the legal requirements for new construction and major renovation of buildings under the Act No. 555/2005 Col. on energy performance of buildings, Decree of the Ministry of Transport, Construction and Regional Development of the Slovak Republic No. 364/2012 Coll. The projected development of the shares of different energy performance levels (aggregated under energy classes A0, A1, B, C and partial renovation) is mainly based on the historical trends in development of energy classes and consultations with experts (especially Krajcsovics 2015, Pifko 2015). The main scenario assumptions are summarized in Table 1.

The assumptions in terms of policies and measures are the same in both scenarios for new construction. Both energy savings scenarios assume for new construction improvement of control system of the energy certificates as well as more strict enforcement of sanctions of non-compliance with minimum requirements.

In terms of major renovation, the ES I. assumes improvement of control system of the energy certificates, support from financial mechanisms provided only to quality projects, provision of consultations in the area of energy savings and financial possibilities; and increasing awareness and skills of installers. ES II. builds upon these assumptions and, in addition, assumes pilot projects funded from public sources and a new financial mechanism supporting highly energy efficient building renovation.

The assumptions on investment costs are based on a review of costs for different energy performance levels both for retrofit, as well as for new construction (especially Csider (2009) and Pájer (2009) cited in Korytarova 2010, Vyparina et. al 1998, SIEA 2015a, www.passivhausprojekte.de). Due to a large range of values, an average investment cost is set for retrofit at the level of A0 at €984 2014/m^2 and €665 2014/m^2 for A0 new construction. Technology learning is assumed for both energy classes A1 and A0: additional investment cost of the new construction of A0 would gradually decrease to the level of 8 % as compared to the investment costs of the standard new construction by 2030. The additional investment cost of renovation to the level of A0 is assumed to gradually decrease by 2030 to half of these costs in 2014.

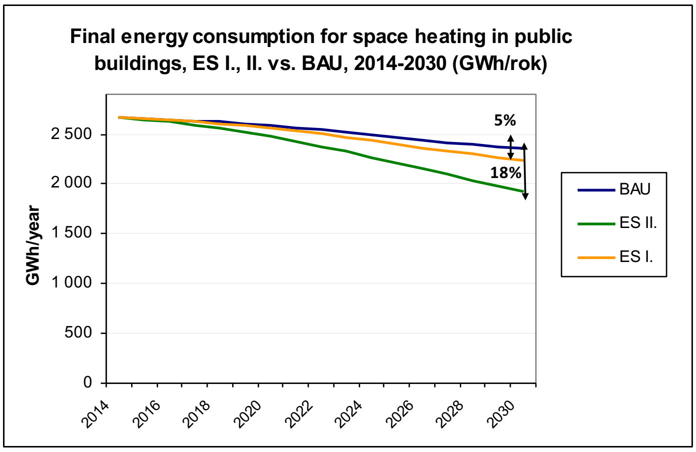

Figure 2. Final energy consumption under energy savings scenarios I. and II. as compared to BAU (GWh).

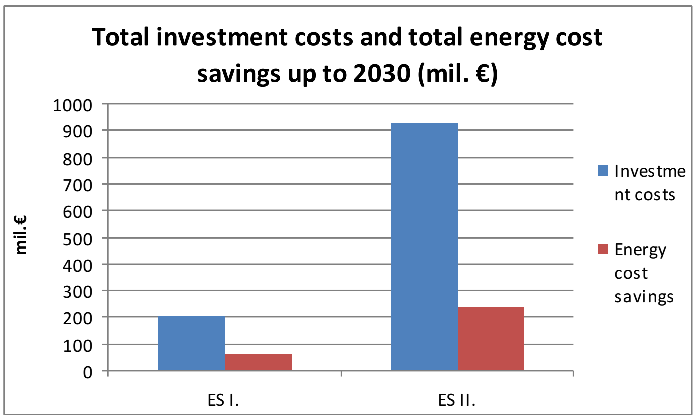

Figure 3. Total investment costs and energy cost savings in ES I. and ES II. up to 2030 (3 % p.a.).

Further details on methodology, as well as on modeling process can be found in Korytarova et al (2015).

Results

As the ES I. scenario assumes only little improvement in the rate of implementation of the minimum requirements for the renovated buildings, the resulting energy savings potential under this scenario is limited to only 5 % by 2030 as compared to the BAU scenario. The ES II. scenario, which assumes both higher rate of implementation of minimum requirements, as well as an additional financial mechanism supporting building retrofit, leads to 18 % by 2030 as compared to BAU scenario (see Figure 2). Due to the faster retrofit rate and higher rate of implementation of minimum requirements, the total additional investment costs in ES II. scenario are higher than in the ES I. (see Figure 3). In both scenarios investment costs highly exceed the energy cost savings. This is mainly due to the limited time frame, which does not allow the energy cost savings to accumulate in such an extent as to balance the investment costs. Another reason for such a significant difference between the investment costs and energy cost savings is the high specific initial investment costs of the highly efficient buildings.

In order to address the above mentioned short modeling time frame, the model was extended until 2050. This required several simplified assumptions on building stock projections, costs and other parameters. The extended timeframe allowed the ES I. to accumulate enough energy savings, and the related energy cost savings, as to become cost-effective. Nevertheless, the ES II. did not become cost effective even under the extended timeframe (see Figure 4). This is due to the higher ambition in the ES II. given higher rates of implementation of minimum requirements in building renovation.

The results of the extended analysis imply that the scenario is rather ambitious in regards of the retrofit rate as well as in terms of the transition of the retrofit towards highly energy efficient buildings.

Due to the fact that the transition is based on realistic expectations of the development of the market of highly efficient buildings including the delay in fulfillment of minimum requirements in the area of renovation as compared to new construction, and the scenario assumes a wider support of the highly efficient buildings (through both pilot projects as well as a new support mechanism for highly efficient renovation), and that the scenario assumptions are considered as a part of the research questions of the project, the projections of the development of energy classes are considered set and unchanged (for the purpose of the project). However, in order to examine the conditions under which the ES II. would be cost effective, as well as based on the results of the previous research (Korytarova 2010), which showed that massive retrofit may not be as cost effective as the ambitious retrofit at lower rates of retrofit, the cost-effective level of rate of retrofit was further examined. This examination showed that with the current building stock as well as other underlying assumptions, the ES II. scenario becomes cost effective under the retrofit rate of 2.4 % p.a. (see Figure 5). In the case of retrofit rate of 2.4 % p.a. energy cost savings exceed the investment costs by 2050 in both scenarios. Energy savings potential of the ES II. scenario reaches more than 40 % by 2050 as compared to BAU, which is approximately ⅔ of the potential under ES II. scenario with retrofit rates of 3 % p.a. The presented research confirms the previous results of Korytarova (2010) that with the same transition strategy and specific investment costs, and with lower rates of retrofit, the possibility of the scenario becoming cost effective in the long term is higher.

Conclusions and recommendations

The presented analysis on energy savings potential for space heating in public buildings in Slovakia shows that there is still significant energy savings potential in Slovak public buildings, especially in the long term.

The model for the analysis is based on a bottom-up performance-based model developed by Korytarova (2010), which analysed energy savings potential in public buildings in Hungary, and which has been further developed, updated and adjusted to national circumstances.

The building stock and its projections are based on the data of the Statistical Office of the Slovak Republic and further development indicators. The analysis utilizes results of a sample of more than 250 energy audits conducted within the project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings" financed from the Structural Funds.

The analysis shows that under the first energy savings scenario – ES I., there is rather small energy savings potential up to 2030 (5 % as compared to BAU) due to rather similar development as under the BAU scenario.

The second energy savings scenario (ES II.) has a larger potential by 2030 (18% as compared to BAU), however, the timeframe is insufficient for the energy cost savings to accumulate and to balance or even exceed the investment costs. Therefore, the ES II. is not cost-effective until 2030. Nevertheless, ES II. is not cost-effective even in the extended time-frame until 2050. However, once the retrofit rate of 3 % p.a. is decreased to a certain level, even the ES II. becomes cost-effective.

The study of Korytarova (2010) implies that first it is important to set a strategy for the transition towards the low-energy buildings and only afterwards the retrofit rates may be increased. Otherwise, massive retrofit to lower levels of energy performance may lead to locking in energy consumption to

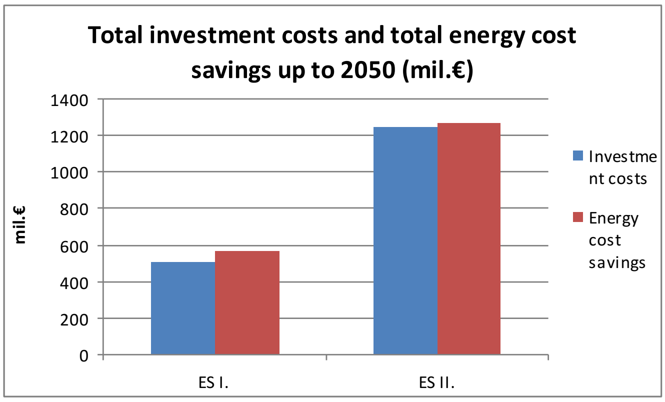

Figure 4. Total investment costs and energy cost savings in ES I. and ES II. up to 2050 (3 % p.a.).

unsustainable patterns, which remain unchanged for several decades until the next renovation cycle. Cost efficiency may be reached by strong transition strategy with lower retrofit rates, which allow to fully utilize the energy savings potential for several decades continuously and gradually.

Therefore, the findings of the presented research support the results of Korytarova (2010); as the transition strategy was based on realistic assumptions on the development of the market of highly efficient buildings, the cost effectiveness could not be reached by lowering the standards of the strategy (this would not even be in line with the research questions), but by lowering the retrofit rate.

WIDER IMPLICATIONS AND RECOMMENDATIONS:

Public buildings have several features, which make them a special type of buildings:

- In the post-communist countries there is a long maintenance gap in the whole building stock. Nevertheless, unlike the residential and commercial buildings, due to undercapitalization of the public sector the proper and complex maintenance of the public buildings is still rather rare even more than two decades after the fall of the previous regime.
- This leads to large energy performance gap of the public buildings and thus also significant energy savings potential,

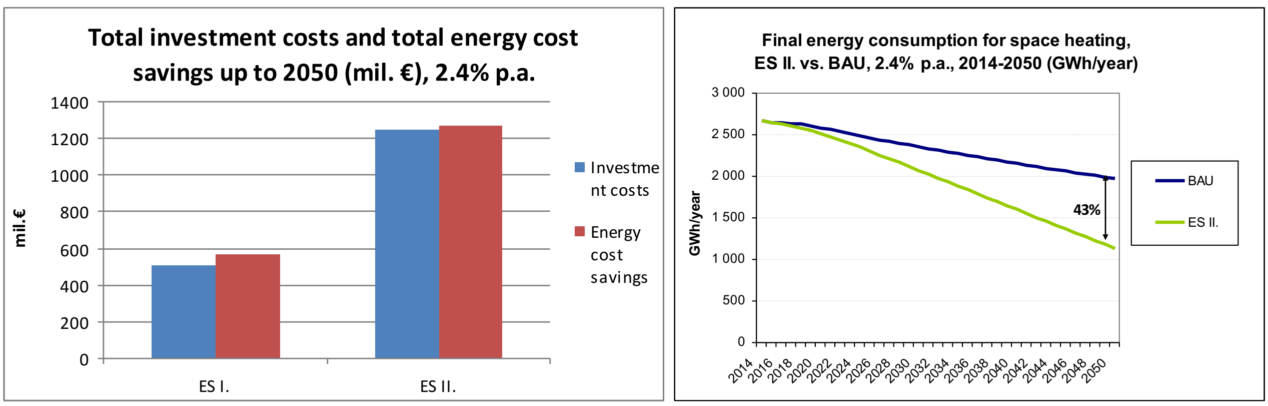

Figure 5. Total investment costs and energy cost savings in ES I. and ES II. up to 2050 at retrofit rate of 2.4 % p.a. and the related energy savings potential (GWh).

especially due to the large number of public buildings in Slovakia.

- Although since 2014 there is a possibility to renovate public buildings from the European Structural and Investment Funds (ESIF), the final allocation of funding for public building renovation may not cover all the needs of the sector and thus,[2] establishment of a new financial support mechanism may be considered.
- This new support mechanism shall build upon the latest research findings, as well as the experience from implementation of several financial mechanisms focusing on renovation of public buildings, such as a credit line for public sector Munseff,[3] Pilot project Energy Efficiency in Public Buildings financed from Bohunice International Decommissioning Support Fund (BIDSF) (SIEA 2015a) as well as projects financed under previous Structural Funds 2007–2013 (Regional Operational Program, Operational Program Science and Development, Operational Program Health care).
- This means that the new support mechanism should:
  - Support pilot projects with highly innovative solutions (however within reasonable cost intensity), including innovative financial solutions,
  - Support only projects of high quality,
  - The support should depend on the level of energy savings – e.g. relative decrease in energy consumption (the support may vary depending on the extent of the achieved energy savings), while taking into account the energy performance of the building before renovation,
  - Extra support could be provided for the projects where the planned energy savings are reached in reality (bonus provided based on post-monitoring),
  - Be flexible enough to enable innovative financial solutions, such as combination of a loan and a grant (depending on the extent of energy savings achieved), or combination of ESIF and energy performance contracting (EPC) financing.
  - Due to the fact that several municipalities and other public entities are heavily indebted, the EPC projects are not viable on a large-scale until the problem of European accounting system remains the same (MoE, 2016-2017). Therefore, it is inevitable to solve the accounting problem of EPC, which is considered as contributing to the public debt of a country.
- Nevertheless, it has to be noted, that solving of the EPC problem will not solve the whole problem of undercapitalization of public sector. Nevertheless, there are other possibilities for the public entities to plan and renovate their buildings, such as the European financial initiative ELENA.
- In order to be able to benefit from the ELENA[4] mechanism, each municipality or higher regional unit shall first make an inventory of their buildings (and other points of energy consumption, e.g. a car park, public lighting etc.). Based on the inventory the municipality can develop investment strategies based on the extent of emergency and investment intensity (€/MWh) of individual buildings. Implementation of energy efficiency projects in public buildings in Slovakia shows that e.g. renovation of cultural buildings is highly cost intensive (especially in municipal cultural buildings), whereas renovation of educational, social care and administrative buildings are much less cost intensive (based on SIEA 2015a). Most of the municipalities operate also several residential buildings (social housing), where the investment intensity may be even more favorable.
- Well prepared investment strategy based on a careful inventory is an inevitable condition of sound renovation and financing of public buildings.
- In summary, an ideal cycle of preparation of renovation projects shall include the following steps:
  - Inventory of buildings operated by the public entity,
  - Identification of the investment priorities (based on urgency and investment intensity),
  - Preparation of investment strategy taking into account the investment priorities and investment possibilities (ELENA for project development, ESIF, EPC, commercial loans, own resources for investment projects),
  - Renovation projects, inspection of the renovation process, commissioning,
  - Post-monitoring of achieved energy savings, operational costs, energy management system and regular maintenance.

In summary, based on the analysis, it is important for the municipalities and other public entities to create strategies on renovation of public buildings and identify the investment priorities. Due to the limited public sources, priority shall be given to the buildings with the highest energy savings potential, which might be renovated to the level o highly efficient building. This way public authorities invest into fewer buildings to reach the level of highly efficient building, while the energy costs will decrease significantly.

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2. Based on an analysis within the preparation of the Fourth National Energy Efficiency Action Plan (MoE, 2017).

3. Munseff – Municipal Sustainable Energy Financing Facility.

4. ELENA – European Local Energy Assistance – provides support for preparation of investments in sustainable energy for investment and financing (e.g. feasibility and market studies, program structuring, energy audits, tendering procedure preparation). It is run by European Investment Bank and financed through Horizon 2020. More at: www.eib.com.

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