Heat consumption in public buildings in Slovakia

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Keywords

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Abstract

Public buildings can play an important role as promoters of energy efficiency. In Slovakia there are approximately 15,000 public buildings. Due to long-term neglected maintenance, operation of technical systems beyond their lifetime, as well as high debt and under-capitalisation in the sector, the public buildings are presumed to be highly energy intensive. Limited access to finances and budgetary restrictions in the public sector are among the main barriers that pose constraints to large-scale investment into energy efficiency in public buildings. Only a small share of public buildings has been renovated through several incentive programmes. This implies that there is still an untapped energy savings potential in the sector. In order to specify the current state of the Slovak public buildings and the real need for their renovation data on the recent energy consumption is needed, especially data on heat and hot water use. Until recently such data existed only for the period 1994–2003. However, during the preparation of the Third National Energy Efficiency Action Plan (3NEEAP) additional data on energy consumption in public buildings were collected.

The paper presents preliminary results of the analysis of this data in terms of average heat consumption, as an indicator of building's energy intensity, in selected categories of public buildings. The analysis is based on heat consumption in 2010–2012, whereas hot water use is included. The results of this data collection based on mainly self-reported energy consumption will be compared to the first results of energy audits (EA) conducted in public buildings within the project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings". The project is financed by the Structural funds and operated by the Slovak Innovation and Energy Agency. One of its main objectives is to conduct energy audits for 250 public buildings (especially administrative buildings, health and social care and educational buildings), based on which further analysis of the energy savings potential in public buildings will be performed.

Introduction

Public buildings can play an important role as promoters of energy efficiency. In Slovakia there are approximately 15,000 public buildings (TSUS, 2003). The number of such buildings is uncertain as the last large-scale survey on public buildings was conducted in 1993–2004. Since then many buildings were sold into private property or the character of their utilisation was changed. Nevertheless, the number of public buildings is still high and, in general, their technical state is rather non-satisfactory. Public buildings in general are considered highly energy intensive due to several reasons: neglected maintenance in the long-term, operation of technical systems beyond their lifetime, as well as high debt and under-capitalisation in the sector. Limited access to finances and budgetary restrictions in the public sector are among the main barriers that pose constraints to large-scale investment into energy efficiency in public buildings.

So far, only a small share of public buildings has been renovated through several incentive programmes, such as the pilot project "Energy Efficiency in Public Buildings" financed through Bohunice International Decommissioning Support Fund (BIDSF), Regional Operational Programme and EBRD's

initiative Munseff I and II,[1] as well as Ekofond of Slovak Gas Industry[2]. Despite their overall positive effect, significant energy savings can only be achieved in public buildings if such renovation programmes apply on a large-scale to a level of high-efficiency buildings. (And, this could be done only through leveraging the finances through innovative support programmes).

Based on the above it can be implied that there is still an untapped energy savings potential in the sector. In order to specify the current state of the Slovak public buildings and the real need for their renovation data on the recent energy consumption is needed, especially data on heat and hot water use. Until recently such data existed only for the period 1994–2003, in a so-called "Database of non-residential buildings" prepared by the Technical Construction Test Institute (TSÚS, 2011). Nevertheless, additional data on energy consumption in public buildings were collected during the preparation of the Third National Energy Efficiency Action Plan (data collection based on mainly self-reported energy consumption). In addition, in 2013 the Slovak Innovation and Energy Agency started to conduct energy audits for approximately 250 public buildings (educational, health care and administrative buildings) within the project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings" (financed by Structural funds).

The aim of this paper is to compare the most actual energy consumption data stemming from the Third National Energy Efficiency Action Plan with the heat consumption data from the available energy audits conducted through the pilot project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings" and to analyse the heat consumption patterns among the selected building types. One of the most important deliverables of this paper is the preliminary results of the average heat consumption profiles for the selected building types and the understanding behind these results.

In summary, the aim of the presented data collection and analysis is to develop a basis for the heat energy profiles for selected building types based on the most recent heat consumption data.

These heat profiles can be further utilised as an input for different types of analysis, such as analysis of energy savings potential in public buildings, long-term building renovation strategy – required under Art. 4 of the Directive 2012/27/EU on energy efficiency, as well as underlying analyses for the purpose of fulfilling of the goal of public building renovation required under Art. 4 of the same directive. As the energy performance certificates do not contain data on real heat consumption, and at the same side, large divergences have been observed between the heat demand reported in the ECBs and the actual heat consumption, the ECB database cannot be used as a basis for the analysis of energy savings potential. Moreover, the analysis presented in this paper points at the challenges stemming from different data sources and as a result underlines the importance of thorough data collection and quality check of such data.

Methodology

The following steps are conducted for the aims of this paper (see also Figure 1):

1. Calculation and analysis of the average heat consumption of the selected building types (educational, health care and administrative buildings) based on the data collection under the Third National Energy Efficiency Action Plan (3NEEAP);
2. Calculation and analysis of the average heat consumption of the selected building types (educational, health care and administrative buildings) of 101 energy audits (EA) conducted under the project "Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings";
3. Comparison of the results under the Step No. 1 and Step No. 2, analysis of the underlying differences.

METHODOLOGY OF DATA PROCESSING BASED ON THE 3NEEAP DATA

During the preparation of the 3NEEAP, data on heat consumption in public buildings were gathered. The initial sample includes buildings of different size, purpose of utilization and geographical location, out of which 145 buildings were initially selected (Korytarova, 2014). The data set includes a large range of building types (educational buildings, health care buildings, administrative buildings, social care buildings, cultural buildings, sports facilities and other). Not all building types are representative enough to be included into the analysis. Based on the available data the following building categories are analyzed:

- Educational buildings (pre-school establishments, elementary schools, middle schools),
- Health care buildings (hospitals, health care centers),
- Administrative buildings (especially municipality office buildings).

From the initial data set the cases with unrealistically low or high energy consumption were excluded from the average (e.g. non-utilized buildings, buildings with missing or invalid input data).

Data on total heat consumption was available for each building, however, separate data on heat consumption for heating and separate data on heat consumption for hot water are missing. An average heat consumption is calculated based on the heat consumption in 2010–2012, which provides partial consideration of annual differences due to different climate conditions. Based on the average heat consumption and the building's floor area, the specific heat consumption is calculated (kWh/(m^2.a)) [Korytarova, 2014].

The sample for average calculation includes buildings in original state (no renovation), buildings which went through major renovation, as well as buildings, which went through

1. Munseff – an initiative of European Bank for Regional Development (EBRD) and European Commission started in 2011. The program has a form of a credit line with incentive payment. The first phase (Munseff I) was extended in 2014 into a second phase – Munseff II. (www.munseff.eu)

2. Ekofond – non-profit fund established under the Slovak Gas Industry. Ekofond provided subsidies for various purposes related to the consumption of natural gas (replacement of boilers, public building renovation, instalation of gas-fired heat pump, support of utilisation of CNG in transport, research and education).

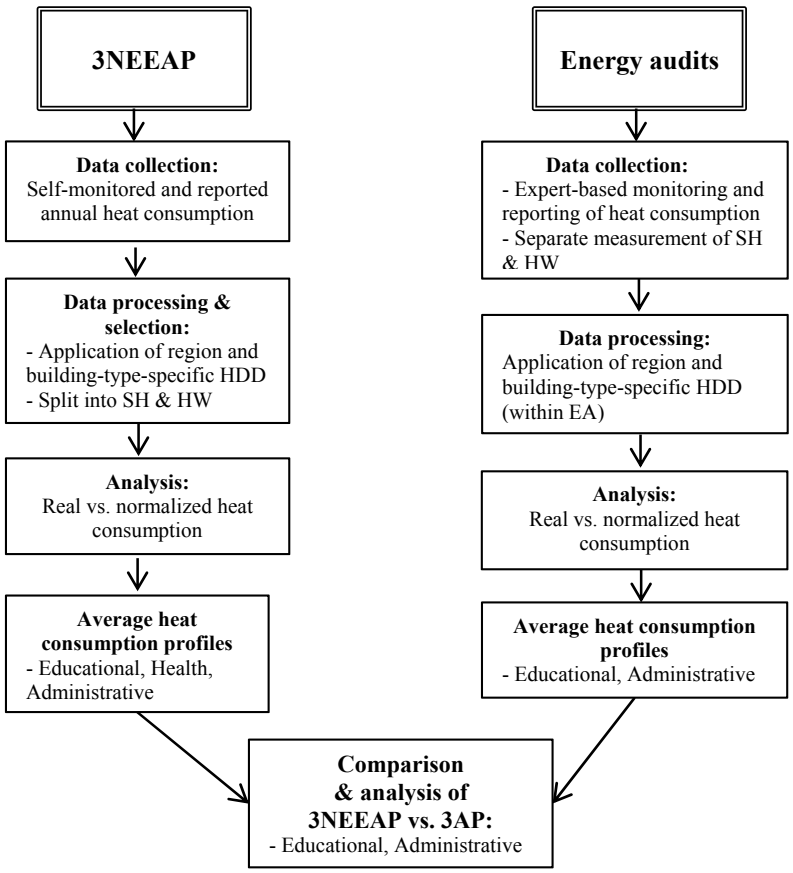


Figure 1. Methodology for calculating average profiles of heat consumption for space heating in public buildings.

partial renovation. The prevailing type of heating system in these buildings is central heating system and natural gas, in few cases wood or coal is used.

Since the 3NEEAP data set provides data only for aggregated heat consumption without further division into space heating and hot water consumption, a ratio for space heating and hot water (further "SH/HW ratio") use is applied in order to further analyze the data sample. The SH/HW ratio is based on demand for space heating and hot water demand from a well representative sample of energy performance certificates of buildings in the region of Banska Bystrica (the sample includes over 100 buildings in each of the analyzed building types, i.e. in educational, health care and administrative buildings).

METHODOLOGY OF DATA PROCESSING BASED ON THE EA DATA

Another set of valuable data of energy consumption in public buildings is available from 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". The project is financed by the Structural funds (Operational Programme Competitiveness and Economic Growth, 2007–2013) and operated by the Slovak Innovation and Energy Agency. One of its main objectives is to conduct energy audits for 250 public buildings (especially administrative buildings, health and social care and educational buildings), based on which further analysis of the energy savings potential in public buildings will be performed. The project is on-going (expected end of the project is December 2015) and in time of writing 102 energy audits have been conducted.

The audited buildings include mainly administrative buildings, as well as educational buildings and buildings of social care establishments. The buildings are mainly state-owned or owned by the municipality. In order to ensure representativeness of the sample, only the administrative and educational buildings are considered in the analysis in this paper.

The energy audits provide complete information on energy consumption in the building in 2011–2013: heat consumption including subdivision into heating and hot water, as well as electricity consumption. Based on this data and building's floor area, average specific heat consumption for heating is calculated (kWh/(m^2.a)). An average heat consumption is calculated based on the measured heat consumption in 2011–2013, which provides a partial consideration of annual differences due to different climate conditions.

In order to further eliminate the effect of the different climate conditions across the different regions of Slovakia, a correction of the real specific heat consumption for space heating through the normalized heating degree days is performed (the minor effect of climatic conditions on HW use is neglected).

Table 1 summarizes the basic characteristics of the two data sets of heat consumption in public buildings and Table 2 shows the size of the analysed samples in both sets of data.

In total, the analysis in this paper is based on data of 275 buildings.

Table 1. Basic characteristics about the 3NEEAP and EA data sample on public buildings.

	3NEEAP	Energy Audits (EA)
Total number of data set/ Number of analysed buildings	>220 174	102 101
Currently available building types	Educational buildings, Health care buildings, Administrative buildings, Social care buildings, Cultural buildings, Sports facilities, Other.	Educational buildings, Administrative buildings, Social care buildings
Selected building types for the analysis	Educational buildings, Health care buildings, Administrative buildings	Educational buildings, Administrative buildings
Ownership	Mainly municipal buildings	Governmental and municipal buildings
Years of heat consumption	2010–2012	Mainly 2011–2013, only few in 2010–2012
Advantages	– Large data sample – Large range of building types	– Expert-based monitoring and reporting of heat consumption – Division of heat consumption into HC and HW
Disadvantages	– No division of heat consumption into HC and HW – Representative sample only for three building types (educational, health care and administrative buildings)	– Rather small data sample due to on-going project – Social care buildings not representative
Methodology of data collection	– Self-monitored and reported annual heat consumption – Selection of final sample based on case-by-case consideration – Calculation of average heat consumption in years 2010–2012	– Expert-based monitoring and reporting of heat consumption – Selection of final sample based on case-by-case consideration – Calculation of average heat consumption in years 2011–2013
Data processing	– Application of SH/HW ratio – Application of building- and region-specific heating degree days (within this paper)	– Application of building- and region-specific heating degree days (within the energy audit)

Table 2. Size of available data sample per building type – 3NEEAP and EA data sample

	3NEEAP	Energy Audits
Educational buildings	73	14
Health care buildings	71	0
Administrative buildings	30	87
Total number of buildings	**174**	**101**

Preliminary results

In this section the results of the average specific heat consumption are presented for both sets of data, i.e. data collected under 3NEEAP and data based on energy audits.

RESULTS OF THE 3NEEAP DATA SET

Based on the available data, the most energy intensive buildings among the analysed building types of public buildings are the health care buildings followed by administrative and educational buildings (see Figure 2a and 2b). Figure 2b shows the average heat consumption profiles of the three building types after the division of the average specific heat consumption into average specific heat consumption for space heating and average specific heat consumption for hot water.

Health care buildings are the most energy intensive primarily due to the large energy consumption of the hospitals. The high specific heat consumption in hospitals can be explained by the non-stop operation of the building (working hours: 24 hours per day, 7 days a week), high inner temperature requirement (e. g. surgeries, hospital wards) and high hot water consumption

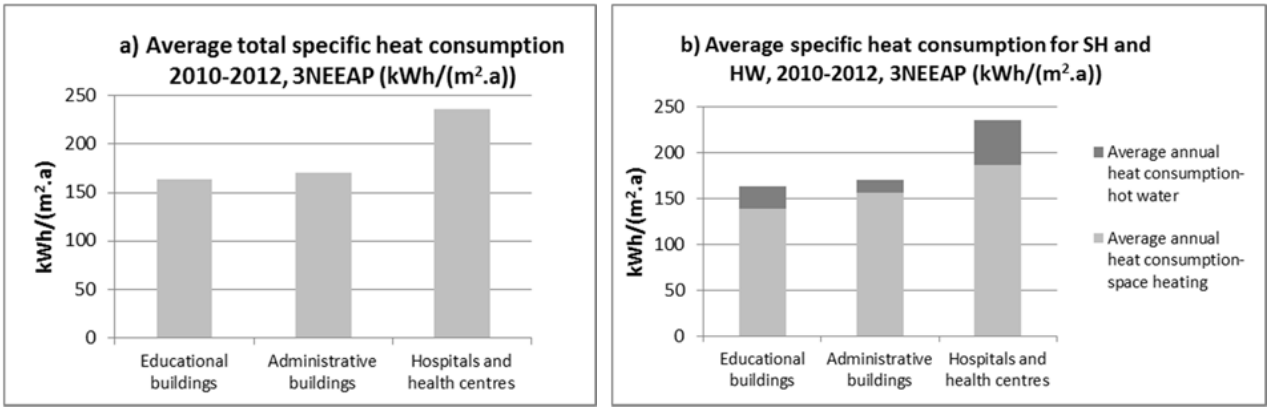


Figure 2. Average specific heat consumption in selected public building types – 3NEEAP – a) total specific heat consumption and b) split of average specific heat consumption into average heat consumption for space heating and average heat consumption for hot water. Sources: SIEA (2013), BBSK (2011–2013).

as compared to the other building types (see Figure 2b). Health centres are less energy intensive (working hours: 8/24, 5 days/week) and relatively comparable to administrative buildings in terms of usage.

The analysed educational buildings include nurseries, elementary schools and middle schools. The most energy intensive buildings (with specific heat consumption of 250 kWh/(m².a) and higher) rank among larger buildings (average floor area of 2,300 m²). Heat consumption of the different subgroups may differ largely due to the different operational times and inner temperatures as well as the use of hot water – the use of hot water in nurseries is higher than in elementary and middle schools, however, nurseries' operational times are shorter as compared to the elementary and middle schools where often double shifts are scheduled (afternoon education, after-school activities, evening schools). In several buildings (about 40 %) some measures have been taken, e.g. isolation of the building envelope, windows replacement, thermal regulation, replacement of the heating source.

Administrative buildings include both smaller municipal mayor's office buildings as well as larger town halls. The energy intensity decreases with increasing building's floor area. Nevertheless, most of the administrative buildings went under partial renovation (e.g. exchange of windows), however, no comprehensive retrofit.

The administrative buildings show comparable specific total heat consumption as the educational buildings. Nevertheless, hot water consumption is higher in educational buildings. The relatively higher specific space heating consumption of the administrative buildings can be explained by the fact that the data of 3NEEAP includes many small and medium-sized administrative buildings located especially in municipalities. The large administrative buildings, where the A/V ratio has a positive impact on the total energy consumption are not included. The similarity of the average profile of the educational and administrative buildings is in line with the average energy profiles in Hungary (Korytarova, 2010).

In order to further eliminate the effect of the different climate conditions across the different regions of Slovakia, a correction of the real specific heat consumption for space heating through normalized heating degree days is performed. The resulting

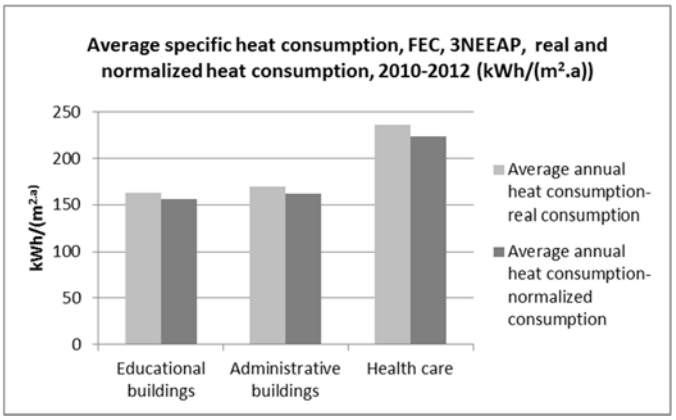


Figure 3. Comparison of real specific heat consumption and normalized heat consumption – 3NEEAP. Source: SIEA (2013).

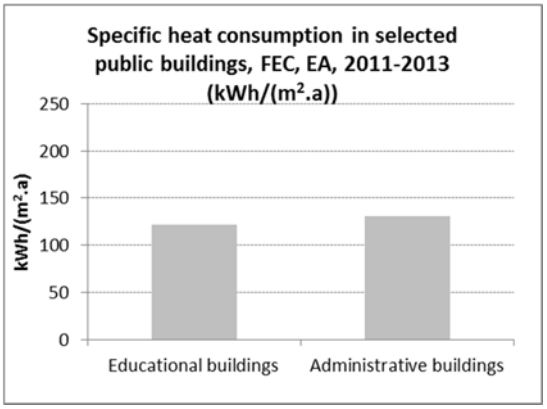
normalized specific heat consumption is on average 5% lower than the real specific heat consumption (see Figure 3).

RESULTS OF THE ENERGY AUDIT DATA

The project aimed at preparing 250 energy audits in public buildings in Slovakia started in 2013 and is still on-going (until end of 2015). Until now, almost half of the planned energy audits have been conducted. In the first phase of the project primarily state-owned administrative and a small number of municipally-owned educational buildings were audited.

Based on the energy audits both administrative and educational buildings show comparable energy profiles.

- The administrative buildings analysed in SIEA (2014) are more energy intensive than the educational buildings. Among the administrative buildings are mainly buildings of police stations and fire stations. The high energy intensity of the administrative buildings is mainly due to the poor maintenance, neglected repair of damaged building elements and technical systems or only partial replacements of the non-functional or outdated equipment (boiler house, window or outer door exchange). In most of the administrative buildings there was no major or complex



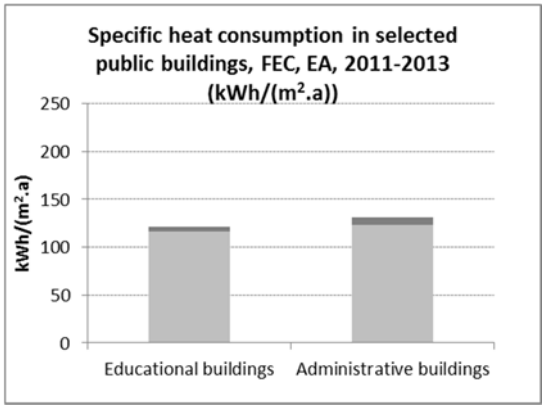


Figure 4. Average specific heat consumption – EA – real consumption. Source: SIEA (2014).

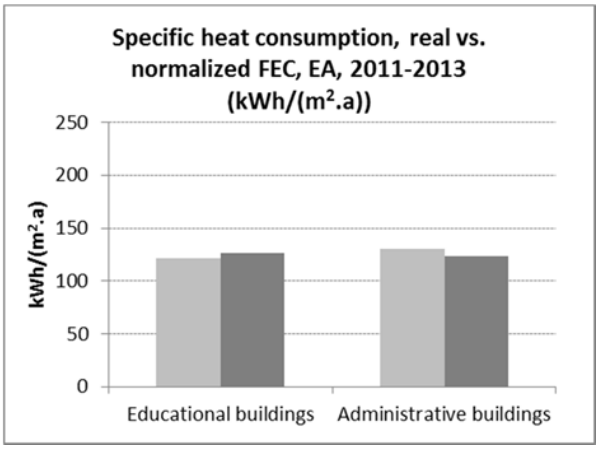


Figure 5. Average specific heat consumption – EA – real vs. normalized consumption. Source: SIEA (2014). Note: The left column for each building type is real heat consumption (lighter colour), the right column is normalized heat consumption.

renovation performed since they were built (1970–1980s or earlier). Hot water is supplied from district heating (33 %), gas-fired boiler house (29 %) or electric hot water heaters (38 %). Some of these buildings operate non-stop (365 days/year, 7 days/week) or on several shifts (251 days/year, 2–3 shifts/day).

- The sample of educational buildings includes pre-school establishments, elementary and middle schools. In the analysed educational buildings heat for space heating is supplied through district heating or gas-fired boiler house. Most of the analysed pre-school establishments and elementary schools prepare their water through electric hot water heaters, whereas hot water in the middle schools is mainly supplied through district heating or natural gas boilers. In most of the analysed buildings there were some partial renovations taking place (especially windows and outer door replacement, some renovation of boiler house), however, no major nor comprehensive renovation was conducted. Pre-school establishments operate only in work days (8 hours/day), while in elementary and middle schools more shifts per day may occur.
- Higher occurrence of partial renovation or replacement of dysfunctional building elements or equipment in the educational buildings can explain their lower energy intensity as compared to the administrative buildings. Longer working hours of the police and fire stations may also contribute to their higher energy intensity.

Nevertheless, once the heat consumption for space heating is normalized for climatic conditions and the normalized utilisation of the building through the normalized heating degree days (based on technical norm STN 73 0540-2:2012), the situation changes and the educational buildings become slightly more energy intensive than the administrative buildings (see Figure 5). This difference may be explained by the fact that in reality the heating system in the educational buildings is often turned off in the afternoon (even despite the thermal discomfort). Therefore, their real heat consumption is lower than the normalized one (considering afternoon class activities as well). In addition, educational buildings are not fully heated during the winter holidays. On the other hand, in the administrative buildings the heating is on even in the afternoon and after normalized working hours. Moreover, some of the analysed police and fire stations have longer working hours than a typical office building. Another contributing factor to this shift is also a fact that the difference in the heat consumption between the two building types is very small (within the range of 5 %).

COMPARISON OF THE 3NEEAP AND EA DATA SETS

In the comparison only the comparable building types available in both data sets are compared in terms of total specific heat consumption (kWh/(m².a)) (including heat consumption for space heating and hot water), see Figure 6. The main points stemming from the comparison of the results of the 3NEEAP and EA data sets are the following:

- In both cases the administrative buildings are more energy intensive in terms of specific total heat consumption than the educational buildings (although the difference in both sets is relatively small).
- The difference between the results for the comparable building types (educational and administrative buildings) is in the range of 19–25 % (depending on the building type and type of heat consumption considered, i.e. real or normalized).

The comparison shows a rather large difference between the two samples. On average the difference between the two sets is smaller for the normalized heat consumption (see Figure 7).

Note, that in the 3NEEAP large sample exists for the educational buildings (73 buildings), while more energy audits are conducted for the administrative buildings (87 buildings).

Based on the above, the comparison points out the importance of the size and representativeness of the sample. This is especially challenging in the current time of limited monitoring of measured real heat consumption in the area of public buildings. This implies that the need for thorough monitoring is essential for a quality assessment of the current state of the public building stock. This is crucial for further analysis of the needs for renovation of public buildings and the total energy savings potential on a large-scale.

Conclusions and lessons learned

Information and sufficient data is necessary in order to assess the current state of the public buildings in terms of energy consumption and the need for their renovation. The paper focuses on two data sets of heat consumption in different building types in various locations across Slovakia. The self-monitored data set collected within the preparation of the Third National Energy Efficiency Action Plan (3NEEAP) provides data on heat consumption in a wide range of building types, however, no division of heat consumption into space heating and hot water preparation is available. Therefore, a ratio of typical space-heating-to-hot-water split is applied to the heat consumption in this set. This enables comparison with the other set. In 3NEEAP educational as well as health care buildings are strongly represented. The second set is based on data from 102 energy audits (EA) gathered within an ongoing project financed from EU Structural funds (2007–2013). Most of the audited buildings are administrative buildings and the split of heat consumption into space heating and hot water is provided in the audits.

The two sets are analysed both in terms of real (measured) consumption and normalized consumption. On average the real specific heat consumption is 5 % higher as compared to the normalized one. This difference is not only due to the different climate conditions, however, also due to differences between the real building operation and the normalized regimes set by the technical standard. Both data sets show that the analysed administrative buildings are more energy intensive than the educational buildings (when considering real heat consumption). This can be explained by both longer working hours of the analysed administrative buildings as well as the operational practices of the building operators (some educational buildings do not fully operate in the afternoon hours). Nevertheless, the two sets show a significant difference in total specific

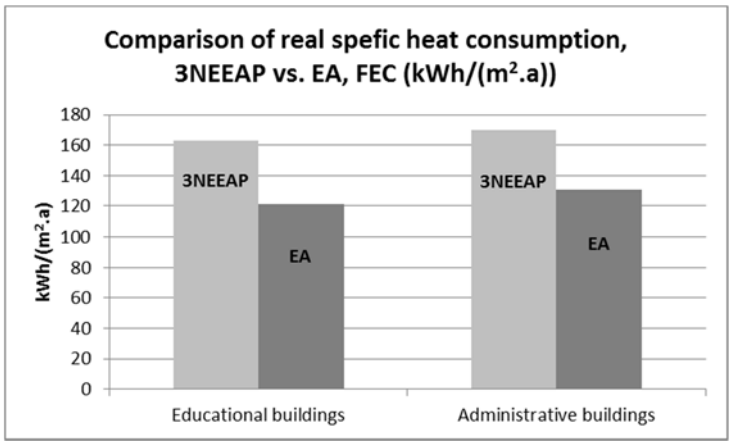


Figure 6. Comparison of average real specific heat consumption – 3NEEAP vs. EA.

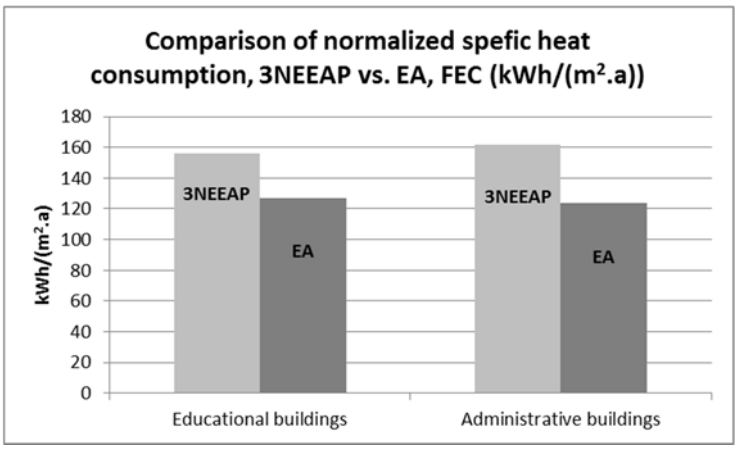


Figure 7. Comparison of average normalized specific heat consumption – 3NEEAP vs. EA.

data consumption. This implies a need for further thorough large-scale monitoring of heat consumption, including separate monitoring of space heating and hot water consumption, based on quality energy audits.

Due to financial difficulties, most municipalities do not procure comprehensive energy audits before renovation. Due to limited budget only the most crucial replacements of dysfunctional equipment or building elements are done. However, the audits show that even such investment is often counter-productive. For instance, non-quality partial renovation may, on one hand, lead to a decreased quality of inner environment and, on the other hand, makes further complex renovation less cost effective. Therefore, an energy audit should be a preconditions for funding public buildings renovation (or building renovation in general), as it provides both a good overview of the current state, as well as recommends the cost effective energy savings measures (which in turn will bring financial savings of public budgets in the long-term). Moreover, energy audits may be used to identify the investment priorities of the municipality, which can be further used in preparation of their Sustainable Energy Action Plan. Similarly, audits may provide a comprehensive overview of the current state and the needs of the state-owned buildings, and thus serve as a basis for a renovation strategy of state buildings for the purpose of both saving the state budget and fulfilment of the obligation under Article 5 of the Directive 2012/27/EU. Last but not least, at the national level, analysis of the results of energy audits may be used for preparation of the average specific energy profiles of the public building, and thus contribute to the knowledge base for the further analysis of energy savings potential in public buildings in Slovakia. For this purpose, energy audits shall be performed for the other types of public buildings, especially for health care buildings, which are the most energy intensive according to the 3NEEAP. In the meanwhile, the 3NEEAP data may be cautiously used for analytical purposes for the categories not covered by energy audits.

In summary, both the data collection and the analysis show at the importance of monitoring of real consumption and accuracy of the data. Although data gathering is often perceived as a challenging task for many municipalities due to lack of skilled capacities, the collected data provides valuable initial insights into the possibilities of lowering their annual budgets. The challenge of data gathering can be lowered by targeted technical assistance, such as that provided by the Slovak Innovation and Energy Agency. The next important step is to secure public funds for preparation of energy audits of selected public buildings aimed at renovation. Then, different financial mechanisms can be applied to finance the renovation itself. Nevertheless, the quality has to be ensured (especially when public funds are used) and the energy consumption of the building should be monitored several years after the renovation has been completed. Further incentives can be applied when the planned energy savings are reached. Last but not least, it shall be ensured that energy performance contracting is performed in line with the overall project of the renovation and does not decrease the cost effectiveness of the whole-building retrofit.

References

BBSK, 2011-2013. Energy performance certificates of public buildings in the Higher regional unit of Banska Bystrica (BBSK).

EU (European Union), 2012. Directive 2012/27/EU of the European parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Journal of the European Union. 14.11.2012, Brussels. L351/1–56.

EU (European Union), 2010. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Journal of the European Union. 18.06.2010, Brussels, L153/13-35.

Korytarova, K., 2014. Spotreba tepla vo vybraných typoch verejných budov. [Heat consumption in selected public building types] In: Conference proceedings of Vykurovanie 2014 [Space heating 2014], 3rd–6th March 2014, Stará Ľubovňa.

Korytarova, K., 2010. Energy efficiency potential for space heating in Hungarian public buildings. Towards a low-carbon economy. Doctoral thesis, Department of Environmental Sciences and Policy, Central European University, Budapest.

MH SR (Ministry of Economy of the Slovak Republic), 2014. Akčný plán energetickej efektívnosti na roky 2014–2016 s výhľadom do roku 2020 [Literal translation: Action plan on energy efficiency for 2014–2016 with an outlook up to 2020. Document stemming from the Directive 2012/27/EU on energy efficiency: Third National Energy Efficiency Action Plan], adopted by a Government of the Slovak Republic by Decree No. 350/2014 on 9 July 2014, Bratislava.

SIEA (Slovak Innovation and Energy Agency), 2013. Self-monitored heat consumption in public buildings. Data of consumption for years 2010, 2011, 2012. Collected during the preparation of 3NEEAP.

SIEA (Slovak Innovation and Energy Agency), 2014, 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 Operational Programme Competitiveness and Economic Growth, 2007-2013. [102 energy audits conducted between 2013–2014]. STN 73 0540-2:2012, 2012. Tepelná ochrana budov Tepelnotechnické vlastnosti stavebných konštrukcií a budov Časť 2: Funkčné požiadavky [Thermal protection of buildings. Thermal performance of buildings and components. Part 2: Functional requirements].

TSÚS (Technical Construction Test Institute), 2011. Predikcia zabezpečenia energetickej hospodárnosti budov s využitím postupov optimálnej technickej, environmentálnej a ekonomickej realizovateľnosti [Prediction of ensuring energy performance of buildings through utilization of methodology of optimal technical, environmental and economic feasibility], 2011, TSÚS n. o.