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Development of Municipal Energy Management as Trigger of Future Energy Savings

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Abstract: Directive 2018/844/EU on energy efficiency claims that almost 80% of the final energy consumption in the EU is used within the buildings. The subsequent Directive (EU) 2023/1791 introduced in 2023 expected 68% of the world population to live in urban areas. Both directives enhanced the role of energy management (EM) applied to the city buildings. This paper introduces the development of energy management in Czech municipalities between the years 2009 and 2023. The main goal of this article is to present selected results of the unique national survey focused on the energy management in Czech municipalities conducted in 2023 and compare it with results of national surveys implemented in 2009 and 2018. The main method is the comparing of two surveys conducted among the municipal representatives or energy managers in the past with the new survey conducted in 2023. The results show that EM became a notably more important issue for most Czech municipalities. The number of cities collecting data on energy consumption grew by 288% and the number of city energy managers increased by 57%. On the other hand, the used potential of energy savings triggered by establishing EM was insufficient and only 4% of the respondents claimed high and exactly measured savings because of EM. This article should be applied to the stress power of municipal EM in performing energy efficiency and RES projects and encouraging the government to support municipal energy managers in their complex role.

Keywords: energy management; management; municipalities; ISO 50001; supporting schemes; SECAP

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1. Introduction

The buildings consume 40% of the final energy in the European Union (EU) and 36% of the energy-related greenhouse gas emissions are connected with them. In addition, 75% of the buildings in the EU are energy inefficient [1]. The main portion of buildings are concentrated in the cities and a significant portion is directly owned by the municipalities. These buildings are both for residential purposes and public purposes (e.g., schools, libraries, and sport and cultural facilities). Over 70% of the citizens of the Czech Republic live in cities [2].

Municipalities search for ways to minimize costs for the energy consumed. Efforts to achieve better energy management are further supported by the current policies of reducing greenhouse gas emissions. A number of EU regulations cover enhancing the energy savings and reducing greenhouse gas emissions (GHGs). The Energy Efficiency Directive (2023/1791) obliges Member States to increase energy efficiency and reduce energy consumption and greenhouse gas emissions [1]. The Directive includes the obligation of Member States to support municipalities technically and financially in their effort to increase energy efficiency. Nonetheless, there is no clear provision expressing specific steps of their support, even if their role is crucial.

The transposition of the Energy Efficiency Directive to the Czech legislation is coordinated by the Ministry of Industry and Trade (MIT). The MIT revealed several acts and

government ordinances to rule the energy performance and energy management. Except for this, the MIT offers subsidy programs for establishing municipal energy management (EM), enhancing energy performance and energy education, mainly the subsidy program EFEKT. The other important source of subsidies focusing on energy performance measures is the Operational Program Environment ruled by the Ministry of Environment.

Although municipalities should be pioneers of EM, the legal power of municipalities is insufficient for the energy sector; 18% of municipalities in the United Kingdom (UK) have no project nor plan to implement local energy innovations [3]. Increasing a city's energy efficiency can influence many dimensions of its competitiveness, spanning economic, social, environmental, and innovation and technology facets. Striving for energy efficiency is a strategic approach that can benefit both the city and its communities and businesses [4].

The reported energy savings show that the conventional methods can be as effective as innovative and emerging approaches. However, ease of installation, scalability, life cycle assessment, and cost benefits are the main drivers/factors in studying and identifying new energy conservation methods [5]. Energy savings and emissions reduction targets can be achieved at lower costs if behavioral changes occur, proving that "soft measures" are an essential lever for the implementation of "hard" technological measures [6].

1.1. Definition of EM in Municipalities and Its Presentation

The prerequisite necessary for spreading EM among municipalities is its clear definition, which is understandable even for people without any previous knowledge in this field. This is very often the case of city mayors or decision-makers. The research area "urban energy management" combines many additional research areas, including energy efficiency, economic efficiency, environmental protection, the use of modern technologies in energy infrastructure and construction, urban spatial planning, and public transport [7].

The definition should be attractive for municipality leaders and should briefly explain what EM means and what benefits it brings. If a municipality does not have an established track record on implementing an effective environmental policy and is not supported in this by its electorate (assuming a democracy), it is unlikely that its politicians will be ready to move forward with the aggressive policies necessary [8]. After EM implementation, the municipality obtains reliable information on energy expenditures. Subsequently, the municipality can adopt appropriate measures and avoid technical and financial risks.

The mapping of urban building energy plays a crucial role in understanding the multitude of agents that take part in the energy performance of buildings and thus in setting up the benchmarks in different districts for various stakeholders [9].

The importance of energy management for a given municipality can be measured primarily by the share of energy and water expenditure in the municipality's total expenses. In the case of cities, towns, municipalities, regions, and organizations with a mainly administrative operation, these expenses usually reach around 10% of the total operational expenses [10]. Energy management implementation is a systematic and not capital-intensive step. The objective is to gradually reach substantial energy savings and improve work organization [11]. Energy management is a set of activities that contribute to the long-term improvement in energy performance within a given energy system [12]. There is a variety of energy-saving measures, and energy management seems to be one of the key instruments for reaching the savings [13]. An energy management system is a set of interrelated or interacting elements to establish an energy policy and energy objectives and processes [14]. The Association of German Engineers released a definition, which includes the economic dimension: Energy management is a proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives [15].

EM should be considered as an important instrument of life cycle costing because EM is the way to reduce operational costs in the buildings. The better design a building has, the lower the operational costs there are. Especially Czech municipalities are still forced by the legal risks to tender building renovations at the lowest bidding price. The private owners

commonly use maximum performance as the key criterion. The maximum value for money could be achieved if all costs included over the whole life span are evaluated. Running costs (operation costs, maintenance, and renovation costs) are an important section of investment during the life cycle [16].

The lack of technical skills, disinterest in energy efficiency improvements, and non-functional regulation were identified as the most significant factors influencing EM [17]. The knowledge shortage of building practitioners can easily lead to the risk of not achieving operational savings and reducing the financial effectiveness of a particular building asset [18]. The plain decision that an organization will reduce energy consumption does not mean it has an energy management system. Understanding how, where, and why energy is being used is essential when devising EM, whatever the motives may be for trying to use less energy [19].

The increase in the number of energy managers in municipalities and improvement in the specialized qualification of the present managers should be supported by an e-learning course designed for municipal managers. The course has been available on the EFEKT program website since 2015 [20]. Municipalities with more than 10,000 inhabitants can apply for a subsidy to fund the EM implementation from the EFEKT subsidy program. The subsidy covers the development of key EM elements, such as a municipality-tailored EM description, process organization (definition of processes, responsibility, information flow, etc.), and an energy consumption assessment. The subsidy does not cover EM certification, but it is assumed that the implemented EM would meet the standard ISO 50001 or the requirements of the system of the environmental procedure and EMAS audit [21]. The extension of the standard ISO 50001 among Czech municipalities was also supported by an illustrative handbook published by the energy agency DEA, explaining the use of the ISO 50001 standard in a clear and comprehensible way using specific examples from the life of an energy manager [22].

1.2. The Base for Municipal EM Implementation

The subsidy programs are important for establishing municipal EM. However, the administrative work of both sides (the funding body and the beneficiary) is perceived as a significant barrier to applying EM. The transaction costs in energy efficiency subsidy programs are of non-negligible levels, altogether averaging 11–14% of the total subsidy allocation [23]. Should the administrative costs of an average application be 520 EUR and the smallest types of application for subsidies in the value of 2200 EUR, it appears that, while sustaining the existing method of administration and approval, such administration is ineffective [24].

The Czech municipalities follow the Act no. 406/2000 Coll. on Energy Management, which orders applying an energy audit to a whole municipal property consuming energy or adopting the energy management system based on the international standard ISO 50001 [25]. The ISO 50001 standard provides a guide on the implementation, maintenance, and further development of the energy management system. The standard is based on a gradual improvement cycle according to the plan–do–check–act rule. The standard ISO 50001 has been available in the Czech Republic since February 2012. After the standard ISO 50001 adoption, energy savings of more than 10% were achieved in some cases within one year [26].

Implementation of EM at the municipal level is indirectly supported by the EU's current efforts to mitigate climate change in municipalities. Municipalities striving for climate change mitigation can join the European co-operation movement called the Covenant of Mayors (CoM). This movement encourages its members to sign a declaration to take measures leading to climate change mitigation, reducing energy consumption, reducing greenhouse gas emissions, and transitioning to a low-carbon economy. Municipalities that signed the Covenant of Mayors have committed to reducing their CO_2 emissions by 40% by 2030, comparing to the chosen baseline year from the past. The procedure leading to a reduction in CO_2 emissions shall be described in the Sustainable Energy and Climate

Action Plan (SECAP). The previous version of this document did not emphasize the climate so much and was called just the Sustainable Energy Action Plan (SEAP). The introduction of energy management on municipal property is obviously a relevant tool for the SECAP implementation. Drawing up the SECAP for Czech municipalities can be funded from the subsidy repeatedly revealed by the Operational Program Environment governed by the Ministry of Environment. Some European cities and municipalities implemented EM when drawing up the SECAP.

In general, cities do not have the authority to implement carbon pricing policies. It follows that they do not have the opportunity to use carbon pricing revenues to run major subsidy programs for energy efficiency or energy-switching technologies either. Cities also tend to have just negligible authority to regulate the sale of the technologies (furnaces and vehicles) and energy forms (gasoline and natural gas) that cause most urban GHG emissions [8]. Local authorities in the UK have no direct energy mandate. In addition, UK local authorities have had no significant role in energy supply for the last century. Municipal energy effectively ended with the early 20th century nationalization and centralization; privatization followed in the 1980s and 1990s. The lack of local statutory powers and resources for energy, and the absence of consistently supportive policy frameworks for implementation, result in plans having limited material impacts [3].

EM is extremely dependent on the human factor, with perhaps the most noteworthy factor being the unpredictability of the people and departments that eventually assume leadership in the smart projects. Arguably, the sustainability outcomes also depend on citizens' uptake of the smart agendas and may involve the continuance and worsening of existing habits [27]. It also shows the necessity to involve occupants in energy management through data sharing and regular information about the consequences of overheating on energy consumption and health. It constitutes a valuable support for decision-makers to set up efficient strategies for the optimal energy management in old buildings through a smart transformation of the social buildings and occupant involvement [28]. There is no single definition for citizen engagement in cities. Citizens play an active role in defining issues, finding solutions, and identifying priorities for action. However, involving citizens is voluntary for cities, and such an inclusion process varies between cities and may even be completely absent in some cities [29].

The CoM's ambition is to gather local governments voluntarily committed to achieving and exceeding the EU climate and energy targets [30].

1.3. The Problems of SECAP Implementation in Small- and Middle-Sized Municipalities

In many cases, municipalities are encouraged to develop sustainable energy and climate action plans, but eventually, they do not know how to properly work with data and make evidence-based decisions [31]. To fulfill the obligatory structure of the SECAP given by the CoM is not easy, especially for medium- and small-sized cities [32]. Most CoM signatories (98% in terms of submissions and involving 40% of the EU population) are small and medium cities (less than 250,000 inhabitants), where the inadequacy of the skills of the municipal staff is certainly a widespread problem [33]. The lack of personnel availability and capacity for funding sustainable energy projects and the availability of training schemes has been confirmed [34]. The technical staff of small- and medium-sized municipalities do not possess the specific expertise for SECAP creation. To overcome this problem, the SECAP preparation is frequently outsourced, which may produce some critical shortcomings in local governments [35]. The commonly recommended measures to reduce energy consumption mentioned in the SECAP are the use of renewable energies, improving energy efficiency in buildings, optimization of public lighting, improvements in air conditioning and ventilation systems, improving the efficiency of small electrical equipment, and improved efficiency of industrial processes and equipment [36]. Most municipalities cannot distinguish how many financial resources are used for SEAP activities and most of them have no specific budget for this purpose. SEAP implementation is seen as a side effect from the municipal budget point of view [37].

1.4. The SECAP Coherence with National Energy Planning

The main activities against climate change should be performed by the cities; however, these activities should be coordinated by national governments in order to maximize the synergy effect. If each city approaches the problem solely from the point of view of its own needs, the final result could be a group of isolated cities instead of a developed society with a reduced carbon footprint. The relationship between local and national government has important elements in local climate action [38]. The municipal energy plans should be allied with the other types of urban planning [39]. In order to successfully implement the municipal energy plans (and national energy objectives), it is necessary to restructure the energy planning system. This entails a move from "parallel energy planning" to "strategic energy planning" in which an alignment of national energy objectives, municipal energy planning, and the necessary instruments for implementation can take place on a continuous basis [40]. Regional and municipal efforts for climate and sustainability do not seem to be aligned [41]. There is a need for coordination in aligning local efforts to successfully contribute to the decarbonization of national energy systems [42]. However, the production of the planned RES not only exceeds the available grid capacity but also is an appropriate share from a national perspective. This is a clear sign that not only should planning permission involve grid considerations, but it should also include consideration for national developments and appropriate shares across municipalities [43]. Accurate monitoring and verification are needed, but they are far from only being a "technical" exercise. This requires checking the actual progress of energy efficiency and the effectiveness of national policies and measures. Monitoring the impact and progress of the strategies remains a weak point [44]. The decision support tools are needed because of increasingly ambitious climate protection goals. These help to identify local conditions and support local decision-makers in the formulation of energy system transformation strategies [45]. The principle of Energy Efficiency First, one of the most important leverages to achieve decarbonization, is not sufficiently addressed. Clearly, Member States prioritize investment in new technologies [46]. Consumer behavior change could be another significant contribution to energy savings, and this could be even enhanced by the monetizing of the required behavior patterns [47].

One of the authors is an energy manager in a middle-sized Czech municipality and was an insider among the focus group. His experience from the city hall helped to address the energy managers of other cities and correctly formulate the questions to be familiar for respondents.

2. Goals of this Study

The main goal of this article is to present selected results of the unique national survey focused on energy management in Czech municipalities conducted in 2023 and compare it with the results of national surveys implemented in 2009 and 2018. For the survey purposes, energy management is defined as a systemic approach, which has its own aims, practices, documentation, and staffing and is organized by the municipality and is focused on municipal equipment. The systematic EM is far away from serial ad hoc energy measures implemented on selected municipal buildings, although these may lead to significant energy savings.

The subsequent goal is to describe the evolution of energy management in municipalities in the Czech Republic between 2009 and 2018. In 2009, the very first survey on municipal energy was conducted. The same survey was repeated in 2018.

The third goal is to describe the most frequent approach to EM in the inspected cities. A systematic approach to the EM can be based on the ISO 50001 standard or on a customized system developed in-house. However, the Czech version of the ISO 50001 standard was published in 2012. Any systematic EM existing before the standard was released is inevitably based on different rules. The pre-ISO system could be replaced by the ISO or the ISO can be refused and the pre-ISO system can successfully continue within the municipality.

3. Materials and Methods

Due to the low data collection through official governmental bodies or tools of the state energy policy, questionnaires among municipalities are the only instrument monitoring progress in municipal energy management. Indirectly, the data are collected via supporting schemes.

The first original information source is the survey, which was carried out by the independent energy advisory Porsenna Ltd. (Prague, Czech Republic) in 2009. This survey focused on larger villages and municipalities and resulted in 53 completed questionnaires out of the 279 that had been sent out in total. This outcome represents a 19% response rate, which is a common result with surveys organized this way. The relatively low response rate is because of the high number of enquired municipalities. In the year 2009, EM was not present in many municipalities. If the municipality did not establish EM, it did not react.

The second original information source is the survey conducted by the independent energy advisory SEVEn, The Energy Efficiency Center. This research contained, among others, the questionnaire examining EM in municipalities in 2018. The survey covered 129 municipalities with more than 10,000 inhabitants, including 22 municipal districts of Prague, the capital city of the Czech Republic, and 13 municipal districts of the second largest Czech city Brno, i.e., a total of 164 respondents. This survey gathered data from 50 questionnaires, with a response rate of 30.4%. The majority of the questions in this survey (37 out of 39) were formulated as close-ended and the respondents had to choose the most suitable answer out of several options. The close-ended questions limit respondents' possibilities to express their opinion. Reducing the number of possible answers is acceptable without the risk of distortion of the data obtained if the respondents represent a homogenous group and the nature of their responses can be predicted based on previous experience with this type of respondent. The three questions were formulated as open-ended and allowed the respondents to reply in more detail and express their own opinions.

In both cases (Prosenna 2009 and SEVEn 2018), electronic questionnaires were sent to the email addresses of energy managers or relevant persons dealing with the energy issue in the given municipalities. The response rate of the questionnaires in both surveys is sufficient to consider both surveys' representative samples. The following text is based on the survey conducted in 2018, partially compared with the previous survey of 2009. Both surveys overlap because some of their questions were identically formulated so the responses can be easily compared. The number of replies is similar: 53, resp. 51. The responses to the questions were used to describe the development of the municipal approach to energy management. Naturally, the survey in 2009 could not investigate the ISO 50000 standard implementation.

The third information source is a survey conducted in 2023 by the authors. The survey focused on municipalities with 10,000–100,000 inhabitants. This time, 62 respondents' replies were obtained, and the return rate was 50%.

The variability of the respondents from different cities is inevitable in such types of surveys. However, all the respondents are working in the same legislative framework and facing similar challenges. The limited number of potential respondents (125 municipalities over 10,000 inhabitants, respectively, 164, if districts of bigger cities are considered) should be considered. The fact is that the municipalities with established EM tend to be more likely to reply than the municipalities without it. All these circumstances allow for neglecting the variability of the respondents in the surveys conducted in different years.

3.1. Methods Used in the Reserch Conducted in 2023

The survey conducted in 2023 reflects both previous surveys; however, it could not just repeat the same questions. The situation within the Czech municipalities has significantly changed because of the energy crisis in 2021 and the consequences of the war in Ukraine.

Before the survey was conducted, the preliminary characteristics were defined, which reflect the essential parts of EM. The survey did not focus on the achieved energy savings, however; it investigated the personal and organizational base of EM in the municipalities.

The questions to energy managers were formulated with regards to these characteristics, which influence the costs and maturity of EM:

(a) The number of and variability in energy delivery points (DPs) affect two basic types of costs of EM. The first type of these costs is the salary of an energy manager. The high DP number or the variability in different types (electric, gas, heat, and water) of DPs imply the high workload for EM and consequently a higher salary cost.

(b) The second type of cost is the expenditure for specialized software. The increasing DP number cannot be administrated by the common office computer programs and the specialized software should be implemented here. The SW is used for energy consumption recording, invoices storage, revisions report archiving, various alerts, and other EM-related services. The SW outputs allow for comparing the energy performance of different buildings, making the graphs of consumption, etc. If the municipality buys the SW, it generates purchasing the cost and the expenditures for annual licenses and possibly the payments for software modification according to user (municipality) requirements.

(c) The modus of EM personnel covering implies the varying levels of energy manager salary costs. If the work position of an energy manager is established as a new one not derived from another work position, then salary costs will be incurred. The alternative approach is that duties for EM are assigned to an existing magistrate employee as an additional task to their current job duties. In this case, the duties for EM are very often not mentioned in the work contract, or the formulation is quite vague. The workload measured in work hours per week or an extra salary for these duties is missing very often as well. This approach is typical for municipalities where EM is not yet perceived as a relevant issue. There are other variables influencing the salary cost. The level of the energy managers' education affects the costs as the salaries of municipal employees are derived from the government ordinance on salaries. Higher education results in a higher salary. The different specialization by the same level of education means different salaries, e.g., a master of electrical engineering is paid better than a master of mechanical engineering. The level and specialization of energy managers were investigated.

(d) A formalized description of EM, in particular, the responsibilities, authorities, and job descriptions for the employees who are significantly involved in EM. A formalized description of responsibilities indicates the maturity of EM. EM needs a correct formal description to work properly. The proper description is the result of the continuous development of EM, and during this development, the maturity of EM increases. In case EM is not described and is only based on daily routine, it collapses the moment the key persons leave. The period of EM re-establishing after the key persons left the scene is often connected with harms and extra payments because of the missing know-how.

(e) Purchasing energy on the commodity exchange. This type of energy purchasing is considered the most efficient way to secure electricity and gas suppliers. If energy manager is able to purchase on the commodity exchange, then this provides a benefit to the city in the form of cheaper electricity or gas prices. The prerequisite for such purchasing is the list of delivery points (gas or electricity), including the records about the previous energy consumption, circuit breaker value (for electric DPs), type of measurement, electric tariff, etc. The existence of such a list is evidence of the certain maturity of EM. Energy exchange purchasing leads to lower unit prices and therefore is popular among cities. In addition, this type of purchasing is significantly easier than the conventional approach according to the Public Tender Act.

(f) EM based on the ISO 50001 standard or EM excluding the ISO. According to the Czech Act no. 406/2000 Coll. on Energy Management, the municipality must implement the EM based on ISO 50001 or conduct the energy audits including the whole municipal equipment with significant energy consumption. If the municipality prefers to establish EM according to ISO 50001, it may generate costs for the consulting company and

surely generate costs for EM certification by an independent certification body. If the city decides to conduct an energy audit, then there will be costs for an energy expert, because the energy audits must be carried out by an official person only.

(g) The period of energy consumption recording. Energy consumption records are an essential part of EM. The records are the basis for decision making on measures to reduce energy consumption. After a measure is applied, the consumption recording is necessary to prove the measure meets the expectations. The long period of recording indicates the higher maturity of EM. In the case of many DPs, the consumption recording is not a trivial task and needs several years to be established properly. The maintenance of the database of records is not trivial either.

The questionnaire was validated by the pre-test. The energy managers from different Czech municipalities (e.g., České Budějovice, Prostějov, and Rožnov pod Radhoštěm) were interviewed and their ability to understand the questionnaire was tested. The questions were consequently modified to be more explicit and clearer for the reader.

3.2. Implementation Phase of this Research 2023

This research was based on the questionnaire survey among energy managers or other municipal staff responsible for energy in their cities. The questionnaire made in Google Forms was attached to an explanatory email, which was sent to the magistrate secretaries of the investigated towns with an appeal to forward it to the municipal energy officer. This approach was used because in many cases emails of the municipal energy managers could not be found on the municipal websites.

This research was focused on the cities with a population of 10,000–100,000 inhabitants. According to the Czech Statistical Office, there are 125 such towns in the Czech Republic. Cities or towns with a lower population were omitted because municipalities with less than 10,000 inhabitants own just a few buildings and there is a lack of street lighting and of other facilities with significant energy consumption in comparison with larger cities. Therefore, the design of EM in small towns is qualitatively different. Cities with more than 100,000 inhabitants were also excluded. Such cities are divided into municipal districts and each of them implements EM separately.

3.3. Wording and Number of Questions

Several surveys have been conducted in the past about EM in Czech cities. Experience shows the length of the questionnaire for energy managers has proved to have a significant impact on the return rate and the number of questions answered. A questionnaire with 21 questions had a return rate of 40% [48]; the SEVEn survey (2018) contained 39 questions, and none of the respondents answered all of them and its return rate was 30%. A study prepared by SEMMO (2020) contained a questionnaire with 134 questions and the return rate dropped to 8.5% (62 responses from 724 respondents).

In this context, the questionnaire was limited to 18 main questions, with one or more additional questions added in 16 cases. The first four questions were answerable with a number. The remaining questions were open-ended. The last question was open-ended and encouraged the respondent to add any voluntary comment.

4. Results

4.1. Research Conducted between 2009 and 2018

The questionnaires used by SEVEn, The Energy Efficiency Center, were fulfilled by 50 energy managers or employees who were responsible for the energy issue in each replying city. The six key questions from this survey were used in this article. The first question investigated the establishing of EM and the adoption of ISO 50001. The second question investigated the personnel of the EM (Figure 1). The consequent questions researched the period of establishing EM and the reached energy savings due to EM (Figure 2). These four questions are the natural basics of all the surveys focused on

municipal EM. The following questions investigated the difficulties perceived by the user of the standard ISO 50001, which is broadly recommended as the basis for EM (Figure 3).

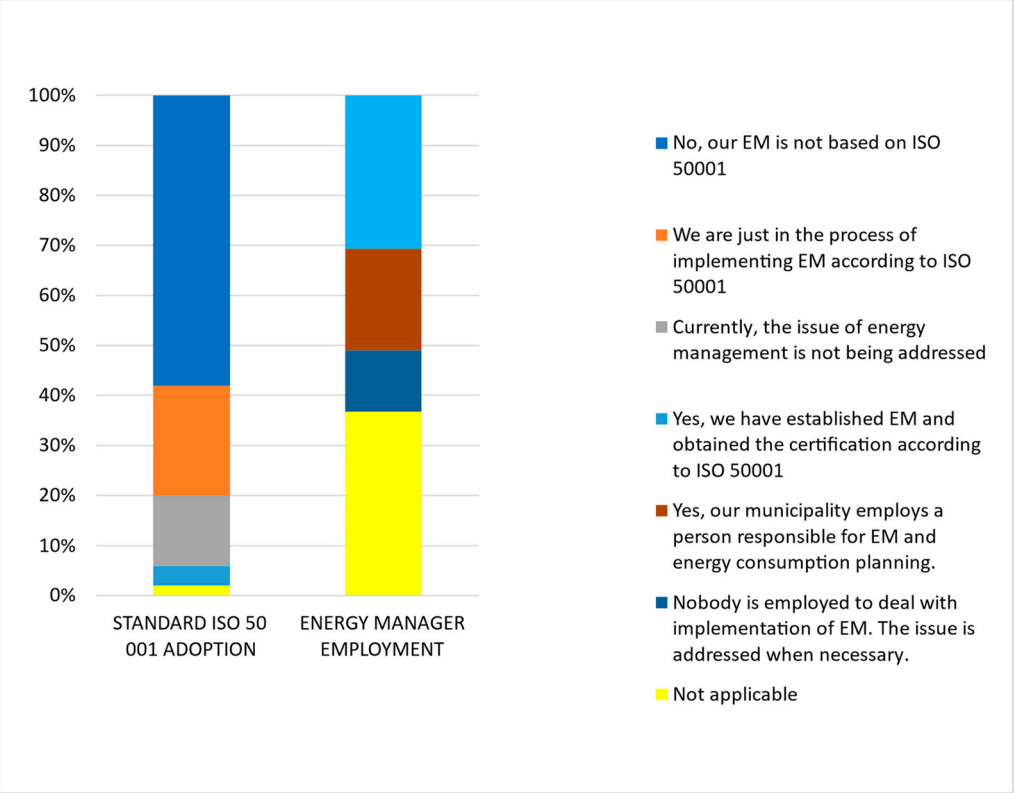

Figure 1. Have you implemented energy management and have you used the Standard ISO 50001? Has your municipality employed someone who deals with energy savings? Data source: authors.

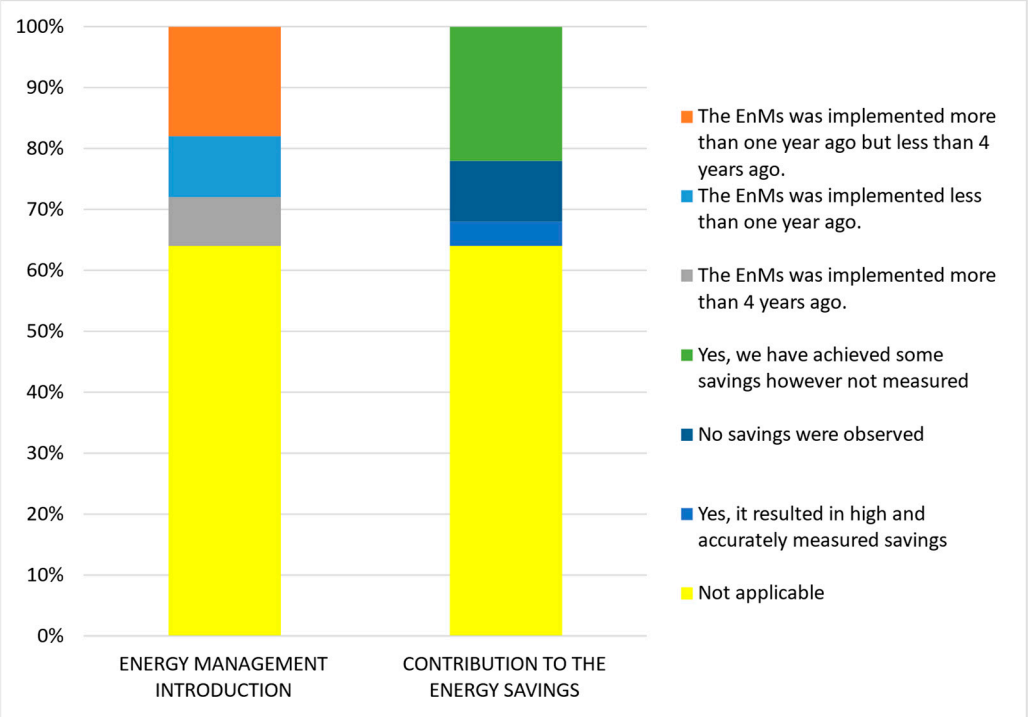

Figure 2. When did you implement energy management in your municipality? Did the implementation of energy management contribute to energy savings? Data source: authors.

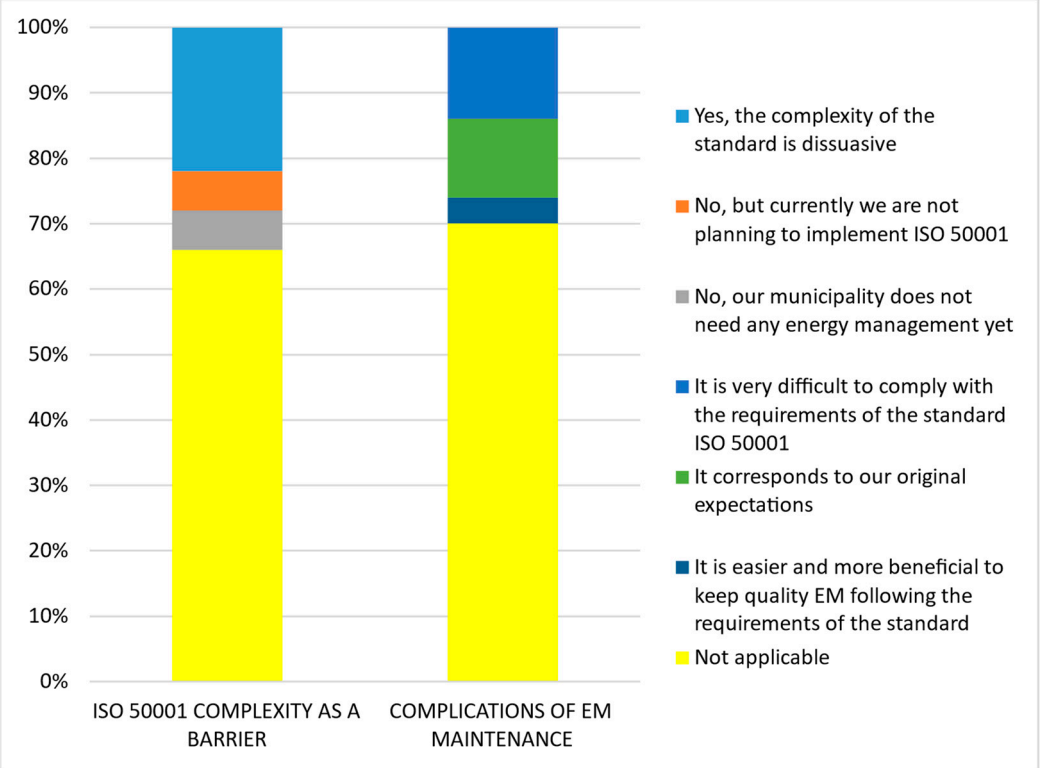

Figure 3. Is the complexity related to implementation and maintenance of energy management according to ISO 50001 a barrier to its implementation? Is the implementation and maintenance of energy management complicated and less sustainable according to ISO 50001? Data source: authors.

The majority of the respondents (58%) stated that they developed their own EM, which is not based on the ISO 50001 standard. In total, 22% of the respondents stated that energy management according to ISO 50001 is just being implemented. A total of 14% of the respondents (i.e., seven municipalities) or municipal districts did not address the issue of energy management at all. Only 4% reported that they had implemented energy management according to ISO 50001 and have been certified by an independent certification body. One municipality did not answer this question.

One-half of the respondents (50%) said their municipality had an employee responsible for energy management and energy consumption planning. In contrast, in 36% of the investigated municipalities, this issue is addressed ad hoc if necessary. The following 12% of the municipalities collaborate with energy specialists. This question is an interesting complement to the previous one. Except one municipality that did not answer this question, all the respondents admitted they were dealing with energy savings. The differences among the municipalities lie in their personal coverage of the issue and the degree of the systematic approach to addressing it.

The moment when EM is properly implemented is hard to capture. In the case where EM is based on ISO 50001, obtaining the certificate can be seen as the completion of the EM implementation. If EM is developed independently of the ISO, the moment of completed implementation is fuzzier because it is defined by the energy manager himself. Considering all these limitations, the respondents were asked when they implemented EM. With most municipalities (64%), this question was not applicable because their EM is not based on ISO 50001. A total of 18% of the respondents implemented EM more than 1 year ago but less than 4 years ago. In total, 10% had experience with EM shorter than one year at the time of the survey. Only 8% of the respondents revealed they implemented EM more than 4 years ago.

The majority of the respondents (64%) avoided telling if their EM contributed to energy savings. This contrasts to their previous expressions about energy consumption

monitoring or implementing ISO 50001. A total of 22% of the respondents admitted that EM contributed to the energy savings; however, these could not be exactly expressed. In total, 10% of the respondent claimed EM has not yet generated any energy savings. Only 4% of the respondents claimed high and accurately measured energy savings. None of them were certified according to ISO 50001. Energy managers from certified cities claimed that EM implementation resulted in certain savings; however, these were not exactly measured.

According to the replies to previous questions, only 4% of the respondents implemented the ISO 50001 standard and 22% of the respondents were just in the process of implementation. That means that most respondents did not have any direct experience with ISO 50001. Therefore, 66% of the respondents were not able to answer the question if the complexity of ISO 50001 is the barrier to implementation. A total of 22% of the respondents found the standard dissuasive due to its complexity. In total, 6% of the potential users did not want to implement energy management based on ISO 50001, regardless of its possible complexity. The remaining 6% of the municipalities did not address the issue of energy management whatsoever.

A total of 70% of the respondents were not able to answer the question about complications of EM maintenance because of insufficient experience with ISO 50001. In total, 14% of the respondents agreed that it is difficult to comply fully with the requirements of the standard. Also, 12% claimed that energy management according to ISO 50001 fulfilled the original expectations. Unfortunately, the answer does not specify what exactly these expectations were. Only 4% of the respondents hold the opinion that thanks to using the ISO 50001 standard, it is easier and more beneficial to keep quality energy management. In their view, it is easier to keep energy management by following the requirements of the standard than without it.

The summary comparison of other relevant information resulting from the surveys done in 2009 and 2018 is in the Table 1 below.

Table 1. Comparison of energy management surveys conducted in 2009 and 2018. Data source: authors.

	Question	2009 53 Replies [%]	2018 50 Replies [%]	2018 vs. 2009
a	Does the energy issue belong to the priorities of your municipality?	73 YES	87 YES	+19%
b	Does your municipality employ somebody to deal with energy savings? Does your municipality collaborate with an energy specialist?	40 YES	63 YES	+57%
c	Do employees in your municipality take part in educational activities in the field of energy savings?	42 YES	63 YES	+50%
d	Does your municipality support renewable energy sources? If so, in what way?	25 YES	35 YES	+40%
e	Does your municipality collect data on energy consumption and on energy production from local renewable energy sources?	17 YES	66 YES	+288%
f	Does your municipality motivate entities in city-owned buildings to energy savings?	72 YES	61 YES	−16%
g	Does your municipality have a database of city-owned buildings together with data on their energy performance?	68 YES	85 YES	+25%
h	Does your municipality collect data on energy consumption related to street lighting annually?	96 YES	68 YES	−29%
i	Have you applied or are you in the process of applying for a subsidy for funding projects focusing on energy savings? If so, which programs did you choose?	70 YES	85 YES	+21%
j	Would you be interested in a comparison of your essential energy data with other municipalities?	77 YES	85 YES	+10%

The number of employees in charge of energy management increased by 57%, which is significant. The question is formulated in a very general way, and it is not possible to tell from the answers whether the city employs a separate energy manager or has only delegated energy management to one of its current employees. The increase in data collection on energy consumption and RES energy production is also remarkable, up 288%, but this is an increase from a small base and is therefore relatively high. A lack of qualified staff was cited as one of the barriers to EnMS development, and systematic data collection is a necessary condition for an effective EnMS. Somewhat unclear is the weakening of the motivation of the entities managing the city's facilities to save energy. Their motivation probably decreased after the insulation of the building envelope, as this led to a significant reduction in energy consumption. These users were under the false impression that there was no need to pursue further energy savings because the maximum had been reached. The same is likely to be the case with regard to the decrease in the monitoring of lighting consumption.

The research on the state of energy management of municipalities in 2018 raised some questions, which should undergo further examination:

- The overwhelming majority of respondents (65%) answered that they do not support RES. What is the main cause of rejecting RES, which enjoys generous political support and ever-decreasing investment costs nowadays?
- A total of 15% of the municipalities responded that they have never applied for a subsidy to obtain funds for projects improving energy efficiency. Why has such a large proportion of municipalities not submitted any application despite the long-term availability and variety of subsidy schemes? Is it the excessive administrative burden or the reluctance of responsible workers in particular municipalities?
- The number of municipalities motivating the users of their buildings to perform energy-saving behavior has shrunk (from 72% to 61%). Undoubtedly, motivation is an essential factor in this field and its appropriate form can lead to significant improvement.
- The decline in the number of municipalities (from 96% to 68%) that collect data on street lighting energy consumption is also unusual and deserves further examination and validation.

4.2. Research Conducted in 2023

In total, 124 cities were contacted, and 62 completed questionnaires were returned, which makes a return rate of 50.0%. The cooperated cities are highlighted in the map of the Czech Republic (Figure 4). All used questions are listed in Appendix A.

The initial questions investigated the numbers of delivery points of different forms of energy (electricity, gas, and heat). These numbers convey the workload of EM and the necessity to use specialized software.

Two-thirds of respondents (66.1%) indicated that a municipal staff member with a primary responsibility for EM had been appointed (Table 2). Only half (21) of them have a full-time job, while for the rest, the workload allocated to EM varies from 0.1 to 0.8 full-time equivalent. Interestingly enough, one of the investigated cities had two employees in this position, an Energy Manager and an Assistant of Energy Manager, with each having a 0.5 full-time equivalent. Some respondents indicated that a work position had not been explicitly appointed and that energy issues were handled by a city staff member as an additional part of their job duties. In this case, it was not possible to speak to a full-fledged EM.

The responses showed a very diverse mix of educational backgrounds in terms of the fields of study and degrees attained (Table 3). Slightly more than half (32) of the energy managers had a university degree. The most common education was a Master's degree in economics followed by an electrical engineering degree. Surprisingly, civil engineer was represented only once. Other types of university degrees were also included, e.g., forestry engineering, training, administrative, safety and legal, chemistry, sports management, environmental regional administration, and physics. For secondary education, there was

also a significant variation: electrical engineering, mechanical engineering, textile specialist, and industrial technologist.

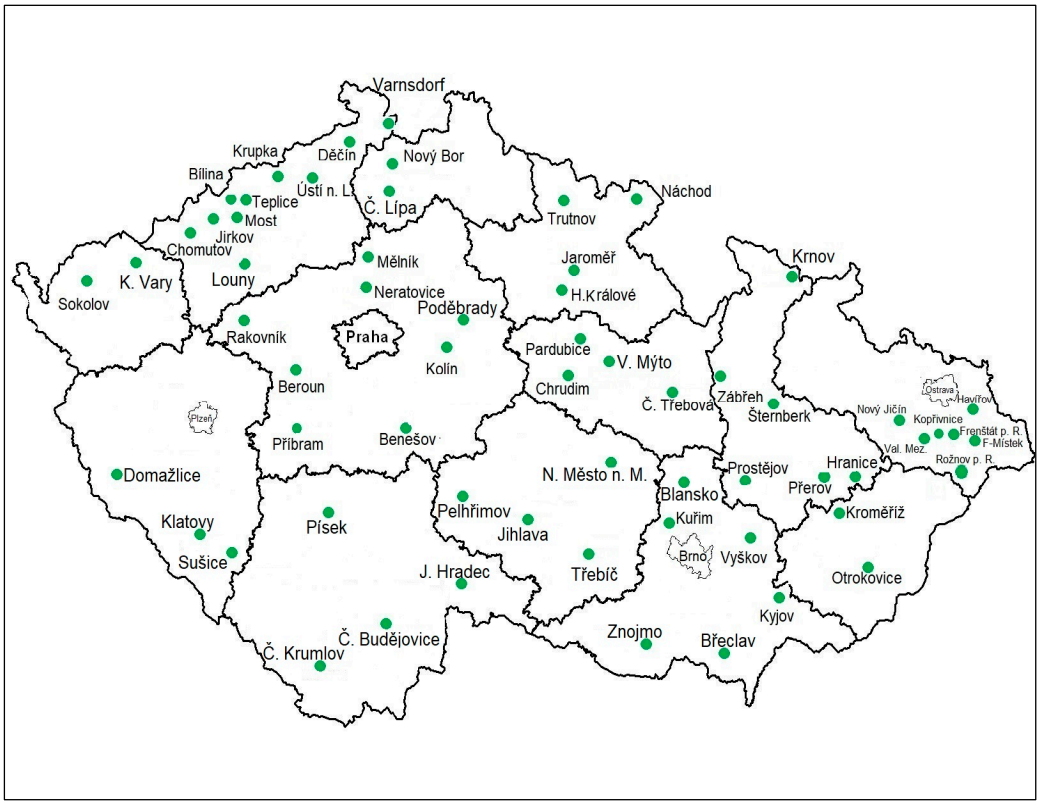

Figure 4. Distribution of municipalities participating in the survey 2023. Data source: authors.

Table 2. The energy manager employment.

Energy Manager	Frequency	Portion
is employed	41	66.1%
not employed	15	24.2%
just in process	2	3.2%
other reply	4	6.5%

Table 3. The energy managers' education and specialization.

Degree	Specialization	Frequency	Portion
master's degree	electrical engineering	6	9.7%
	civil engineering	1	1.6%
	economy engineering	10	16.1%
	other engineering	11	17.7%
bachelor's degree	specialization not divided	4	6.5%
high school	specialization not divided	11	17.7%
no EM	-	19	30.6%

Based on the questionnaire, it was found that 25 cities, i.e., 40% of the respondents, do not use any specialized software (Table 4). The remaining 37 cities use a total of 11 different types of SW, and of these, only two types of SW are used in more than 3 cities. These results

show that the use of SW for EM purposes is not yet established and that even in a relatively small market there is a large number of producers operating. A gradual stabilization and reduction in the variety of SW producers can be expected, because the requirements of cities regarding SW for EM do not significantly differ, and once developed, SW can be used in more cities without any significant further adaptations.

Table 4. Type of used SW for EM.

Type of Used SW	Frequency	Portion
no SW	25	40.3%
energy broker	16	25.8%
e-manager	7	11.3%
own developed software	3	4.8%
MS Excel sheets	2	3.2%
SW from other 7 diff. producents	9	14.5%

The vast majority (69.4%) of the respondents reported that the city does not have a document defining employees participating in EM and their responsibilities (Table 5). The reasons for the lack of a document include the following: the city is just starting with EM; responsibilities have been communicated to staff but not formalized; and only one staff member is dedicated to EM. In less than 15% of the surveyed cities, an internal document had been developed, most often a directive from the magistrate, an order of the Secretary, or a modification of the organizational regulations. Less than 10% of the respondents reported having a document according to the requirements of ISO 50001.

Table 5. Existence of a basic formal document of EM.

EM Basic Document	Frequency	Portion
no document exists	43	69.4%
document according to ISO	6	9.7%
internal magistrate document	9	14.5%
other type of document	4	6.5%

Purchasing energy (natural gas and electricity) on the energy exchange is considered a cost-effective way of securing energy supply. A total of 84% of the investigated cities claimed to purchase on the energy exchange (Table 6). This contrasts to the fact that an energy manager was employed in just 66.1% of them. There are two registered exchanges (PXE Praha and ČMKB Kladno) that dominate. Some respondents (8.1%) did not want to reveal which exchange they preferred. Two respondents used both exchanges. The rest of the respondents (16.1%) purchase energy without the exchange.

Table 6. The preferred energy exchange by Czech municipalities.

Exchange Purchasing	Frequency	Portion
ČMKB Kladno	24	38.7%
PXE Praha	21	33.9%
unknown exchange	5	8.1%
both possibilities	2	3.2%
without exchange	10	16.1%

According to the requirements of Act 406/2000 Coll. on Energy Management as amended, cities must implement EM certified by an independent certification body or conduct an energy audit (EA) on their entire energy management. Each city can choose one of the two legal options. The largest portion of responses (32.3%) admitted to not complying with the requirements of the Act because it did not conduct either an energy audit nor had certified EM (Table 7). Conducting an EA was significantly more popular than certifying an EnMS to ISO 50001 (30.6% vs. 9.7%). Some respondents (14.5%) claimed that the city was just in the process of preparing the certification of EM. A small portion of the cities (4.8%) were deciding between EM certification and commissioning an EA.

Table 7. Do you prefer EM certified according to ISO 50001 or energy audits?

Certified EM or Energy Audits	Frequency	Portion
both possibilities negative	20	32.3%
energy audits	19	30.6%
ISO certification is not planned	8	12.9%
EM certified according to ISO	6	9.7%
EM certification just in process	6	9.7%
considering both possibilities	3	4.8%

According to the replies, most cities record energy consumption (Table 8). The energy crisis in 2021 motivated many cities to start with consumption recording. A total of 12.9% of the cities revealed that they do not keep records about energy consumption. It means they are far away from any form of effective EM.

Table 8. The records about consumption in different municipalities.

Consumption Is Recorded Since	Frequency	Portion
2000	2	3.2%
2010	4	6.5%
2015	10	16.1%
2017	9	14.5%
2018	9	14.5%
2019	5	8.1%
2020	3	4.8%
2021	1	1.6%
2022	6	9.7%
2023	5	8.1%
no records	8	12.9%

5. Discussion

The results of all the mentioned surveys (2009, 2018, and 2023) are consistent and indicate the continual trend of growing municipalities' interest in energy management. In total, 86% of the municipalities deal with energy management. A total of 9.7% of the municipalities were in the process of certification by ISO 50001 and 4.8% were thinking about it. In total, 9.7% of the cities were certified at the time of the survey was conducted. The number of energy managers has increased by 57%, the employees of magistrates and municipal budget organizations are being trained in the field of energy savings, and the interest in using renewables has risen as well. Energy consumption is monitored even in the cities where EM is not being addressed. As a result, the municipalities submit more

subsidy applications for energy projects, and energy consumption is better monitored. The number of subsidy applications submitted by municipalities to the Fund for Modernization for photovoltaics plants is 95 just in the year 2023 [49]. The number of subsidy applications submitted by the municipalities to the program EFEKT for establishing EM is increasing as well—see Table 9 below.

Table 9. The number of subsidy applications for establishing EM sent by municipalities to the program EFEKT. Source [50].

Year	Subsidy Application for Establishing EM
2017	18
2018	10
2019	12
2020	11
2021	13
2022	46
2023	40

Municipalities focused on the energy management issue can become a member of the specialized organization SEMMO (Association of municipal energy managers), which should educate its members in the field of municipal energy management [51]. The Association was established in 2019 with the subsidy from MIT with the aim to reduce the energy consumption and promote the renewable energy sources within municipalities. The increasing number of participating municipalities indicates the growing importance of this issue for municipalities—see Table 10 below.

Table 10. The number of members in the Association of municipal energy managers. Data source: authors.

Year	Number of Members
2019	4
2020	15
2021	20
2022	24
2023	27

The research indicates that municipal energy management is an important topic, and its development is worth observing. Nevertheless, studies about municipal energy management are scarce [26]. This paper summarized all the research focused on energy management that was conducted in the Czech Republic in the last 15 years.

There is a relatively lower comparability of the results reached in 2009 and 2018 compared to those in 2023 due to the different goals and methodology. Given the changes in approach, the 2023 survey resulted in a 50% return rate, which is very high compared to other questionnaires in the field. Secondly, the results reached through the questionnaires are influenced by the individual understanding of EM; also, an international comparison of the results is limited.

6. Conclusions

The comparison of the surveys conducted in 2009, 2008, resp., 2023 revealed that energy management has become more important among Czech cities. There are two basic approaches to EM. The first approach is focused on energy performance and pursuing ways to reduce energy consumption. It can be based on the ISO 50001 standard, although a useful EM can be developed without the standard as well. The second approach emphasizes the

energy production from the renewable energy sources and reducing the CO_2 emissions. It is obvious that both approaches can be naturally mixed in order to maximize their potential. Regardless of the approach taken, municipal energy management is based on the energy managers and their performance.

The survey revealed that the maturity of EM among Czech municipalities is very variable. There are cities with long-lasting EM and there are cities where EM is in its infancy or totally absent. The work position of an energy manager is not covered in a significant part (24.2%) of Czech cities. Some cities solve this issue by making it an additional task to the job duties of some of their current municipal employees. This solution is without perspective, because EM is too complex to be accepted as overwork that is given to an employee with a full-time job of other duties. The very variable education and workload of existing energy managers indicated that this work position is not commonly established. One-third of Czech municipalities do not meet the legal requirements because they neither conduct the energy audits nor have EM certified by ISO 50001. Therefore, there is a huge space for the strengthening of governmental policies in EM (data collection, data storage, education, and sharing best practice).

Increasing the unit price of energy, on the one hand, and the pressure to reduce CO_2 emissions, on the other hand, will ensure that EM shall become an ordinary part of municipal duties in the near future. The work position, workload, education, and job description of an energy manager will become standardized. This process can be accelerated by the knowledge transfer from the experienced cities to the beginners.

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Appendix A. Questionnaire Used in 2023

The questions on the organizational provision of EM were intended to find out the material conditions for EnMS in the city under study:

1. How many delivery points for electric, gas and heat are placed in your city?
2. Is there any binding document describing how many employees of the city, contributory organizations and possibly other organizations managed by the city are dedicated to EM and what specifically they are supposed to do for EM?
3. If you use any software for EM purposes, please specify: since when is it used, from which supplier and for what purposes?
4. How does the city provide its energy supply? If by purchasing from a energy exchange—since when, what energy, on what exchange?
5. Since which year have regular records of energy consumption been kept for most city buildings?
6. Is your EM system ISO 50001 certified or do you conduct energy audits? If you have ISO 50001 in place, in which year was the certification done? Alternatively, when do you plan to certify?

Appendix B

1. Does your city have a staff member who is responsible for energy saving? Or does the municipality work with an energy expert?
2. Does the municipality's staff participate in energy saving training?
3. Does your city promote energy savings? If so, in what ways?
4. Does your city support renewable energy? If yes, in what way?
5. Does your city collect data on energy consumption and generation from local renewable energy sources?
6. Have you applied or are you applying for grants to fund energy efficiency projects? If yes, in what programs?
7. Would you be interested in comparing your city's baseline energy data with other cities?
8. How long have you had an energy management system in place through the implementation of energy management?
9. Is implementing and maintaining an energy management system according to EN ISO 50001 complex and difficult to sustain?
10. Has the implementation of energy management resulted in energy savings?
11. Is your city trying to reduce energy expenditure within the city's operational expenditure?
12. Does your city motivate entities managing city facilities to save energy?
13. Does your city have a database of city-owned buildings with data on their energy performance?
14. Does your city keep records of the energy class of its buildings according to the energy performance certificate?
15. Does your city collect data on energy consumption in public lighting on an annual basis?
16. Are you interested in implementing energy management according to EN ISO 50001?
17. Is the complexity of implementing and maintaining energy management according to EN ISO 50001 a barrier to implementing energy management?

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