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Topic
Energy Management and Sustainable Development from Economic, Social and Environmental Aspects

Edited by
Prof. Dr. Kittisak Jermsittiparsert and Dr. Thanaporn Sriyakul

https://doi.org/10.3390/en17195014

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Evaluation of the Energy Management System in Water and Wastewater Utilities in the Context of Sustainable Development—A Case Study

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Abstract: Energy management in enterprises is an important issue in the context of improving energy efficiency, energy use, and energy consumption. This is consistent with the Sustainable Development Goals. The purpose of this study was to evaluate the energy management system of water and wastewater utility in the context of sustainable development based on the opinions of managers and employees. The results indicate the involvement of the surveyed enterprise in energy management system development activity. This demonstrates the orientation of the surveyed enterprise to support activities to improve energy performance in line with the implementation of sustainable development. The added value is that the developed research tool can be used in studies of other enterprises to assess the level of energy management.

Keywords: energy management; energy management system; sustainability

Citation: Machnik-Slomka, J.; Pawlowska, E.; Klosok-Bazan, I.; Goňo, M. Evaluation of the Energy Management System in Water and Wastewater Utilities in the Context of Sustainable Development—A Case Study. *Energies* **2024**, *17*, 5014. https://doi.org/10.3390/en17195014

Academic Editor: Brian D. Fath

Received: 12 July 2024
Revised: 17 September 2024
Accepted: 27 September 2024
Published: 9 October 2024

1. Introduction

The design and implementation of energy management systems in companies must comply with contemporary requirements related to the growing importance of sustainability. It is an important area of the national energy policy that contributes to reductions in utility consumption and costs [1,2]. Thus, the concept of energy management plays a major role in the realization of economic, environmental and social goals [3], because constructing an effective energy management system has a major impact on energy efficiency, both within and outside the enterprise. Energy management in the water and wastewater sectors plays a significant role because water and wastewater are areas where energy consumption is very high [3]. Water transportation and treatment require large amounts of energy; therefore, water and wastewater companies need to focus on efficient energy management to reduce energy consumption and lower costs [4].

In addition, efficient energy management by water and wastewater companies reduces their negative environmental impacts. Currently, energy consumption in the industrial and commercial (service) sectors accounts for almost 40% of global greenhouse gas emissions [5]. This contributes to global warming and other negative environmental effects.

In this context, an important role is played by the international standard EN ISO 50001:2018 [6], which defines the minimum requirements and provides practical guidance for the implementation of an energy management system in enterprises, directing their activities towards energy management.

The concept of the energy management system research undertaken by the authors was based precisely on the international standard EN ISO 50001:2018. The rationale for undertaking this study was the identified research gap, which shows a paucity of research on multidimensional energy management based on this standard in the context of water and wastewater enterprises. Hence, the main purpose of this study is to evaluate the energy management system of water and wastewater utility in the context of sustainable development based on the opinions of managers and employees. In addition to the main objective of the work, specific objectives of a theoretical–cognitive, methodological, research and practical nature have been formulated. The research hypotheses are formulated and verified through empirical research using a standardized interview technique. The main research problem focuses on the search for an answer to the following question: at what level of advancement is the energy management system in the surveyed enterprise?

The structure of this study includes an introduction to the topic undertaken, an analysis of the literature on energy management and energy management systems, and a description of the research methodologies. In the next section, the results of the research are presented, and the results are evaluated in the Section 5. In the conclusion, however, a general summary is made, and recommendations for practice and directions for future research are also presented.

2. Literature Review

An important contemporary challenge for companies operating in the water and wastewater sectors is to strive for transformation towards a circular economy (CE) [7,8] and sustainable development [9]. The sustainability of water and wastewater companies is linked to meeting these requirements and challenges, not only financial but also social and environmental, aimed at more environmentally friendly and efficient water treatment and distribution, lower energy costs, reduced water pollution, and better use of natural resources [10]. At the same time, it improves the quality of life in society. The issue of energy management systems in water and wastewater utilities fits with the Sustainable Development Goals of Agenda 2030:

- Goal 6. Ensure availability and sustainable management of water and sanitation for all;
- Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy;
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation;
- Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable;
- Goal 12. Ensure sustainable consumption and production patterns;
- Goal 13. Take urgent action to combat climate change and its impacts.

Water and sewage companies are obliged to manage energy responsibly and rationally due to these challenges and goals, as well as the fact that water is essential to human life [11]. Implementing an effective energy management system can help with this [12]. This requires a special approach that should permeate the organization's culture and practical sphere of activity [13]. In the water and wastewater sector, due to the burden on the often sprawling infrastructure of storage, water pumping, and power generation capacity, to gain benefits through proper management, "leveraging the water-energy nexus" is important [14]. It may also be important to use project management methodologies for a more effective implementation of such projects [15].

The literature recognizes the paucity of scientific studies on energy management construction. To date, no single, unambiguous definition of this concept has been developed. Therefore, when interpreting this, clarifying the concepts of management and energy first is necessary. In modern terms, management is defined as a set of activities (including management functions such as planning and decision making, organizing, and leading, i.e., directing people and controlling) directed at the resources of an organization (human, financial, physical, and information) and performed to achieve the organization's goals in an efficient and effective manner [16]. Management is associated with several functions, such as planning, organizing, motivating, and controlling.

In terms of the concepts of management and energy, attempts have been made to define the concept of energy management. Some authors believe that "energy management is considered a combination of energy efficiency activities, techniques, and management of related processes that result in lower energy costs" [17], while others argue that "energy management aims to reduce energy costs by increasing energy efficiency, using technology, and promoting management activities and procedures to achieve this efficiency" [18].

Voltz and Grischek note that energy management depends on the organization in question and should be tailored to its needs [13]. In conclusion, it can be said that energy management is an important issue that helps the organization achieve its key objectives of rational management, reduction in energy consumption, cost reduction, and environmental impact.

According to contemporary concepts, particularly the systems approach, creating and developing an effective and efficient energy management system are important in the management of energy in the enterprise [19–21]. An energy management system (EMS) can be defined as a set of synergistically connected elements to achieve energy goals. An energy management system can have various social, economic, technical, and environmental objectives [21]. Managers of companies, especially from the water and wastewater sector, must appropriately address their energy management objectives and ensure that the appropriate level of development of the energy management system is maintained [20]. As results from the literature on the subject, some authors undertake research on the level of implementation of the energy management system in various enterprises [17,22]. Interesting research on this subject was conducted in Serbia in enterprises of the wood industry. The research conducted among 104 enterprises shows that the systems approach is insufficiently implemented; top management is not sufficiently involved in energy management and takes sporadic actions depending on financial possibilities. The research also indicates that employees are not sufficiently involved in the energy management process, and communication in the field of energy management is not satisfactory [22]. Similar survey studies on the level of implementation of the energy management system were conducted in enterprises in Turkey in the five most energy-intensive industrial sectors. The research shows that 22% of the surveyed companies manage energy. The authors point out the main barriers to the implementation of the energy management system: insufficient knowledge and awareness of managers and employees, lack of synergy between different stakeholder groups, and insufficient financial support for activities in this area [17]. Meanwhile, the literature indicates that synergetic combination of the various elements is essential for the efficient operation of any energy system [23]. The energy management system should ensure synergetic and coordinated energy exchange among all energy resources for the safe and efficient operation of the energy system [21].

When referring to the definition of management, considering the functions of planning, implementing, monitoring, and controlling an organization's energy performance in the context of establishing and developing an energy management system is important.

The concept of an energy management system is described in EN ISO 50001:2018-09 [6]. According to this standard, an energy management system is defined as "a management system for establishing energy policies, objectives, specific energy objectives, action plans, and processes for achieving these objectives and specific energy objectives." The PN-EN ISO 50001:2018-09 standard (a Polish standard that is equivalent to EN ISO 50001) is aimed at all organizations, regardless of size, type, object of activity, geographical location, and organizational culture. This standard sets out guidelines for establishing, implementing, maintaining, and improving energy management systems. The purpose of implementing this system is to create conditions for effective energy management in a given organization or enterprise based on a systematic approach. The implementation of the system requires the organization to strive for continuous improvement, thereby improving energy results by introducing a control system. This is related to the management principle of the iterative

PDCA cycle: Plan, Do, Check, Act [24]. The principles of the ISO 50001 energy management system reflect good practices based on international standards.

The ISO-50001 standard distinguishes the following dimensions of an energy management system:

1. *Organizational context* relates to understanding the organization and its context, stakeholder needs and expectations, and defining the scope of the energy management system.
2. *Leadership* is related to the commitment of the organization's top management to a continuous improvement in energy results, striving to ensure an effective energy management system, establishing an energy position, and assigning responsibilities and decision-making scope to those involved in energy management.
3. *Planning*: Identifying risks and opportunities; planning actions to address these opportunities and risks; planning ways to integrate with the energy management system; establishing goals and specific energy objectives; and planning ways to achieve them. Planning also involves preparing and conducting an energy review, determining energy outcome indicators, establishing a baseline, and collecting planning energy data.
4. *Support* is related to the need to identify and provide resources for the implementation and maintenance of the energy management system by identifying the necessary competencies of people, their awareness of energy policy and the energy management system, defining the principles and processes for internal and external communication, and creating, updating, and overseeing the required documentation for the system.
5. *Operational activities* consist of planning, implementing, and steering processes related to the energy management system, managing planned changes, reviewing unintended changes and mitigating their effects, and design and acquisition activities.
6. *Performance evaluation* of the monitoring, measurement, analysis, and evaluation of the energy performance and energy management system; assessments of compliance with legal and other requirements; conducting internal audits of the energy management system; conducting reviews of the management of this system; and keeping records of these reviews.
7. *Improvement* consists of correcting the arising non-conformities and continuously improving the energy results and energy management system.

Figure 1 presents a multidimensional view of the energy management system according to the standard ISO 50001.

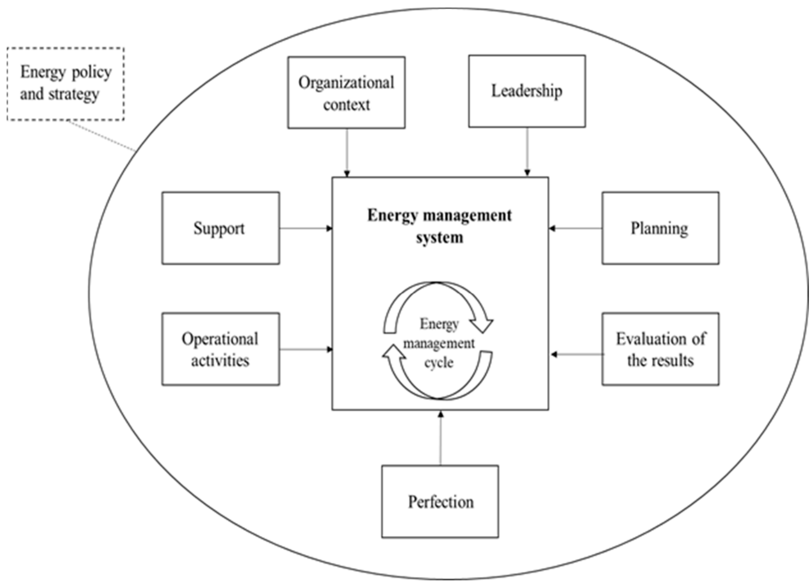

Figure 1. A multidimensional view of the energy management system according to the ISO 50001 standard. Source: own study based on PN-EN ISO 50001:2018-09 [6].

An energy management system based on ISO 50001 is intended to contribute to the efficient use of an organization's energy resources by optimizing its processes to save energy and minimize negative environmental impacts. Based on a critical review of the literature and drawing on the international standard EN ISO 50001:2018, the authors adopted a definition of the energy management system, treating the system as a multidimensional construct consisting of an organizational context, leadership, planning, support, operational activities, performance evaluation, and improvement for the realization of energy goals based on the established energy policy and strategy.

We developed an assessment tool for a multidimensional energy management system based on the ISO-50001 standard to fill the research gap.

3. Research Methods

Based on the main objective of this work, specific objectives were formulated as theoretical–cognitive, methodological, research, and practical. The theoretical–cognitive objectives were as follows:

- Identify the importance of energy management in the development of water and wastewater enterprises;
- Identification of the dimensions of the energy management system in water and wastewater enterprises.

The methodological objective is to build an instrument for measuring and evaluating energy management systems in water and wastewater enterprises. The research objective, in turn, concerns the empirical verification of the research hypotheses. The practical objective was to formulate recommendations for the development of an energy management system for water supply enterprise managers, which is part of a research process conducted by an interdisciplinary research team from Poland and the Czech Republic. The research process consisted of the following stages: theoretical–cognitive research, formulation of research hypotheses, verification of research hypotheses through empirical research, and synthesis of research results.

Theoretical–cognitive research is based on an analysis of the literature relating to the issues of energy management, energy management systems, and a review of energy management standards. The authors attempted to develop a tool to measure this construct by identifying the international standard ISO 50001 based on a literature analysis. A research gap was identified based on the literature analysis, indicating the paucity of research on multidimensional energy management based on the international standard ISO 50001 for water utilities. The analysis of the energy management standard made it possible to isolate its various dimensions and construct an interview questionnaire, which was used to conduct the study. The dimensions studied and the sub-dimensions used in the research questionnaire were developed based on the standard ISO 50001. As part of the empirical research, a case study method was used, which allowed for in-depth insight into the specifics of the energy management system of a purposefully selected water and sewage enterprise operating in the Czech Republic. Energy management aspects are particularly important for enterprises operating in this sector because they provide the local community with water supply, water treatment, and wastewater disposal. Water and wastewater utilities operating in the Czech Republic are increasingly focusing on energy management to improve efficiency and minimize negative environmental impacts. One noticeable trend is the implementation of ISO 50001-compliant energy management systems at companies in the sector [25].

Energy efficiency efforts in the Czech Republic in this sector are being supported by large-scale investments. The funding is aimed at strengthening water management services and that special emphasis is being placed on reducing energy consumption by modernizing wastewater treatment and water supply systems [26].

Detailed statistics on the implementation of the energy management system in water and wastewater enterprises in the Czech Republic are difficult to obtain in the form of publicly available and precise statistics. This further justifies our undertaking a survey at a selected water and sewage company operating in the Czech Republic.

Based on theoretical–cognitive research, the research problem was formulated in the form of the following question: how is the level of development of the various dimensions of the energy management system (EMS) constructed in the analyzed water and sewage enterprise in the opinion of employees and management?

To answer the indicated research problem, the following research hypotheses were formulated:

- H1: Statistically significant differences exist between the various dimensions of an energy management system.
- H2: Statistically significant differences exist in how managers and employees evaluate the level of the EMS dimension within the energy management system.
- H3: Statistically significant differences emerge in how respondents with different professional experiences evaluate the level of each EMS dimension within the energy management system.

The present research aims to assess the level of development of an energy management system in water utilities, considering the evaluation of the individual dimensions of this system. Assessing whether individual dimensions are shaped at the same level or whether differences exist in their levels of development is possible.

The surveyed company, which employs over 800 people, produces and supplies water to more than 700,000 residents in the region. Additionally, it treats wastewater at several-dozen treatment plants, returning over 270,000 m^3 of it to the environment daily. The company's services are used by almost 100,000 inhabitants of the region. In line with its CSR (Corporate Social Responsibility) policy, the company acknowledges its responsibility for the future of the region where it operates. The company prioritizes activities that support both the working and natural environments. It is certified under the ISO 18001:2007 standard, which defines the requirements for an occupational health and safety management system, and it undergoes regular monitoring and control assessments. Additionally, as part of its commitment to quality, the company holds certifications for ISO 9001 Quality Management Systems and ISO 14001:2006 Environmental Management Systems.

This study was conducted using a questionnaire. A five-point Likert scale (where 1 indicates a very low level of energy management, 2 indicates a low level of energy management, 3 indicates an average level of energy management, 4 indicates a high level of energy management, and 5 indicates a very high level of energy management) was used to assess the level of development of the energy management system through the perception of the company's employees and management. The respondents were managerial (n = 45) and operational staff (n = 100) from various departments.

The developed research tool was tested in unstructured interviews with managers from 10 different water and wastewater companies before conducting the survey. The interviews allowed for verification of the correctness of the prepared survey questionnaire.

After checking the completeness of the obtained data, 145 questionnaires out of the total 150 questionnaires received were used for analysis. The survey was addressed to all employees and managers employed in the company. The managers who filled out the returned surveys constituted about 65% of all managers employed in the company. In turn, in the case of the surveyed employees, they constituted about 20% of all other employees of the company. Statistical methods were used to analyze the obtained data and verify the hypotheses.

4. Results

Based on the data obtained from the research conducted using a research tool at a selected water and sewage company in the Czech Republic, statistical analysis was performed using STATISTICA 13.3. software. Factor analysis was used to check the validity of the selection of variables describing the individual dimensions of the energy management system. Prior to conducting factor analysis, we checked the factorability of the data by applying the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy [27] and Bartlett's test of sphericity [28]. The factorability of the data was determined when the KMO measure was higher than 0.6 and Bartlett's test was significant ($p < 0.05$). The Kaiser criterion (acceptance of factors with eigenvalues greater than 1) was used to select the number of factors. It was assumed that variables with factor loadings less than 0.6. were removed from the group of variables describing the EMS. The values of the KMO measure and the results of Bartlett's test of sphericity for the individual dimensions of the energy management system are included in Table 1.

Table 1. KMO measure and Bartlett's test of sphericity results for EMS dimensions.

	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.735
Organisational context	Bartlett's Test of Sphericity	Approx. Chi-Square	328.63
		Df	6
		Sig	0.000
	Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.818
Leadership	Bartlett's Test of Sphericity	Approx. Chi-Square	394.62
		Df	15
		Sig	0.000
	Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.795
Planning	Bartlett's Test of Sphericity	Approx. Chi-Square	315.52
		df	6
		Sig	0.000
	Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.91
Support	Bartlett's Test of Sphericity	Approx. Chi-Square	290.61
		df	10
		Sig	0.000
	Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.837
Operational activities	Bartlett's Test of Sphericity	Approx. Chi-Square	547.02
		df	6
		Sig	0.000
	Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.749
Evaluation of results	Bartlett's Test of Sphericity	Approx. Chi-Square	460.4
		df	10
		Sig	0.000

Source: own survey result.

As we found a KMO value greater than 0.7 and a significant Bartlett's test ($p < 0.000$) for all areas of EMS, we concluded that the data were appropriate for factor analysis. According to Kaiser's criterion, the analyzed areas were assumed to be univariate constructs. To assess the reliability of the scale for each factor, the value of the Cronbach's alpha coefficient was considered. The reliability of the scale for each factor was assessed using Cronbach's alpha coefficient, which should be greater than 0.6 [29]. Table 2 presents the factor loadings and Cronbach's alphas for each EMS dimension.

The variances explained by the identified factors exceed the standard cut-off point of 50% percent for the explained variance. Cronbach's alpha was greater at 0.84, suggesting that the subscales were internally consistent. The empirical distribution of EMS is presented in Figure 2.

Table 2. Factor loadings and Cronbach's alpha for each EMS dimension.

Dimensions EMS	**Factor Loadings**	**Cronbach's Alpha**
Organizational Context	Factor	0.87
1.1 The company has identified internal factors (e.g., human, technological, material, political, methodologies) influencing more efficient energy management	0.88	
1.2 The company has identified external factors (e.g., demand, network load, climatological conditions, stakeholders) influencing more efficient energy management	0.89	
1.3 The company's development strategy takes into account the energy policy and its objectives	0.84	
1.4 The company provides stakeholders with information on legal requirements and other documents related to energy performance (energy use and consumption)	0.79	
Eigen value	2.89	
% Var	72.30%	
Leadership	Factor	0.86
2.1 Management is committed to continuous improvement of the company's energy performance	0.80	
2.2 Management communicates energy policy and the importance of effective energy management to employees	0.79	
2.3 The company's energy policy is available to employees and other stakeholders	0.78	
2.4 The energy policy of the enterprise is subject to updating	0.82	
2.5 The department/team/person responsible for energy management has an important role in the enterprise	0.76	
2.6 Management provides necessary training/mentoring and procedures for hiring competent management personnel	0.68	
Eigen value	3.59	
% Var	60.0%	
Planning	Factor	0.88
3.1 The company has defined procedures for countering the occurrence of potential risks and taking advantage of emerging energy management opportunities	0.85	
3.2 The company has defined measurable energy goals and ways to achieve them, which have been communicated to employees and other stakeholders	0.90	
3.3 The company has defined metrics and indicators for energy performance	0.89	
3.4 Acquired energy data is identified, measured, analyzed, documented, and monitored as part of energy reviews	0.78	
Eigen value	2.93	
% Var	73.2%	

Table 2. *Cont.*

Dimensions EMS	**Factor Loadings**	**Cronbach's Alpha**
Support	Factor	0.84
4.1 The company has the resources needed to establish, implement, maintain, and continuously improve energy management and energy result improvement	0.68	
4.2 At the company, people involved in the work for the energy result and energy management have the necessary competence (education, skills, experience)	0.83	
4.3 When acquiring new equipment/apparatus, the enterprise pays attention to its energy class	0.78	
4.4 Employees are aware of their contribution and the consequences of activities leading to the achievement of energy goals and the benefits of improving the energy result	0.79	
4.5 The company has identified ways to communicate internally and externally for energy management (e.g., organization of meetings, ways to transfer information, flow of knowledge)	0.81	
Eigen value	3.04	
% Var	60.8%	
Operational activities	Factor	0.93
5.1 The company plans and controls operational activities for energy management	0.81	
5.2 The company has criteria for the most important energy-using processes, taking into account the efficient operation of water supply systems and water treatment plants	0.95	
5.3 The company has criteria for the most important energy-using processes, taking into account the effective operation of sewage systems and wastewater treatment plants	0.95	
5.4 The company has criteria for the most important processes that use energy, taking into account the effective operation of other facilities	0.93	
Eigen value	3.32	
% Var	83.1%	
Evaluation of results	Factor	0.87
6.1 The company has implemented procedures relating to criteria related to energy-using processes	0.85	
6.2 The company analyzes, monitors, evaluates, and documents procedures relating to criteria related to energy-using processes	0.88	
6.3 The defined criteria have been communicated to the enterprise's employees and other stakeholders	0.77	
6.4 The company's thermal energy consumption is monitored	0.74	
6.5 The company's electricity consumption is monitored	0.82	
Eigen value	3.31	
% Var	66.3%	

Source: own survey result.

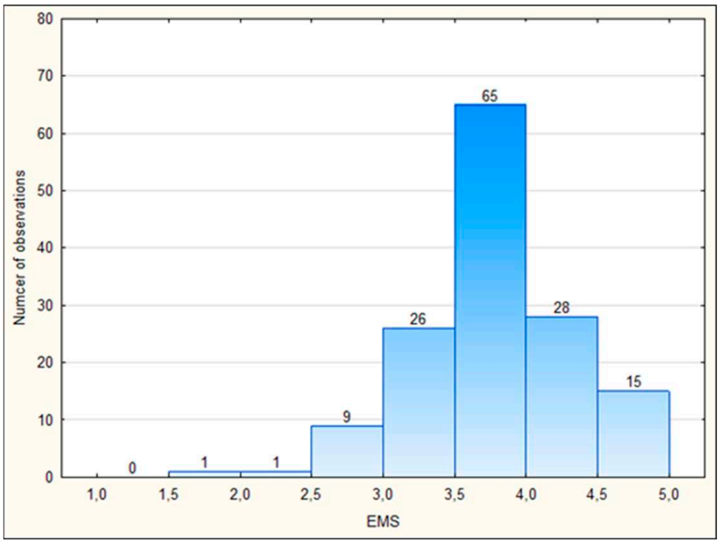

Figure 2. Histogram of the variable EMS. Source: own survey result.

The histogram in Figure 2 shows that of the 145 respondents, 134 rated the energy management system (EMS) above level 3. The largest group comprised respondents who rated the EMS in the range of 3.5 to 4 (65 people). Fifteen participants rated the EMS position at the highest level, between 4.5 and 5. Only 11 respondents rated the EMS variable at 3. Based on the analysis, three research hypotheses were verified.

The Kruskal–Wallis test was used to verify Hypothesis 1, assuming statistically significant differences exist between the various dimensions of the energy management system. The Kruskal–Wallis test was used because the assumptions of the classical ANOVA analysis were not met (the analyzed variables were not normally distributed). Descriptive statistics were obtained for each ESM dimension and are presented in Table 3.

Table 3. Descriptive statistics of dimensions of EMS.

Variable	N	Mean	Me	Min.	Max.	Q1	Q3	SD	CV
Organizational context	145	3.82	3.75	1.00	5.00	3.50	4.00	0.65	16.92
Leadership	145	3.63	3.67	1.67	5.00	3.17	4.00	0.64	17.54
Planning	145	3.63	3.75	1.50	5.00	3.25	4.00	0.63	17.34
Support	145	3.80	3.80	2.00	5.00	3.40	4.00	0.58	15.24
Operational activities	145	4.03	4.00	2.00	5.00	3.75	4.50	0.65	16.03
Evaluation of results	145	4.00	4.00	1.60	5.00	3.80	4.40	0.60	15.06
Perfection	145	4.08	4.00	2.00	5.00	4.00	4.00	0.63	15.37

Source: own survey result.

Table 3 shows that among the evaluated EMS dimensions, the highest average value was obtained by the perfection dimension (4.08), followed by operational activities (4.03) and the evaluation of results (4.00). On the other hand, the lowest mean value of 3.63 was obtained for two dimensions: leadership and planning. The highest coefficient of variation (CV), indicating the greatest variation in values, characterized the leadership dimension (17.54) and the lowest dimension evaluation of results (15.06). The results of the Kruskal–Wallis test are shown in Figure 3.

The result of the Kruskal–Wallis test revealed a statistically significant difference in score between the different dimensions of EMS, as indicated by the value of Kruskal–Wallis test H (6. N = 945) =70.89 and p = 0.0000. After obtaining a significant result in the nonparametric Kruskal–Wallis test, the Dunn test was performed, which allowed for comparisons between individual dimensions of the system to identify which specific pairs differ significantly in terms of medians. Pairwise comparisons using Dunn's test indicated that ratings of the perfection dimension are significantly higher than ratings of organizational context (p = 0.004), leadership (p = 0.000), planning (p = 0.000), and support (p = 0.002); ratings of the operational activities dimension are significantly higher than ratings of organizational context (p = 0.048), leadership (p = 0.000), planning (p = 0.000), and support (p = 0.03); and ratings of the evaluation dimension results are significantly higher than ratings of leadership (p = 0.000) and planning (p = 0.000). In summary, pairwise comparisons using Dunn's test showed differences between the perfection and operational activities dimensions compared to organizational context, leadership, planning, and support, and scores for the other pairs of dimensions did not differ significantly. Thus, this hypothesis was confirmed.

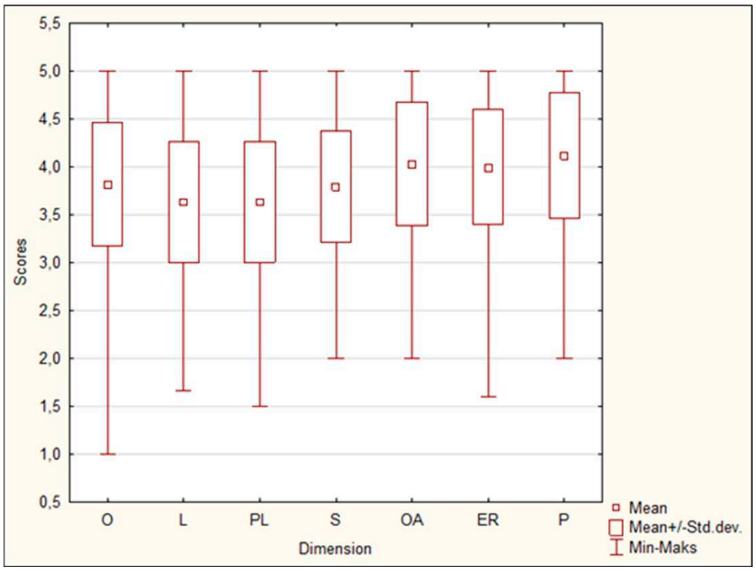

Figure 3. Graphical interpretation of the Kruskal–Wallis test results for H2. Source: own survey result.

To verify Hypothesis 2, which assumes that there are statistically significant differences in the assessment of the level of the energy management system dimensions by managers and employees, the Mann–Whitney test was used. For managers and employees, Table 4 presents descriptive statistics for each EMS dimension.

Table 4. Descriptive statistics of the evaluation of the level of each dimension of EMS by managers and employees.

Dimension of EMS		N	Mean	Me	Min.	Max.	Q1	Q3	SD	CV
Organizational context	Managers	45	3.89	4.00	1.00	5.00	3.50	4.25	0.70	18.03
Organizational context	Employees	100	3.79	3.75	2.50	5.00	3.25	4.00	0.62	16.39
Leadership	Managers	45	3.74	3.83	1.67	5.00	3.50	4.00	0.68	18.31
Leadership	Employees	100	3.58	3.67	1.83	4.83	3.17	4.00	0.61	17.05
Planning	Managers	45	3.80	4.00	1.50	5.00	3.50	4.00	0.57	14.95
Planning	Employees	100	3.56	3.50	1.50	5.00	3.00	4.00	0.64	18.11
Support	Managers	45	3.91	4.00	2.00	5.00	3.60	4.00	0.46	11.89
Support	Employees	100	3.75	3.80	2.40	5.00	3.20	4.10	0.62	16.52
Operational activities	Managers	45	4.03	4.00	2.00	5.00	4.00	4.25	0.59	14.63
Operational activities	Employees	100	4.03	4.00	2.25	5.00	3.75	4.75	0.67	16.69
Evaluation of results	Managers	45	4.11	4.00	1.60	5.00	4.00	4.40	0.58	14.15
Evaluation of results	Employees	100	3.95	4.00	2.20	5.00	3.60	4.40	0.61	15.39
Perfection	Managers	45	4.16	4.00	2.00	5.00	4.00	4.00	0.60	14.47
Perfection	Employees	100	4.04	4.00	2.00	5.00	4.00	4.00	0.64	15.78
Energy management system	Managers	45	3.92	3.97	1.66	5.00	3.66	4.17	0.53	13.54
Energy management system	Employees	100	3.78	3.78	2.41	4.90	3.45	4.03	0.54	14.17

Source: own survey result.

The data in Table 4 indicate that there are some differences in the assessment of the dimensions by managers and employees. The results of the Mann–Whitney test calculations, which allowed for a comparison of the assessment of the level of individual dimensions of the energy management system by managers and supervisors, are presented in Table 5.

Table 5. Results from calculation of the Mann–Whitney test.

Dimension	Rank Sum Group 1	Rank Sum Group 2	U	Z	*p*	N1	N2
Organizational context	3649.50	6935.50	1885.50	1.556	0.120	45	100
Leadership	3735.00	6850.00	1800.00	1.921	0.055	45	100
Planning	3875.50	6709.50	1659.50	2.522	0.012	45	100
Support	3674.50	6910.50	1860.50	1.662	0.096	45	100
Operational activities	3250.50	7334.50	2215.50	−0.145	0.884	45	100
Evaluation of results	3735.50	6849.50	1799.50	1.923	0.054	45	100
Perfection	3483.00	6957.00	2007.00	0.948	0.343	45	100

Source: own survey result.

The results of the Mann–Whitney test indicate a significant difference between the assessments of managers and employees only for the planning dimension ($p = 0.012$, less than the significance level of 0.05). A graphical interpretation of the results obtained is presented in Figure 4.

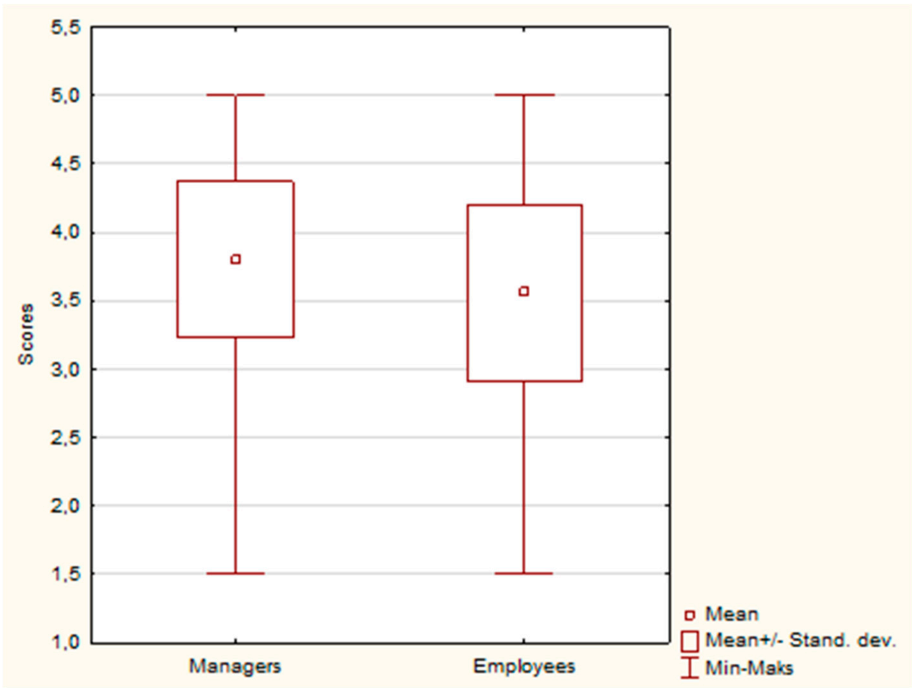

Figure 4. Graphical interpretation results for H2.

Hypothesis 2 was confirmed only for the planning dimension.

A Kruskal–Wallis test was conducted to verify Hypothesis 3, supposing that statistically significant differences existed in the evaluation of the level of each dimension of the energy management system by respondents with different professional experiences. The results of this test are presented in Table 6.

The results of the Kruskal–Wallis test presented in Table 6 show no significant differences exist in the evaluation of the level of each dimension of the energy management system by respondents with different work experiences, as all *p*-values are greater than 0.05. Thus, this hypothesis was not confirmed.

Table 6. Results of the Kruskal–Wallis test.

Dimension	Value of Test Statistic Kruskal-Wallis	*p*
Organizational context	H (4. N = 145) = 4.296	0.367
Leadership	H (4. N = 145) = 7.384	0.117
Planning	H (4. N = 145) = 2.787	0.594
Support	H (4. N = 145) = 3.276	0.513
Operational activities	H (4. N = 145) = 3.546	0.471
Evaluation of results	H (4. N = 145) = 5.104	0.277
Perfection	H (4. N = 145) = 5.319	0.256

Source: own survey result.

5. Discussion

In the context of sustainable development, effective energy management by water and wastewater companies is becoming increasingly important. The literature emphasizes the growing threat of the depletion of vital resources such as water due to the pollution of water resources and the continuous production of wastewater around the world.

As Wang et al. [30] showed, for wastewater treatment plants to be energy-self-sufficient, a combination of practices and solutions for energy recovery from wastewater and energy efficiency is necessary [14]. Therefore, it is necessary to take measures to ensure the rational management of energy use by reducing water and energy consumption without involving additional resources [31,32]. An established and improved energy management system can facilitate the rational use and management of energy.

Based on the literature analysis and considering the guidelines of ISO-50001, a study was conducted at a selected water and sewage company to evaluate its energy management system.

The following seven dimensions were considered in evaluating this system: organizational context, leadership, planning, support, operational activities, evaluation of results, and perfection.

The results obtained by applying the Kruskal–Wallis test confirmed Hypothesis 1, regarding significant differences between the various dimensions of the energy management system. Additionally, the Dunn's test showed differences between some dimensions. This indicates a lack of care on the part of the company's management and employees about the even development of all elements of the energy management system.

Regarding Hypothesis 2, a significant difference existed between the evaluations of managers and employees for the planning dimension, which includes activities related to the establishment of goals and ways to achieve them, as well as the preparation and conduct of an energy review, and the determination of indicators was confirmed.

However, no differences existed in responses from the perspective of work experience (Table 6). Thus, Hypothesis 3 was not confirmed. Despite the small differences, the analyses indicate that the development of the various dimensions of the evaluated energy management system in the studied enterprise was not even. Taking care of more harmonious development in all dimensions is important for the system to be more effective. Based on this study, it was also found that the level of the energy management system was relatively high. Leadership and planning were rated the lowest. This indicates that managers should focus on improving these two areas.

Similar studies on the issue of the functioning of the energy management system conducted in wood-industry companies in Serbia also showed uneven development of individual elements in this system, which is caused, as the authors claim, by the lack of a comprehensive approach and the lack of sufficient involvement of management staff and employees [22].

Using modern management concepts and tools, it is possible to shape the even development of individual elements of the energy management system more effectively while increasing the level of knowledge and involvement of company employees. Among others, using participatory forms of management, building an organizational culture that supports the issues of better energy management and environmental protection, as well as focusing on continuous improvements in the energy management system and ongoing monitoring of this system must be applied. The management staff are the carrier of real standards and values in the organization, which is why they should primarily take care of the constant development of knowledge and awareness of the company's employees in the field of energy management system development.

The validity of the actions we proposed is confirmed by studies by other authors conducted in enterprises in Turkey, identifying barriers related to insufficient knowledge and awareness of management staff and employees in the field of energy management system development [17]. Building potential based on better use of material and human resources supported by education and training will certainly contribute to the development of the entire energy management system.

6. Conclusions

Energy management systems are key to the efficient use of energy resources and cost reduction and support sustainable development goals. Energy management is an important aspect of the activities of water and sewage companies. Water supply, sewage disposal, and stormwater management lead to high energy consumption. Therefore, these companies must take conscious actions to minimize energy consumption. This research contributes to deepening knowledge about the energy management system and its perception by both employees and company management. The results fill the identified theoretical, cognitive, and research gap. The main objective and detailed objectives of a cognitive and empirical nature formulated in the work were achieved through the conducted literature analysis and research. The formulated recommendations, in turn, allowed for achieving the practical objective.

The literature and empirical research allowed for the formulation of the following conclusions and recommendations regarding the theoretical, cognitive, and utilitarian nature:

1. Energy management is a multidimensional and interdisciplinary approach. This is an important issue in the context of improving energy efficiency, rational management, reducing costs and environmental impact by reducing energy consumption and greenhouse gas emissions.
2. In the context of implementing an energy management system in enterprises, a holistic and systemic approach based on the ISO 50001:2018 standard is important. A special role in this respect is played by the management staff and their influence on raising employee knowledge and awareness. A lack of involvement of management staff and employees can lead to the uneven development of the system.
3. The developed tool for assessing the energy management system, based on the ISO 50001:2018 standard, allowed for the identification of areas in which changes can be introduced to optimize the energy management system. According to the standard, these areas concern the following: organizational context, leadership, planning, support, operational activities, performance evaluation, and improvement.
4. Research conducted in a selected water and sewage company in the Czech Republic confirmed the validity of the analytical methods used and showed high internal consistency of the energy management system under study. The Kruskal–Wallis test showed significant differences between some EMS dimensions, while the Mann–Whitney U test revealed significant differences in the assessment between managers and employees of one dimension—planning. However, no differences were indicated in the assessment of the level of EMS dimensions among respondents with different professional experience.
5. The literature analysis and the conducted research indicate that the systemic approach to energy management is still insufficiently implemented in many enterprises, which results from, among others, the lack of involvement of the management staff, insufficient communication, and insufficient financial support.

6. The implementation of management tools, such as participatory forms of management and building an organizational culture supporting the energy management system, can contribute to a more even development of this system. Raising employee awareness is also important, because studies conducted in other countries confirm that the lack of appropriate knowledge is a significant barrier to the development of the EMS.

The above conclusions and recommendations can contribute to actions aimed at improving the energy management system in similar organizations. As a result, these actions can have an impact on environmental protection and sustainable development. In addition, the implementation of these recommendations can have a positive impact on the company's image and the satisfaction of various stakeholder groups.

This study has some limitations due to the chosen case study method for assessing the energy management system of the selected water and sewage company. This limitation indicates the future direction of research on a larger scale in a larger number of companies and in companies from other industries and countries. This allows for the formulation of more generalized conclusions. In particular, it would be interesting to find answers to the conceptual problems that have appeared in the literature and empirical studies. They are expressed through the following questions:

- How is the energy management system shaped by other water and sewage companies in the country and abroad?
- Is the energy management system at a higher level in organizations where the EN ISO 50001:2018 standard has been implemented than in organizations where it is not implemented?

Finding answers to the above questions would allow for the formulation of more universal conclusions, as well as the observation of many interesting phenomena that will contribute to more effective energy management in enterprises and may be the subject of interest in this area in the future.

Author Contributions: Conceptualization, J.M.-S., E.P. and I.K.-B.; methodology, J.M.-S., E.P. and I.K.-B.; validation, J.M.-S.; formal analysis, J.M.-S., E.P. and I.K.-B.; investigation, E.P.; resources, I.K.-B.; data curation M.G.; writing—original draft preparation, J.M.-S., E.P. and I.K.-B.; writing—review and editing, M.G.; visualization, E.P.; supervision, J.M.-S. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by Politechnika Slaska and Politechnika Opolska, Poland.

Data Availability Statement: The datasets presented in this article are not readily available due to privacy.

Conflicts of Interest: All authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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