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CHALLENGES AND BUSINESS SOLUTIONS FOR LOCAL GOVERNMENT SUSTAINABLE ENERGY MANAGEMENT IN POLISH MUNICIPALITIES

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Purpose: The purpose of this paper is to analyze and assess the efforts of Polish local governments (communes) in managing energy consumption within public buildings, with a particular focus on the challenges they face and the potential business-driven solutions available to them. The study aims to bridge the gap in the existing literature by offering a comprehensive review of scientific research, official reports, and legal frameworks related to energy use in government-owned infrastructure. It also incorporates quantitative data from Polish communes to evaluate how well local-level actions align with national and European energy efficiency targets.
Design/methodology/approach: A quantitative methodology was used when the objective of the research was to confirm research questions.
Findings: This research seeks to demonstrate that, while Polish communes have made progress, their efforts remain insufficient to meet the broader governmental expectations for long-term energy savings. By highlighting the limitations of current strategies and emphasizing the role of innovative business activities, the study advocates for enhanced support and coordination between local and national authorities. The research ultimately aims to contribute to the ongoing discourse on the sustainable energy transition by underscoring the importance of local autonomy, government incentives, and business involvement in realizing European sustainability goals.
Research limitations/implications: There are several limitations of the research that should be overcome in the future. The final research sample size of communities examined might be higher or correspond to the structure of communes in Poland. The questions of the survey miss information about thermal insulation of public buildings. The research also does not study the local law acts, directives, and orders, which might have an important influence on local government actions.
Practical implications: The proposed analysis of energy savings provides insights into the actions that should be intensified to achieve a sustainable energy transition within the public sector, focusing on public buildings. This analysis can be a valuable resource for decision-makers responsible for managing energy consumption in public buildings. Investing in the predictor attributes of buildings identified in this analysis has the potential to significantly reduce their energy consumption and associated costs. Furthermore, the examination of building attributes can assist decision-makers in prioritizing their investments in energy-efficiency measures. By selecting buildings and their specific characteristics that have the

greatest impact on reducing energy consumption, decision-makers can make more informed choices.
Social implications: By shedding light on the efforts and challenges faced by Polish local governments in reducing energy consumption in public buildings, this paper could help raise awareness among citizens about the importance of energy efficiency in everyday governance. This research may inspire businesses to take on more proactive roles in supporting local authorities by providing innovative solutions for energy management. The findings of this research could inform both public and industry policy by advocating for more robust frameworks that facilitate collaboration between local governments and the private sector. Although this study is primarily focused on energy consumption in public buildings, its broader implications could positively affect the quality of life in the long run. More efficient energy use in government-owned infrastructure can lead to lower operational costs, which could be redirected to other public services or infrastructure improvements.
Originality/value: The novelty of this paper lies in its focus on local-level energy management and the need for intensified business initiatives, addressing a clear gap in both academic and practical research on this subject.
Keywords: energy consumption, Polish local governments, Smart City, regional development, European sustainability goals, public buildings.
Category of the paper: Research paper.

1. Introduction

The European Union's 2015 Energy Union strategy outlines five key objectives (European Commission, 2015). First, it seeks to diversify energy sources and enhance security through cooperation among member states, safeguarding against supply disruptions. Second, the EU aims to create a fully integrated internal energy market, facilitating the free flow of energy and promoting competition. Third, improving energy efficiency is prioritized to reduce imports, lower emissions, and support economic growth. Fourth, aligned with the Paris Agreement, the EU is committed to transitioning to a low-carbon economy by reducing carbon emissions and adopting sustainable energy sources. Finally, the EU emphasizes research and innovation in low-carbon technologies to drive the energy transition and enhance global competitiveness.

While the EU aims for a unified energy policy, Article 194 of the Treaty on the Functioning of the European Union (TFEU) (Treaty on the Functioning of the European Union (TFEU), Article 194(2)) allows member states to determine their own energy sources and supply structures. Current EU energy policy focuses on energy security and climate goals, notably through the 'Fit for 55' package (European Commission, 2021), which targets a 55% reduction in greenhouse gas emissions by 2030 and net-zero emissions by 2050 (European Parliament, 2009). The 2030 goals include increasing renewable energy to 32%, improving energy efficiency by 32.5%, and achieving 15% electricity interconnections Directive (EU) PE/48/2018/REV/1. New targets set in 2023 aim to raise renewable energy to 42.5% and further reduce energy consumption. To meet these goals, member states must implement national energy and climate plans, report on progress, and develop long-term strategies aligned with the Paris Agreement (europa.eu).

In February 2022, the Russian invasion of Ukraine disrupted the EU's energy framework review, as Russia's manipulation of oil and gas exports caused market turmoil. In response, the EU swiftly acted under the Versailles Declaration (Kirova, 2022), leading to the launch of the REPowerEU plan to enhance energy security. Later in 2022, the European Commission introduced new legislative proposals (European Commission, 2022), sidelining the European Parliament. From September to December 2022, the Council enacted measures to reduce electricity demand, cap income for inframarginal electricity producers, impose a temporary levy on excessive fossil fuel profits, accelerate the renewable energy transition, and establish a mechanism to curb natural gas transactions during price surges (europa.eu).

Due to energy carrier market crisis of 2022-2023 stemming from geopolitical circumstances, managers in the Polish public finance sector were mandated to cut electricity consumption by 10% in fiscal year 2023. The directive aimed to reinforce the public finance sector's exemplary role in energy savings, thereby motivating a broader audience to adopt effective measures to reduce electricity usage. Collective efforts by public sector units are expected to significantly lower energy consumption and enhance Poland's energy security.

In response to EU regulations, Poland introduced the 2022 Act on "Special Measures for Safeguarding Electricity Consumers," which mandates a 10% reduction in electricity consumption in public buildings from December 1 to December 31, 2023 (published in the Journal of Laws of 2022, item 2127)[1] (Ustawa z dnia 7 października 2022 r.). This target is based on average annual consumption from 2018-2019, adjusted for the pandemic's impact. Key measures include limiting external lighting, maintaining set indoor temperatures, upgrading lighting systems, implementing energy management controls, and promoting energy-saving practices. Local governments have flexibility in implementing these measures due to the general nature of the legal guidelines. Key measures to improve energy efficiency include:

1. Limiting external lighting and turning off daily or holiday building illumination.
2. Maintaining room temperatures at 19°C during heating and 25°C during cooling.
3. Modernizing or replacing lighting systems.
4. Implementing measurement, monitoring, and control systems for energy management.
5. Introducing organizational improvements and educational activities to encourage office employees to use energy rationally.
6. Using waste heat from server rooms to heat occupied buildings.

[1] hereinafter referred to as "the Act".

The actions taken by the EU and the Polish government obliged Local governments to reduce energy consumption in public buildings. The freshness of the legal conditions and their generality meant that local governments had a free hand in shaping tasks aimed at reducing energy consumption.

The article aims to identify areas where Polish communes need improvement to meet sustainable development goals, particularly in achieving a 10% reduction in electricity consumption in public buildings. It examines whether local government leaders actively promote sustainable energy use and efficiency. The study also assesses residents' views and local government initiatives on energy consumption in public buildings. The primary goal is to visually represent the reduction of energy consumption in heating and electricity by Polish local governments.To facilitate the accomplishment of the article's objectives, the following research inquiries have been formulated: RQ1: Do the actions of Polish local governments align with the energy efficiency standards recommended by the Polish government? RQ2: Which actions should be intensified to accelerate the sustainable energy transition in reducing energy consumption in public buildings?

2. Literature review

In the 21st century, the EU faces challenges supporting high environmental standards for sustainable development. These challenges include energy security, an aging population, and climate change concerns. The EU aims to achieve climate neutrality by 2050, with specific goals like reducing emissions by 55% by 2030. The EU is revising the Effort Sharing Regulation as part of the Ready for 55 legislative package to reach these targets (Selin, Van Deveer, 2015; da Graça Carvalho, 2012; Cifuentes-Faura, 2022; Regulation (EU) 2023/857).

The Effort Sharing Regulation ensures all EU member states participate in reducing emissions with annual targets from 2021 to 2030. On March 14, 2023, the European Parliament voted to increase the greenhouse gas reduction goal from 30% to 40% by 2030 compared to 2005 levels. EU member countries have varying greenhouse gas emission reduction obligations based on GDP. They must also stay within their emission limits annually. Poland's new 2030 target is -17.7%, compared to the previous -7%. Nations may face constraints on offsetting emissions, using future allowances, or trading emissions. Efforts to share information will be made public to promote accountability. Rules require formal approval by EU member countries before enactment (Regulation EU 2018/842).

Buildings in the current era of climate change require energy-saving solutions (Dudkiewicz et al., 2021). The construction industry, known for high energy usage, needs more attention to energy efficiency (de la Cruz-Lovera et al., 2017). Emphasis on improving energy efficiency in residential buildings due to their large share in the EU sector, with potential savings in non-residential buildings as well (Santamouris, Vasilakopoulou, 2021; Bosseboeuf, 2015). Energy-efficient measures could significantly reduce costs by over 28% in these buildings (Ekins, Lees, 2008). The importance of energy efficiency has grown in the early 21st century due to its economic and environmental impacts (Ayres et al., 2007). Efforts are underway to enforce Directive 2018/844, amending Directives 2010/31/EU and 2012/27/EU. Implementation includes adopting the "Long-Term Strategy for the Revitalization of National Building Resources" to aid in renovating residential and non-residential buildings (Regulation EU Directive 2012/27/UE).

Energy efficiency in public buildings refers to the use of energy-efficient technologies, practices, and design principles to reduce the amount of energy consumed while maintaining or improving the functionality and comfort of the building (UNIDO; Munguia et al., 2020). This is important for several reasons (Hafez et al., 2023; EPEC, 2021):

1. **Cost Savings**: Improving energy efficiency can lead to significant cost savings in terms of energy bills for public buildings, which are often funded by taxpayers.
2. **Environmental Benefits**: Reduced energy consumption means lower greenhouse gas emissions and a smaller carbon footprint, contributing to environmental sustainability and efforts to combat climate change.
3. **Resource Conservation**: Energy-efficient buildings typically use fewer natural resources, such as fossil fuels and electricity, reducing the strain on energy infrastructure.
4. **Improved Comfort**: Energy-efficient buildings often have better insulation, ventilation, and heating/cooling systems, which can lead to improved indoor comfort for occupants.
5. **Long-Term Sustainability**: Investing in energy efficiency can extend the lifespan of a building's systems and reduce maintenance costs over time.

Nevertheless, it's crucial to consider the thermal comfort of the building occupants at this juncture. The impact of occupant behavior is just as significant as the quality of the building's envelope (Schweiker, 2017).

Despite growing recognition of the role local governments play in achieving national and European sustainability goals, there is a notable lack of comprehensive research specifically focused on the energy management practices of Polish communes in public buildings. Existing literature often addresses energy policies and efficiency measures at the national or EU level but overlooks the granular, local-level actions and their effectiveness. Furthermore, limited attention has been given to the intersection between public-sector energy management and potential business solutions that could support a faster transition to sustainable energy use. This gap highlights the need for studies that examine the unique constraints faced by local governments, assess the adequacy of their actions in meeting broader sustainability expectations, and explore business-driven strategies for enhanced energy efficiency in government-owned properties.

The current body of research lacks sufficient empirical data and in-depth analysis on the specific role of local government discretion, the challenges of policy implementation at the commune level, and the impact of these factors on long-term energy savings. Moreover, the limited integration of business solutions into local government energy practices presents a critical area for exploration to accelerate the sustainable energy transition.

3. Research

3.1. Methodology

A quantitative methodology was used when the objective of the research was to confirm research questions. The initial section of the article provides an overview of scientific literature, international organization reports, and national and regional legal documents pertaining to energy usage in buildings owned by local government entities. The second part is the analysis of data obtained in the survey study of the representatives of Polish local governments. The study focuses on collecting and measuring numerical data from a sample of participants. To collect data an online survey, consisting of 50 closed questions, was conducted between June and August 2023. The survey was sent to 378 random local governments in Poland (table 1). The obtained sample is sufficient to conduct statistically significant analyses.

Table 1.
Sampling statistics

Item	Head in uppercase letters
Population size (number of communes in Poland)	2.477
Sample (communes examined = N)	378
Confidence level (α)	0.95
Sampling fraction (f)	0.5
Maximum error of estimation (E)	5%

Source: own calculations.

3.2. Research method

Descriptive analysis and inferential analysis, including statistical analysis and comparisons, were used to analyze the collected data. In the exploration of the relationship between variables, the correlation was used. These analyses allow a statistical description of the attitudes and requirements of local governments in the fight to lower energy consumption in public buildings. All statistical calculations were made in PS Imago Pro 9.0.

3.3. Characteristics of the study group

51.59% of respondents identified themselves as women, 39.68% as men, and at the same time 8.73% refused to answer this question (table 1). 13.49% of respondents were Secretaries of the commune, 7.94% were Treasurers of the commune, 3.17% were Mayors, 2.38% were councilors (with 0.79 being Chairman of the council), and the rest of the respondents were commune official of different specialization. The overwhelming majority of the surveyed communes were governed by men, to the contrary to Treasurers, among whom 82.54% were women.

Table 2.
Sampling statistics of respondets

Item	Statistics	
	Representants	**Share of population (%)**
Respondent's role in local government		
Mayor	12	3.17
Secretary of Municipiality	51	13.49
Treasurer	30	7.94
Other	285	75.40
Sex of a Mayor		
Woman	51	13.49
Man	327	86.51
Sex of a Treasurer		
Woman	312	82.54
Man	66	17.46
Number of residents of the commune:		
up to 50 thousand residents	336	88.89
50-100 thousand residents	15	3.97
100-500 thousand residents	18	4.76
over 500 thousand residents	9	2.38
Type of municipality		
City with county rights	36	9.52
Urban municipality (without county rights)	33	8.73
Urban-rural municipality	105	27.78
Rural municipality	204	53.97
Municipality income per capita		
up to PLN 1,000	33	8.73
PLN 1,000-1,500	108	28.57
PLN 1,501-2,500	72	19.05
over PLN 2,500	165	43.65
Voivodeship		
pomorskie	63	16.67
śląskie	42	11.11
podkarpackie	33	8.73
lubelskie	30	7.94
małopolskie	30	7.94
wielkopolskie	27	7.14
mazowieckie	24	6.35
dolnośląskie	24	6.35
łódzkie	21	5.56
other	85	22.49

Source: own calculations.

The respondents were asked about the characteristics of the communes they represent. The provided data presents a breakdown of respondents based on the population size of their respective areas of residence. Let's analyze each category:

The majority of respondents were from small communities under 50,000 inhabitants, with distinct needs. A small group was from areas with 50,000-100,000 inhabitants, making up less than 4% of respondents. A slightly higher percentage of respondents (4,76%) were from areas inhabited by 100,000-500,000 people, potentially representing m.id-sized cities. The smallest group, around 2.38%, comes from areas with over 500,000 people, likely larger cities. Their views may reflect urban living characteristics.

The distribution of respondents' incomes in their communes shows a diverse pattern. Many live in communes with moderate to high incomes, while fewer are from lower-income areas. This data aids in grasping the economic context of respondents and is useful for policy-making and resource allocation to address varying income levels in different communes.

The analysis shows different representation levels among voivodeships. Pomorskie and Śląskie are by characterized high percentages of respondents (over 10% each) while Lubuskie, Warmińsko-Mazurskie, and Podlaskie have the lowest shares. Basic information on the sample may be found in Table 2.

3.4. Results of the survey

3.4.1. Lights

Data regarding various decisions made by communes regarding the reduction of lighting in different contexts has been provided. It can be inferred that just a little bit over 25% of communes have chosen to reduce park lighting during nighttime hours. However, there is a significant number of communes (42.9%) where either there is no data or no such decision has been made. Close to half of the communes (47.62%) have opted for a complete shutdown of street lighting on some streets during nighttime hours. The minority of communes (23.80%) have taken action to partially restrict nighttime street lighting by turning off every second street lamp. Nearly 37% of communes have chosen to partially restrict nighttime street lighting by reducing brightness. Around 12% of communes decided to modernize or replace street lighting, but only if the investment would receive external funding, e.g. from EU funds. Data from this group show no, or insignificant correlation with voivodeship, type of commune, population, income per inhabitant, sex of mayor, or sex of treasurer (Appendix 1, points 1.1-1.4)

3.4.2. Sports, Leasure, and Decoration

The vast majority of communes (85.71%) have not implemented a reduction in operating hours for sports facilities. Most communes do not have such a spa zone, but in those that do, the decision to turn it off is very rare (2.38%). What is interesting, the higher the commune’s income per capita (Vc = -0,616, Appendix 1, point 2.2), and population size (Vc = 0-,508, Appendix 1, point 2.2), the less likely is the commune to close the public spa zone. There is also a correlation between the reduction of spa zone opening hours and the voivodeship of a commune (Vc = -0,616 Appendix 1, point 2.2). Nearly half of the communes 53.17% have decided to eliminate street lighting during holidays, especially lights during the Christmas season. Around 25% of communes have opted to eliminate the placement of holiday trees. Almost 29% of communes have decided to discontinue the illumination of municipal monuments after 8:00 PM. The majority of communes do not have this type of illumination. However, of those that do, approximately 15% have chosen to turn it off. This fact is significantly correlated to the voivodeship of a commune (Appendix 1, point 2.6).

3.4.3. Less Frequently Used Rooms

Data concerning decisions made by communes regarding turning off heating in less frequently used rooms was analyzed. Most of the analyzed communes did not make the decision to turn off heating in archives (65.87%), basements (59.52%), employees' changing rooms (70.63%), nor utility rooms (61.11%). There is no or insignificant correlation with voivodeship, type of commune, population, income per inhabitant, sex of mayor, or sex of treasurer (Appendix 1, points 3.1-3.4).

3.4.4. Hot Water and Heating

Data pertaining to whether communes have decided to discontinue hot water for handwashing in public utility facilities shows that 16.43% of communes have decided not to discontinue hot water for handwashing in their Community/Town Halls. It appears that 72.90% of communes have not decided to discontinue external lighting in their Community/Town Halls, while 27.10% have chosen to do so. 82,98% of communes have not decided to limit the temperature to 19°C in the heating season nor to 25°C during the cooling season in their Community/Town Halls, while 7.02% did not provide applicable data. None of the surveyed communes decided to use waste heat from server rooms to heat-occupied buildings. There was no or insignificant correlation with voivodeship, type of commune, population, income per inhabitant, sex of mayor, or treasurer (Appendix 1, points 4.1,4.3).

3.4.5. Monitoring and Investment

Approximately 42.06% of communes have not decided to invest in renewable energy sources of any kind in their Community/Town Halls, while 4.76% did not provide applicable data. 53.17% decided to invest in photovoltaic panels, and it is the only renewable energy source reported. Only two of the surveyed communes implemented some kind of measurement, monitoring, or control systems for energy management, reported as: "installation of a wireless radiator heating control system in the Municipal Office building", and "implementation of a remote utility reporting system". No significant correlations were found (Appendix 1, point 4.4).

3.4.6. Additional Undertakings

One of the actions recommended by the government was an introduction of organizational improvements and educational activities to encourage office employees to use energy rationally – only one commune reported: "Talk with employees about the rules for using electronic devices and energy saving habits".

In the last, and open question, communes' representatives were given a chance to report undertakings, which came from specific characteristics of the commune. The answers may be divided into groups described in Table 3.

Table 3.
Specific undertakings

Group	Example
Light optimization	1. Switching off the lighting in the corridors; 2. Introducing automatic light switch in corridors and toilets; 3. Reducing the number of light points in office rooms and corridors.
Optimization of electronic equipment	1. Unplugging the refrigerator or reducing the number of refrigerators in the office; 2. When the workday was over, disconnecting the power supply to all office equipment; 3. Limiting the use of air heaters in the autumn and winter season; 4. Rationalizing the use of kettles and coffee machines.
Usage of daylight	1. Cleaning the office building only in the daylight; 2. Using as much daylight as possible by raising the blinds during the day.
Optimization of working time	1. Shortening the time spent working at the computer; 2. Introducing online work from home.
Energy Audit	1. Conducting an audit of the parameters of electricity distribution for all energy consumption points, which will allow for the adjustment of contracts to the needs of a given facility.

Source: own research.

4. Discussion

The relationship between climate change and local government actions is indeed a topic of significant interest and discussion among scholars and policymakers. It involves examining how government policies and regulations at the local level can impact greenhouse gas emissions and energy consumption (Lupa, 2020; Zhang, Zhang, Liang, 2017; Grafton, Kompas, Long, 2014). Before starting the study, three research questions were asked, the first of which concerned communes' actions in accordance with governmental expectations for decreasing energy usage in public infrastructure. It should be noted that when it comes to electricity consumption, only 10-25% (depending on the kind of entity analyzed) of Polish local governments have opted to reduce energy consumption in their buildings. Yet, in other research Other studies conducted in Polish cities also showed that one of the most important barriers hindering the implementation of climate change adaptation activities was the lack of financial resources. This problem was reported in the case of cities belonging to all studied size groups. However, these studies were carried out before the crisis caused by increases in the prices of energy and energy raw materials in 2022, so the possibilities of communes to independently finance changes in infrastructure are certainly lower than before the pandemic (Karaczun et al., 2022). However, a worse financial situation should translate into an increased willingness to save (Niculescu-Aron, 2012). As for the consumption of energy in areas unspecified by the law, such as park lighting or illuminating historic sites, it should be noted that, on average, about half of the communes emphasize reducing consumption. However, these restrictions do not apply to sports facilities, where only approximately 15% of communes have opted to reduce energy consumption. At the same time, a whopping 94% of the surveyed communes declared that they have carried out or planned investments in renewable energy installations on at least one municipal building. These actions can be found in other countries (Thumann, Mehta, 2020), where necessity of RES installation is obligatory. Yet, the worsening fiscal situation of communes may increase the meaning of EU funds in local investments (Bień, 2023).

When analyzing the data from the study, it should be remembered that the study was carried out in the middle of the period related to reducing energy consumption in local government units. This restriction was ordered for the first time, so local governments had no experience in limiting energy consumption in public entities. It is also necessary to remember that in accordance with Art. 37 Section 5 of the Act, managers of public finance sector units are obliged to submit to the President of energy Regulatory Office a report on the implementation of the electricity savings target by March 31, 2024. This means that a full answer to the question of how local government units coped with the task commissioned by the Polish government will only be possible after this date.

In almost 95% of communes, there has been no discontinuation of using hot water in toilets, kitchens, and other areas. The only exception is municipal guard premises, where 30% of communes reported discontinuing hot water usage. It is worth noting that the discussed law does not apply to heating (especially water heating), and in many communes, coal is still used to heat water. Its consumption translates into greenhouse gas emissions and, consequently, affects the achievement of sustainable development goals and climate change. When it comes to heating savings, on average, 36% of the surveyed communes have opted to reduce heating in less frequently used spaces such as dressing rooms or archives. On average, 30% of municipal governments have lowered the temperature in the buildings they manage. Temperature reduction was most frequently implemented in Municipal Offices, and least frequently in nurseries and schools at all levels. Polish communes seem to have the same patterns of heating saving, as Danish cities, e.g. Copenhagen (Roundtable on Finance for Energy Efficiency in Denmark, 2019).

Public buildings' energy efficiency has been the subject of scientific interest of domestic and foreign scientists (Piotrowska-Woroniak, Szul, 2022; Guo et al., 2022; Hu et al., 2023), as well as national policies. Among a variety of models, two were chosen for further description – energy Saving Model (ESM) presented in the Act of 2022 and a model of Energy Saving Interventions.

According to the Act on public finances, the obligation to reduce electricity consumption in public finance sector units may be implemented through cost-free activities or through investment activities. The act includes, among others, the following expenditure activities: 1) limiting external lighting, e.g. turning off every day or holiday lighting in buildings; 2) lowering the room temperature (building heating max. to 19 degrees C, cooling max.

to 25 degrees C); 3) modernization or replacement of lighting; 4) implementation of energy management systems, including measurement, monitoring, and control systems; 5) introducing organizational, educational and informational activities aimed at reducing energy consumption by employees of public institutions; 6) using waste heat to heat buildings. According to this EMS, the surveyed communes undertook most of the activities.

The directions of activities should be intensified to accelerate the sustainable energy transition of Polish local governments in terms of reducing energy consumption in public buildings may refer to policies of The Global Covenant of Mayors (Covenant of Mayors – Europe), which suggest that energy transformation toward climate action should include Sustainable mobility, Circular economy, Just transition, Nature-based solutions and adaptation, Food system sustainability, and Renovation Wave (EnEffect, 2010). The Center for Climate-Energy Analysis suggests, that Communes should focus on similar aspects to achieve Net-Zero economies (Krajowy Ośrodek Bilansowania i Zarządzania Emisjami, 2021). These guidelines are, however, too general and broad to create a single procedural diagram.

Still, the number of actions taken by communes in analyzed fields suggests that lowering the temperature of or total resign from hot water is a sort of policy, that might be taken in more communes (Smith et al., 2021). Limiting the building lighting, or savings in energy used in entities for sports and culture are actions taken only by 25% of communes, which in other countries (Fiaschi, Bandinelli, Conti, 2012). Although investments in RES seem to be the most developed and popular actions, they are taken by up to only 50% of communes. To boost this trend, the investments should be co-financed by the EU (Standar, Kozera, Satoła, 2021).

There has been ongoing debate about whether both expenditure and revenue decentralization impact environmental quality. However, there is no agreement on the connection between fiscal decentralization and environmental quality - certain studies have shown that fiscal decentralization leads to increased environmental degradation due to competitive pressures known as the "race to the bottom." Conversely, other studies have suggested that fiscal decentralization enhances environmental quality by encouraging a competitive "race to the top" (Elheddad et al., 2020). The dynamics of the tax-sharing system, which governs the distribution of tax revenue rights between central and local governments, allows local governments to influence the practical implementation of financial resources and investment ideas. This signifies that they can implement central government policies as a means of vying for sustainable resources, resulting in a "strategic interaction" in the execution of environmental regulations (Zhang, Wang, Zhang, 2021).

Raising energy efficiency of a public building involves various measures and strategies aimed at reducing energy consumption and improving overall sustainability (Ryan, Campbell, 2012; Copiello, Bonifaci, 2015). The author may suggest some steps to consider:

1. **Energy Audit**: Mayors may begin by conducting a comprehensive energy audit of the building. This assessment will identify areas where energy is being wasted and help prioritize improvements (Fresner, 2017).
2. **Lighting**: Mayors may replace traditional lighting with energy-efficient LED bulbs and fixtures. Implement occupancy sensors and daylight harvesting to reduce unnecessary lighting (Dubois, Blomsterberg, 2011; Shailesh, Raikar, 2010).
3. **Appliance Upgrades**: Mayors may replace old, energy-intensive appliances with Energy Star-rated models. Ensure that equipment is properly maintained for optimal efficiency (Rana et al., 2021; Dalal, Saini, 2023).
4. **Renewable Energy**: Mayors may consider installing renewable energy sources other than solar panels, e.g. heat pumps or wind turbines to generate clean energy on-site (Oh et al., 2014; Ardente, Beccali, Cellura, 2011).
5. **Building Automation**: Mayors may implement building automation systems (BAS) to monitor and control energy usage in real time. BAS can optimize lighting, HVAC, and other systems based on occupancy and time of day (Vandenbogaerde, Verbeke, Audenaert, 2023).
6. **Behavioral Changes**: Mayors may educate building occupants about energy-saving practices, such as turning off lights when not in use, using appliances efficiently, and reporting maintenance issues promptly (Lokhorst, Staats, van Iterson, 2015).
7. **Monitoring and Benchmarking**: Mayors may continuously monitor energy usage and benchmark it against industry standards. Regularly review and adjust energy-saving strategies based on data analysis (Cabello Eras et al., 2020).
8. **Financial Incentives**: Mayors may investigate available incentives, grants, and rebates for energy-efficient upgrades from local, state, or federal government programs (Liu et al., 2023).
9. **Energy Management Plan**: Mayors may develop a comprehensive energy management plan that outlines goals, strategies, and responsibilities for improving energy efficiency in the building (Fragkos et al., 2021).
10. **Sustainability Certifications**: Mayors may pursue certifications like LEED - Leadership in Energy and Environmental Design (Fontana, 2019).
11. **Public Awareness**: Mayors may promote the building's energy efficiency efforts to the public and engage with stakeholders to garner support and awareness (Xu, Mumford, Zou, 2021).
12. **Employee Engagement**: Mayors may encourage and involve building occupants and staff in energy-saving initiatives and solicit their input for improvement ideas (Liu et al., 2023).

By implementing these strategies and fostering a culture of energy efficiency, local authorities can significantly reduce energy consumption in public buildings, lower operating costs, and contribute to a more sustainable future.

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Appendix

Table 4.
Statistics

	χ2	df	P-Value	Vc if P-value <0,005	Φ if P-value <0,005
1.1 Limited lighting in the park					
Voivodeship	**47.807**	**15**	**<.001**	**0.470**	
type of commune	8.675	3	**0.034**		
population size	1,625	3	0,654		
income per inhabitant	5,638	3	0,131		
Sex of a Mayor	0	1	1,000		
Sex of a Treasurer	0,402*	1	0,526*		
1.2 Complete turnoff of lighting on some streets at night					
Voivodeship	**60.472**	**15**	**<.001**	**0.400**	
type of commune	2.689	3	0.442		
population size	8,870	3	0,310		
income per inhabitant	**17.561**	**3**	**<0.001**	**0,216**	
Sex of a Mayor	0,705*	1	0,401*		
Sex of a Treasurer	1,220*	1	0,269*		
1.3 Limited street lighting at night					
Voivodeship	**66,245**	**15**	**<0.001**	**0,419**	
type of commune	5,806	3	0.121		
population size	3,849	3	0,278		
income per inhabitant	**18.359**	**3**	**<.001**	**0,220**	
Sex of a Mayor	0,873	1	0,350		
Sex of a Treasurer	0,005*	1	0,946		
1.4 Reduced street lighting intensity					
Voivodeship	**44,842**	**15**	**<.001**	**0.344**	
type of commune	**38.697**	**3**	**<.001**	**0,320**	
population size	**10,885**	**3**	**0,012**	**0,170**	
income per inhabitant	**25,636**	**3**	**<0.001**	**0,260**	
Sex of a Mayor	**4.125***	**1**	**0,042***		**0,029**
Sex of a Treasurer	1.870*	1	0,171*		
2.1 Reduced opening hours of sports facilities					
Voivodeship	23,619	15	0.072		
type of commune	**14.250**	**3**	**0,003**	**0,194**	
population size	11,725	3	0,008		
income per inhabitant	**16,118**	**3**	**0,001**	**0,206**	
Sex of a Mayor	**4,114**	**1**	**0,043**		**0,104**
Sex of a Treasurer	**11,951**	**1**	**<0.001**		**0,188**

Cont. table 4.

2.2 Reduced spa zone operating hours					
Voivodeship	**46.667**	**12**	**<0.001**	**-0.861**	
type of commune	6.514	3	0,089		
population size	**16,227**	**3**	**0,001**	**-0,508**	
income per inhabitant	**23,917**	**3**	**<.001**	**-0,616**	
Sex of a Mayor	0,000*	1	1,000*		
Sex of a Treasurer	0,519*	1	0,471*		
2.3 Not hanging up Christmas street lighting					
Voivodeship	**63,309**	**15**	**<.001**	**0.409**	
type of commune	**22,897**	**3**	**<.001**	**0,246**	
population size	3,053	3	0,384		
income per inhabitant	4,257	3	0,235		
Sex of a Mayor	0,516*	1	0,385*		
Sex of a Treasurer	1,914	1	0,167		
2.4 Resign from commune Christmas tree					
Voivodeship	**42,952**	**15**	**<0.001**	**0.337**	
type of commune	**38,081**	**3**	**<0.001**	**0,317**	
population size	6,033	3	0,110		
income per inhabitant	0,752	3	0,861		
Sex of a Mayor	0,466*	1	0,495*		
Sex of a Treasurer	**9,384***	**1**	**0,002***		**0,166**
2.5 Resign from lighting of municipal monuments after 8:00 p.m.?					
Voivodeship	**36,058**	**15**	**0,002**	**0.309**	
type of commune	2,216	3	0,529		
population size	**31,115**	**3**	**<0.001**	**0,287**	
income per inhabitant	**13,718**	**3**	**0,003**	**0,191**	
Sex of a Mayor	0,477*	1	0,490*		
Sex of a Treasurer	1,014*	1	0,314*		
2.6 Resign from permanent illumination (e.g. fountain illumination) after 8:00 p.m.?					
Voivodeship	**44.633**	**14**	**<.001**	**0.569**	
type of commune	6,802	3	0,078		
population size	1,883	3	0,597		
income per inhabitant	**16,025**	**3**	**0,001**	**0,341**	
Sex of a Mayor	1,558	1	0,212		
Sex of a Treasurer	1,073	1	0,218		
3.1 Reducing heating in archives					
Voivodeship	**52.101**	**15**	**<0.001**	**0.371**	
type of commune	1,671	3	0,643		
population size	**8,084**	**3**	**0,044**	**0,146**	
income per inhabitant	**20.154**	**3**	**<0.001**	**0,231**	
Sex of a Mayor	2,126*	1	0,078*		
Sex of a Treasurer	**8,127***	**1**	**0,004***		**-0,154**

Cont. table 4.

3.2 Reducing heating in basements					
Voivodeship	**61.430**	**15**	**<0.001**	**0.403**	
type of commune	4,016	3	0,260		
population size	**9,717**	**3**	**0,021**	**0,160**	
income per inhabitant	**21,263**	**3**	**<0.001**	**0,237**	
Sex of a Mayor	0,768*	1	0,303*		
Sex of a Treasurer	**10,583***	**1**	**0,001***		**-0,174**
3.3 Reducing heating in cloakrooms					
Voivodeship	**53.741**	**15**	**<0.001**	**0.377**	
type of commune	1,953	3	0,582		
population size	**8,073**	**3**	**0,045**	**0,146**	
income per inhabitant	**40,685**	**3**	**<0.001**	**0,328**	
Sex of a Mayor	0,696*	1	0,404*		
Sex of a Treasurer	**4,485***	**1**	**0,034***		**-0,117**
3.4 Reducing heating in utility rooms					
Voivodeship	**71.258**	**15**	**<0.001**	**0.434**	
type of commune	5,624	3	0,131		
population size	**9,149**	**3**	**0,027**	**0,156**	
income per inhabitant	**22,658**	**3**	**<0.001**	**0,245**	
Sex of a Mayor	0,042*	1	0,837		
Sex of a Treasurer	**7,469***	**1**	**0,006***		**-0,148**
4.1 Restriction on hot water for hand washing at the Commune/Town Hall					
Voivodeship	46.859	15	<.001	0.358	
type of commune	5,142	3	0,162		
population size	2,657	3	0,448		
income per inhabitant	5,740	3	0,125		
Sex of a Mayor	2,480*	1	0,115*		
Sex of a Treasurer	0,028	1	0,867*		
4.2 Limiting external lighting in the Commune/Town Hall					
Voivodeship	**58.443**	**15**	**<0.001**	**0.427**	
type of commune	2,829	3	0,419		
population size	7,123	3	0,068		
income per inhabitant	**17,656**	**3**	**<0.001**	**0,235**	
Sex of a Mayor	0,002*	1	0,819*		
Sex of a Treasurer	**13,187***	**1**	**<0.001**		**-0,212**
4.3 Limit the temperature in buildings, e.g. to 19°C in heating season nor to 25°C during cooling season in Community/Town Halls					
Voivodeship	**37,809**	**15**	**<0.001**	**0.321**	
type of commune	**20,024**	**3**	**<0.001**	**0,234**	
population size	**24,933**	**3**	**<0.001**	**0,261**	
income per inhabitant	1,080	3	0,782		
Sex of a Mayor	0,083*	1	0,774*		
Sex of a Treasurer	0,008*	1	0,927*		

Cont. table 4.

4.4 Investment in renewable Energy resources in Community/Town Halls					
Voivodeship	**70.487**	**15**	**<0.001**	**0.442**	
type of commune	4,116	3	0,249		
population size	2,278	3	0,517		
income per inhabitant	**21,706**	**3**	**<0.001**	**0,246**	
Sex of a Mayor	1,353*	1	0,245*		
Sex of a Treasurer	**29,050***	**1**	**<0.001***		**-0,291**

Note. *Yates Continuity Correction if needed.
Bold font indicates statistical significance. df, degrees of freedom.

Source: own research.