Smart Energy for a Smart City

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Review

Smart Energy for a Smart City: A Review of Polish Urban Development Plans

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Abstract: Smart Energy is a key element of a Smart City concept and understanding the current state and prospective developments of Smart Energy approaches is essential for the effective and efficient energy supply for the needs of the exponentially growing energy demands of contemporary cities. This review analyzes the inclusion of the Smart Energy agenda in Polish Smart City development plans applying content analysis methodology. The stakeholders' involvement, spatial dimensions, Smart Energy conceptions, and Smart Energy key sectors were identified as the most commonly referenced Smart Energy agenda components. Stakeholders' involvement in Smart Energy agendas covers all the crucial key actors—universities, local businesses, and public governance institutions. The spatial dimension components of the Smart Energy agenda comprise the individual, city, regional (sub-regional), country, and international (EU) levels, with the natural dominance of the city's level. The Smart Energy conceptions component shows a profound disparity in the referencing frequency of the four "core" Smart Energy conceptions (renewable energy, energy efficiency, energy-saving technologies, and energy security) and "peripheral" Smart Energy conceptions. Buildings, transportation, lighting, and manufacturing sectors were found to be the only sectors referenced in reviewed urban development plans with regard to the Smart Energy agenda. The research results contribute to the better understanding of the Polish Smart Energy and Smart City planning landscapes and can be helpful in improving the cities' spatial planning strategies.

Keywords: Smart City; Smart Energy; urban development plans; Poland

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1. Introduction

Although there is no universally adopted definition of what a Smart City is and all the existing definitions require further clarifications [1], the significant majority of these definitions include the Smart Energy domain as one of main structural domains of the Smart City concept [1,2]. The importance of Smart Energy for a Smart City function is first of all based on the worldwide rapid growth of the cities and consequently the growing demand for an energy supply [2]. Another factor which determines the importance of energy is its tight interdependence with the successful development of the other Smart Cities structural domains: e.g., transportation and manufacturing [2]. In the worldwide sample of 20 Smart Cities, it was found that increase in the Smart Energy index by 25% doubles the overall Smart Economy index [1].

However, the increased need for a Smart Energy supply in a context of Smart Cities requires taking into consideration the spatial aspect of Smart Energy [2–4], as the Smart Energy provision leads to the increase of energy-specific land demand [3]. This is because a major aspect of Smart Energy sources (e.g., renewable sources) is that they emerge on and require every square meter of land surface, therefore, making the land an ultimate resource for the Smart Energy provision [3]. This makes the Smart City planning, Smart Energy planning, and spatial planning deeply interconnected and be perceived and analyzed not as separate parts, but as a progressive continuum [3,4], which will lead to the improvement of the quality of life and the overall socioeconomic development of the Smart City [3,4].

Despite the importance of the integrated research on Smart Cities, Smart Energy, and spatial planning, there is still a substantial gap in the analysis and systematization of the current state of knowledge on this issue [3], as the academic scholarship has mainly emphasized the energy supply component [5–9], leaving the spatial dimension aside. Only a few studies [10–13] have recently started the drift towards the research on the integrative interaction of urban policy, energy policy, and spatial planning.

Another important shortcoming is the predominant interest in developed countries as the object of the research and some oversight of advances in this area made by the transition economies from the Central Europe region, despite the growing importance of these countries in the current and future increasing demand for energy consumption, due to the progressive socio–economic development of this region. Few studies tackle this issue [14,15] thus emphasizing the pressing need for focus on transition economies and accentuating the specificity of the energy transformations from traditional energy to Smart Energy supply.

Last, but not least shortfall is in the prevalence of studies based on single cities (or just a few cities) as the object of the research, (e.g., [16–21]), which was the natural starting point at the initial phase of the development in this research field. However, the progressive development and pressing need for improvements in this area are giving rise to a trend of using multi-city samples as the objects of the research, (e.g., [22]), to which this review contributes.

This review provides the analysis of how the Smart Energy agenda is reflected in Smart City spatial planning, using the Urban Development Plans (UDPs) of the 17 metropolitan cities of Poland as an object of the research. This aims to fill the aforementioned gaps in understanding the interconnections between the Smart City, Smart Energy, and spatial planning; the multi-city samples gap; and the oversight of the advances made by transition countries.

The UDPs were chosen as the object of the review as they are the representative sample of the cities' strategies in terms of the Smart City concept in Poland, and they comprise the integrated information about the Smart City, Smart Energy, and the spatial planning, which make them a suitable object for this review.

Therefore, the main aim of this review is to analyze how the Smart Energy agenda is embedded in the Polish Smart City plans, by the identification of the main components of the Smart Energy agenda included in Polish Smart City plans and analyzing their representation from the point of view of the recent academic knowledge.

This paper is structured as follows. It begins with the outline of the methodology, the object, and the data for this research in Section 2, "Materials and Methods". Following this, Section 3, "Results and Discussion", proceeds with the analysis of the research results, combined with the discussion on their inclusion and relevance in recent academic literature, followed by the concluding remarks. Section 4, "Limitations and Future Research directions", outlines the limits and prospects for the potential future research. In Section 5, "Recommendations", some suggestions for the key stakeholders involved in the Smart Energy and Smart Cities policies are provided. Finally, Section 6, "Conclusions", completes the paper by summarizing the research results and outlining the paper's contribution to the recent academic scholarship and its potential use for the industry and public policy stakeholders.

As a concluding remark, it is worth to notice that this review is not about the evaluation of the Polish Urban Development Plans, rather it is about the systematization of the Smart Energy agenda's components included in the Smart City plans, which could provide a contribution to the understanding of a Polish Smart Energy and Smart City planning landscape and would potentially be helpful in improving the cities' spatial planning strategies.

2. Materials and Methods

This review is based on a content analysis of the Urban Developmental Plans (UDPs) of 17 Polish cities (Table 1), as these documents were found to be the representative examples of the cities' strategies on the Smart City, Smart Energy, and spatial planning by the Petersen (2018) [23] and Levandowska et al. (2020) [24]. All UDPs in this sample are written in the Polish language and were downloaded from the official web-pages of the cities' administrations. The UDP's start date (year of enactment) was identified either according to the exact statement in UDP's text or according to the statement in the document on when the work on this UDP's project had begun. For some UDPs, the start date was not clearly specified in UPDs text. The average planning horizon for the UDPs selected was about 10 years, with some of them being for more than 20 years.

Table 1. Overview of UDPs selected for the review.

		UDP's Start Date (Year Enacted)	UDP's End Date	Aprx. Planning Horison (Years)	City Size according to Bartoszewicz (2016) [25]	Number of Inhabitants (th.people) as of 1 January 2021	City's Administrative Status
1	Bialystok	2010	2020+	10	large city	297	regional (viovodship) center
2	Bydgoszcz	2020	2030	10	large city	344	regional (viovodship) center
3	Czestochova	2016	2030+	24	large city	218	regional (viovodship) center
4	Gdansk	not stated	2030+	-//-	large city	471	regional (viovodship) center
5	Gdynia	2016	2030	24	large city	245	regional (viovodship) center
6	Glivice	2017	2022	5	large city	177	regional (viovodship) center
7	Katowice	2015	2030	15	large city	291	regional (viovodship) center
8	Kielce	not stated	2030+	-//-	large city	194	regional (viovodship) center
9	Krakow	2018	2030	12	large city	780	regional (viovodship) center
10	Lodz	2021	2030+	9	large city	672	regional (viovodship) center
11	Poznan	not stated	2020+	-//-	large city	532	regional (viovodship) center
12	Rzeszow	2015	2025	10	large city	198	regional (viovodship) center
13	Szczecin	2011	2025	14	large city	398	regional (viovodship) center
14	Torun	2018	2028	10	large city	199	regional (viovodship) center
15	Warszawa	2018	2030	12	large city	1794	regional (viovodship) center
16	Wroclaw	2017	2030	13	large city	642	regional (viovodship) center
17	Zabrze	not stated	2030	-//-	large city	171	regional (viovodship) center

All cities from the sample could be defined as the large-cities according to Bartoszewicz (2016) [25], as the number of inhabitants in all of them exceed one hundred thousand people, and all of them are also the administrative centers of the Polish regions ("*viovodships*"). The number of inhabitants for each city was taken from the Polish Central Statistical Office data [26].

To compile the information about the presence of a Smart Energy agenda in the UDPs selected for this review, the commonly used methodology of content analysis based on a key words search and several steps of proceeding, was applied [27,28].

Specifically for this review, the four stages content analysis using the key word "energy" was employed. First, all entries in the UDPs' texts, which included the word "energy" were identified. Second, only the entries relevant to the Smart Energy agenda were selected for the analysis. Following this, all the entries that were relevant to a Smart Energy agenda were organized into the four most commonly referenced thematic areas i.e., the Smart Energy agenda's components, which are: the stakeholders' involvement, spatial dimensions, Smart Energy conceptions, and the Smart Energy key sectors. Finally, the review of these Smart Energy agendas' components was conducted, aiming to answer the following questions: (1) Which are the main components of the Smart Energy agenda included in Polish Smart City Plans? and (2) How are these Smart Energy agenda's components represented in the recent academic knowledge?

3. Results and Discussion

This section provides a detailed analysis of the four Smart Energy agenda's components identified during the content analysis of 17 UDPs: the stakeholders' involvement, spatial dimensions, Smart Energy conceptions, and Smart Energy key sectors.

3.1. The Stakeholders' Involvement

Representative involvement and diverse representation of Smart Energy key stakeholders in Smart City planning and implementation is a paramount characteristic of the Smart Energy agenda [27,29,30]. Its significance is based on the cooperative nature of stakeholders' collaborations, which provides the intersectoral perspective and accelerates the better understanding and consensus among the key actors [4,31], leading to the joint decisions that are better accepted among the interested groups and are more sufficiently implemented with the lesser risks of the projects' failures [27,31].

However, the competing interests, conflicting objectives, divergent tactics and other barriers [1,4,23] constitute a challenge, which requires flexibility [23], specific communication infrastructures, and collaborative tools [31] in the form of specific platforms and decision support tools, etc. [32,33].

The literature on a Smart Energy inclusion in Smart City planning abandons in numerous taxonomies of the stakeholders' involvement in the planning, decision-making, and implementation processes. Some of these taxonomies just mention the key stakeholders such as: "decision makers, service providers, target groups, and lateral effective stakeholders" [31] and "municipality, utilities, transport companies, citizen groups, market associations" [33]. Further taxonomies classify them by the specific clusters, e.g., Energy Providers and Utility Companies, Building Components Manufacturers, Construction Companies, and Investors and Financiers [32]. Other taxonomies have either categorized them as: institutional, field of expertise, and key sectors (key words) [2], or organized them according to a bottom-up approach within the triple helix system of internal, external, and lateral stakeholders [27].

Almost one-third of the reviewed UDPs comprise the key stakeholders' involvement either in a form of legal entities involved in the UDPs' compilation or as the key stakeholders involved in the Smart Energy Cities' projects. The taxonomy of the stakeholders involved in these projects includes all the main stakeholders playing leading roles in the implementation of the Smart Energy agenda, like Universities, local businesses, and public governance institutions with the projects focused on Smart Energy investment processes, the establishment of Technological Centers for Smart Energy technology transfer, and relevant educational activities aimed at raising the general public awareness of Smart Energy issues.

The future areas of potential improvements of Smart Energy agenda's inclusion in Smart City planning in terms of the stakeholders' involvement could potentially cover the involvement of the so-far under-represented stakeholders like NGOs, community groups, experts' organizations, and the more comprehensive spectrum of collaboration projects which go beyond just the organization of discussion groups and the financing of collaborative projects.

3.2. The Spatial Dimensions

The importance of the specification of the spatial dimensions (spatial scales) for a Smart Energy agenda and Smart City planning is widely recognized, as the different spatial structures (e.g., single building, quarters, municipalities, cities, provinces, and countries) require different strategies and techniques for the planning and implementation of the Smart Energy solutions [2,3,31]. Ideally, each Smart Energy solution proposed by the Smart City planners should be adjusted by its spatial scale applicability.

Recent academic literature provides the numerous classifications of spatial structures (spatial scales) relevant to a Smart Energy agenda 's components included in Smart City planning and implementation. They could roughly be categorized as either pure "dimension-oriented" or "business-driven" classifications of spatial structures. The "dimension-oriented" classifications most commonly comprise the individuals, buildings, quarters, districts, municipalities, cities, regions (provinces), and countries (nations) as the main structural elements [2–4,23], while the "business-driven" classifications include the residential, commercial, and industrial spatial structures [3].

The city-level is the most commonly referred spatial structure of the UDPs included in this review. All seventeen reviewed UDPs have multiple references to the city-level as the main spatial structure of Smart Energy planning and implementation, which is *a priory* naturally, as the Smart City plans are innately city-specific. Other explanations of the dominance of the city-centric approach imply the prevalent role of the cities in the total greenhouse gas emissions [34], the sole responsibility of the cities' governors for setting the Smart Energy priorities in the absence of international agreement on Smart Cities' development paths [4], and therefore, the higher potential of the cities for the implementation of the Smart Energy solutions [31].

The next most commonly referenced spatial structures were the regional (sub-regional) and country levels: three of the reviewed UDPs referenced these spatial structures. Most often, they were mentioned in the context on how the particular city's Smart Energy development plan could align with or contribute to the regional (national) development or the national Smart Energy or Smart City development agendas.

The international (EU level) was another spatial structure mentioned almost as often as the region–country level: two UDPs made references to it, pointing out the importance of the cooperation efforts on an international level for Smart Energy investments and the country's international specialization in the sustainable energy industry (among other specializations).

Although the movement from city-level towards region–country level, and then up to international level is a logical path, the gap between the number of references to the city-level and region–country–international levels is remarkably noticeable. This could be explained by the developmental stage of the incorporation of the Smart Energy agenda into Smart City planning for most of the UDPs reviewed, which provides the avenues for the future improvements of the Smart City spatial plans.

The individuals' level is another under-represented spatial dimension in the reviewed UDPs, with the only two references to the citizens' relevance to a Smart Energy agenda in the context of energy effectiveness and energy poverty issues. Such under-representation of the individual's involvement in a Smart City agenda, and the mainly passive attitude toward their potential involvement, is commonly acknowledged in academic literature and does not constitute a Polish-specific deficiency, but rather a world-wide tendency [27,35]. This is recognized as a substantial deficiency of the Smart Energy agenda inclusion in a Smart City context, as the individuals are the most under-represented group at the planning stage, even though the majority of Smart Energy projects are implemented at the individual level [27]. Therefore, the increased involvement of the citizens in a Smart Energy agenda would substantially improve the Smart Energy policies [35] and contribute to "people-smart sustainable cities" [36].

The commercial and industrial spatial scales were found to be the least represented spatial structures with only one reference to them concerning the potential relevance of small and medium enterprises to a renewable energy agenda and the overall importance of the energy efficiency and renewable energy for a business sector of the city. This, once again, calls for the more comprehensive and diverse representation of all relevant spatial structures in the planning and implementation processes of a Smart Energy agenda in the context of Smart City.

3.3. Smart Energy Conceptions

The review of the various Smart Energy conceptions and technologies referenced in the UDPs shows that renewable energy is the most commonly referenced conception. All the analyzed UDPs include the renewable energy notion, with the prevalent majority of them referencing it on a repetitive basis (Table 2).

This aligns with the academic mainstream findings, where the Smart Energy systems are supposed to be *a priori* 100% renewable systems and are considered to be one of the main aspect of Smart City development [2].

Renewable energy in the literature was also found to be coupled with the energy-efficiency conception, which was found to be the second most commonly referred conception in the reviewed UDPs. Energy saving technologies were found to be the third most commonly referenced Smart Energy conception, followed by the energy security notion, which is either only briefly mentioned in the UDPs without a specific definition or very broadly defined ranging from the sufficient supply of energy to cover the city's needs to the physical security of energy lines. The remaining Smart Energy conceptions and technologies found in the reviewed UDPs were energy security, energy balance, Smart Energy storage, sustainable energy, smart grid, microgrid, energy from waste, energy poverty, and clean energy.

Table 2. A quantified overview of the Smart Energy conceptions and technologies referenced in the UDPs.

Smart Energy Concept	Smart Energy Concept's Definitions	Number of References in Reviewed UDPs
"Core" Conceptions and Technologies		
Renewable Energy	"Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. The examples of few common sources of renewable energy are solar energy, wind energy, geothermal energy, hydropower, ocean energy, and bioenergy" [37] *United Nations' definition*	14
Energy Efficiency	"Energy efficiency refers to the amount of output that can be produced with a given input of energy" [38] *European Parliamentary Research Service definition* "Energy efficiency is the use of less energy to perform the same task or produce the same result" [39] *US Department of Energy, Office of Energy Efficiency and Renewable Energy's definition*	13
Energy Saving Technologies	"Energy saving means a lower consumption of energy and this could be accompanied by changes in the quality or quantity of an output or activity" [40] *United Nations Industrial Development Organization's definition*	12
Energy Security	"Energy security is the uninterrupted availability of energy sources at an affordable price" [41] *International Energy Agency's definition* "Energy security is a stable access to energy sources on a timely, sustainable and affordable basis" [42] *Organization for Security and Co-operation in Europe definition*	8

Table 2. *Cont.*

Smart Energy Concept	Smart Energy Concept's Definitions	Number of References in Reviewed UDPs
"Peripheral" Conceptions and Technologies		
Smart Grid	"Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly. When coupled with smart metering systems, smart grids reach consumers and suppliers by providing information on real-time consumption" [43] *EU Directorate-General for Energy definition* "The digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart. Like the Internet, the Smart Grid will consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to our quickly changing electric demand" [44] *US Department of Energy definition*	3
Energy Balance	"Energy balance is an accounting framework for the compilation and understanding of data on all energy products entering, exiting and being used in a country" [45] *EU–Eurostat definition*	1
Smart Energy Storage	"Energy storage is a means of improving energy efficiency and integrating more renewable energy sources into electricity systems by balancing power grids and saving surplus energy" [46] *EU Directorate-General for Energy*	1
Sustainable Energy	"Sustainable Energy in a broad sense comprises three pillars: energy security, quality of life, and environmental sustainability, each of which contributes to achieving sustainable energy, but none of which individually or even jointly fully describes sustainable energy" [47] *UN Commission for Europe definition*	1
Microgrid	"A microgrid is a local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously" [48] *US Department of Energy definition*	1
Energy from Waste	"Energy from waste (EfW)–is the process of creating energy-usually in the form of electricity or heat but also potentially biofuels-from the thermal treatment of a waste source via technologies such as incineration, Anaerobic Digestion, Gasification or Pyrolysis" [49] UK Department for Environment, Food, and Rural Affairs Definition	1
Energy Poverty	"Energy poverty (at a local level) is Inability of households to ensure their energy needs" [50] *European Commission–Energy Poverty Advisory Hub definition*	1
Clean Energy	"Clean energy refers to energy generated from recyclable sources without emitting greenhouse gases" [51] *Cornell Law School, Legal Information Institute definition*	1

This initial quantitative analysis shows the profound gap between the most commonly referenced Smart Energy technologies and conceptions, (i.e., renewable energy, energy security, energy efficiency, and energy saving technologies) and the least-mentioned conceptions (i.e., smart grid, energy balance, Smart Energy storage, sustainable energy, microgrid, energy from waste, energy poverty, and clean energy), allowing the consideration of the former four conceptions and technologies as the "core" and the rest as the "periphery", thus implying that further research on the reasons for this divergence is needed and advocating for a wider inclusion of them in the UDPs' Smart City agenda.

Another very important characteristic of the prevalent majority of all the reviewed UDPs is that they are not single-focused on a specific Smart Energy conception or technology, but most commonly include at least three conceptions or technologies from the "core" and several others from the "periphery", leading to a more comprehensive inclusion of the Smart Energy agenda in Smart City planning.

As a concluding remark, it is noteworthy that despite being addressed to the general public, most of the reviewed UDPs have not provided the specific definitions or explanations of each Smart Energy conception or technology (except for those which have a glossary as a part of UDP), and are either relying on the self-explanatory nature of some conceptions or are preferring the broad statements over the specific ones [24], which could sometimes lead to the overlapping use of some conceptions.

3.4. Smart Energy Key Sectors

Buildings, transport, ICT, manufacturing industries, and energy sectors *per se*, are commonly acknowledged as the main "domains of intervention" and the key sectors for a Smart Energy agenda in Smart City plans [27,31]. This is mainly due to the significant share of the energy consumption by these sectors in the urban areas, e.g., Abu-Rayash & Dincer (2021) [1], and consequently the higher energy-saving capability of these sectors, was found to range from 25% up to 30% [52].

In the reviewed UDPs the buildings, transportation, lighting, and manufacturing sectors were the only sectors found to be referenced with regard to the Smart Energy agenda, with the remarkable dominance of references to the building sector over all the other sectors. The importance of the introduction of Smart Energy solutions for the building sector was highlighted in ten reviewed UDPs, for the transportation sector in four UDPs, for the lighting sector in four UDPs, and for manufacturing in one UDP, only.

This dominance is not surprising, as the overall and constantly growing importance of the building sector for the Smart Energy agenda in a context of a Smart City is highlighted in several EU directives and has led to the introduction of energy certifications and the definition of the Net Zero Energy Building (NZEB) conception, where the building's operational energy performance is one of the key elements [27]. This key significance of the building sector's energy performance is well-reflected in the reviewed UDPs, where the building-related references are primarily focused on the set of the "core" Smart Energy technologies: i.e., renewable energy, energy security, energy efficiency, and energy saving technologies.

Another distinguishing characteristic of the reviewed UDPs is that despite the significant gap among the building sector and the rest, the interconnection between these four key sectors is found to be very strong, i.e., all the UDPs included at least two key sectors, with a prevalent majority of them including the three key sectors. Such interconnection between the key sectors is found to be very important for the Smart Energy agenda's issues included in Smart City plans, as it allows for more achievable and affordable Smart Energy solutions and is widely recognized within the broad conceptions of "interoperability", "interconnectivity", "integrated focus, and "integrated holistic focus" defined by [4,27,31,53].

3.5. Concluding Remarks

The detailed content analysis of the 17 Polish UDPs allowed for the identification of the following four most commonly referenced components of the Smart Energy agenda: stakeholders' involvement, spatial dimensions, Smart Energy conceptions, and Smart Energy key sectors. All of these Smart Energy agenda components are found to be well-reflected in recent academic scholarship, thus granting the conclusion that this review's findings are in line with the mainstream research in this area, although they also provide a more nuanced picture of the representational specificity of some of these components in the Polish context.

The thorough dissection of the aforementioned four Smart Energy agenda components shows that the development of the Smart Cities' spatial planning in the transitioning Polish economy follows the steps of the developed countries, leading to a more effective and efficient Smart Energy agenda inclusion. Some inconsistencies and divergences found by this review could mainly be attributed to the initial stage of the Smart Energy agenda development in Poland, rather than the transitioning economy specificity, thus, allowing for the smooth inclusion of Polish Smart Energy and Smart City agendas into the wider international and developmental contexts.

4. Limitations and Future Research Directions

This research is based on a sample of a large-sized cities [25] all of which are the administrative centers of the Polish regions (*"voivodships"*), which allowed for the comprehensive analysis of the inclusion of Smart Energy agendas in a context of Smart Cities' planning. However, it calls for the inclusion of the small- and medium-sized towns in the sample for the future research, as energy demand and energy management are dependent on the city's physical size and overall local conditions, and are very "place-specific" in general [11]. In addition, focusing the research on the administrative centers only (a substantial number of which are recognized locally and internationally as a model cities for the Smart Energy solutions) excludes the "ordinary" cities, therefore, suggesting their inclusion in future research samples [23].

Poland was chosen as a country-case for this research due to the specificity of energy transformations in Central European transition countries [24] and an overall call for the in-depth analysis of the specific country-cases from this region [15]. However, future studies would benefit from the inclusion of the other transition countries from the Central European region, as well as other geographical regions, like Asia and Latin America [27].

The addition of not only the transition countries to the future research samples, but also the developed economies, will provide the ground for more comprehensive comparative analysis and would allow the assessment of the specific impact of the socioeconomic and governance factors on the inclusion and development of the Smart Energy agenda in Smart City planning [27].

Extending the focus of the research from the UDPs only to the other energy-relevant, but sector-specific, policy documents (like municipal energy strategies, Low-Emission Economy Plans, Strategies for Responsible Development) would provide the ground for the analysis of the interconnections of the Smart City agenda with the other sector-specific policies.

Going further and considering the broader spatial scale and extending the scope of analyzed documents to the national strategies and international policy documents would allow to analyze how the local Smart Energy and Smart City strategies are embedded in the national and international agendas, showing the ways for the adjustment and improvement of the local Smart Energy and Smart City strategies.

Adding the temporal dimension by providing the retrospective analysis of the earlier past versions of UDPs of the selected cities from the studied sample would reveal the directions in which the local Smart Energy and Smart City policies have been developed in the past and will be developing in the future.

5. Recommendations

This review examined the inclusion of the Smart Energy agenda in 17 Polish Smart City development plans, by conducting the analysis of the main components of the Smart Energy agenda included in these Smart City plans, investigating the quantitative representation of each component of the Smart Energy agenda, and interpreting this quantitative representation in the context of the recent academic knowledge. The stakeholders' involvement, spatial dimension, several Smart Energy conceptions, and Smart Energy key sectors were identified as the most commonly referenced Smart Energy agenda components, each of them with its gaps and deficiencies, and this review could provide the potential avenues for the improvement of future UDPs in terms of the aforementioned components.

The stakeholders' involvement in the analyzed UDPs covers all the main actors involved in the Smart Energy agenda (i.e., universities, local businesses, and public governance institutions), either in the form of the legal entities involved in the UDP's writing, or as a part of the Smart Energy projects' participants. However, the civil society actors, e.g., the NGOs, community groups, and experts' organizations were found to be underrepresented, thus calling for a more inclusive approach for the stakeholders' involvement in Smart City planning.

The spatial dimension of the Smart Energy agenda includes the individual, city, regional (sub-regional), country, and international (EU) levels, with the natural dominance of the city's level, as the Smart City plans are constitutively city-specific. The main deficiencies found were: (i) the significant gap between the number of references to "city-level" versus "region–country–international levels" and (ii) the under-representation of the individual citizen's involvement in Smart Energy agenda planning. While the former could be considered to be a Polish-specific characteristic, attributed to the developmental stage of Polish Smart City planning (as well as the other Central European transition economies), the latter is a widely recognized deficiency for the significant number of Smart City plans worldwide, independent of a country's development stage. Both these deficiencies provide the directions for potential improvements in the Smart Cities' development policies.

A substantial gap was also found with regard to the referencing frequency of the Smart Energy conceptions, with the "core" conceptions like renewable energy, energy efficiency, energy-saving technologies, and energy security being most frequently referenced (sometimes on a repetitive basis) in the reviewed UDPs, with the rest of the Smart Energy conceptions (i.e., smart grid, energy balance, Smart Energy storage, sustainable energy, microgrid, energy from waste, energy poverty, and clean energy), only sporadically referenced. Therefore, some additional work would be required for the more comprehensive incorporation of these "peripheral" conceptions into future UDPs.

Buildings, transportation, lighting, and manufacturing sectors were the only sectors referenced in the reviewed UDPs with regard to the Smart Energy agenda, with the remarkable prevalence of the building sector over the other sectors. Although this disparity was mitigated by the strong interconnection between these four key sectors (which is commonly recognized as a significant achievement) the inclusion of the other sectors in future UDPs would be beneficial for reaching the more achievable and affordable Smart Energy solutions.

The terminology ambiguity is also one of the shortfalls of the analyzed UDPs, as despite being addressed not only to the specialists, but also to the general public, only some of the analyzed UDPs have glossaries included in their texts. Therefore, future UDPs would definitely benefit from adding specific glossaries. It would be helpful for eliminating the potential difficulties in understanding and for avoiding any misinterpretations, as it is found to be quite common that each city applies its own terminology [11] due to the lack of the unified, commonly agreed, and legislatively approved nomenclature of the Smart City and Smart Energy definitions.

All aforementioned tentative recommendations are formulated bearing in mind that analyzed UDPs are mostly in their first or second iteration and they are quite new instruments of public regulation. Therefore, local authorities and other key stakeholders involved in the process of introducing these UDPs deserve recognition, notwithstanding the already identified gaps and deficiencies to be addressed in the next editions of these UDPs.

6. Conclusions

The importance of the Smart Energy solutions for a proper Smart City function is widely recognized and is based on the rapid growth of the cities' increased demand for an energy supply and the pivotal role of energy for the development of other Smart City's key sectors, e.g., transportation, housing, construction, and manufacturing. Using the content analysis of the 17 Polish UDPs, this review identified the most commonly referenced conceptions in these UDPs' Smart Energy agenda components, namely: the stakeholders' involvement, spatial dimension, Smart Energy concepts, and Smart Energy-related sectors.

Despite the substantially comprehensive coverage of the aforementioned components, some deficiencies were also found, e.g., underrepresentation of the civil society stakeholders, oversight of the national and international dimensions, "core-periphery" conceptual bias, selective focus on the specific industry's sectors only, and some terminological ambiguity. All these shortages are the natural result of the developmental stage of Smart City planning in transition economies from the Central European region and are also compelling and intrinsic directions for the potential avenues for the further improvement of the next iterations of the Polish UDPs.

This review's results are generalizable for wider regional and sectoral contexts and are transferable to other Smart Energy and Smart City-related settings, thus providing the potential benchmark's value for future academic studies in this area. They could also be used by local authorities and other key stakeholders for the further improvement of the succeeding Smart Cities' spatial planning strategies.

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