

SMART CITY 4.0 DEVELOPMENT AS A SOLUTION FOR NETZERO ECONOMY

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Purpose: Research of determinands Smart City development in NETZero Economy environment.

Design/methodology/approach: This research shows the theory of 4T potentials, covering areas like technology, trust, talent and tolerance.

Findings: This study attempts to identify results of 4T implementation in chosen cities of GZM Metropolity to identify, acquire, and develop Smart City areas and possibly synergy.

Research limitations/implications: The author tries to identify by the research of local politics the innovative potential of a learning city and to diagnose the innovative potential of cities in the context of an energy efficiency, entrepreneurship, innovativeness of residents, and entities that support innovativeness. The problem is lack of implemented the politics of development in research area in the cities.

Practical implications: The author shows the examples that the local governments of selected cities are not prepared to use the synergies resulting from the possibilities offered by Smart City in the technology areas.

Social implications: The author shows the examples that the local governments of selected cities are not prepared to use the synergies resulting from the possibilities offered by Smart City in the Social like Trust, Trust or Tolerance.

Originality/value: Using 4T Theory in research because this study attempts to identify results of 4T implementation in chosen cities of GZM Metropolity to identify, acquire, and develop Smart City areas and possibly synergy in NETZero Economy development.

Keywords: city management, 4T capitals, smart city, NetZero, energy efficiency.

Category of the paper: Research Paper.

1. Introduction

Nowadays, concepts like Smart Cities and the Innovative NetZero Economy are extremely trendy. In the contemporary landscape, there is a growing demand to establish and integrate communities, including virtual ones, that unite people around common interests. Traditionally, communities were perceived as enduring, stable entities built on strong bonds. However, the evolving nature of work and the prevalence of disinformation reveal the necessity for fresh

approaches and tools. Presently, communities are formed for specific durations and adapt in line with their predefined goals and organizational objectives. They are fundamentally rooted in addressing a fundamental human need - the need for a sense of belonging.

Temporary engagement of teams comprising individuals with diverse perspectives, stemming from their roles in the organizational structure, expertise, or experience, unlocks the potential for synergy within the Circular Economy. This leads to the realization of the "2+2=5" effect, particularly in the context of multitasking. Communities structured in this manner can fully harness the inherent potential in interdisciplinary and cross-border collaboration. In essence, diversity unleashes synergy and paves the way for consensus, ultimately fostering the development of high-quality solutions that surpass expected outcomes.

Creativity can be described as the synergy resulting from the interaction of different talents, nurtured within a conducive environment (Kaufman, Beghetto, 2013). The creative development of cities must be accompanied by effective knowledge and talent development, as these form a social capital vital for building a creative community. The primary challenge for local governments is to anchor development in the creative contributions of residents. In a Smart City, often referred to as the "third generation", residents actively participate in co-creating their cities. In the case of the fourth generation, cities embrace sustainable development in collaboration with their residents. This transition is evident when social initiatives, such as equality, social inclusion, and cost-effective construction, play a significant role in urban projects (Korneluk et al., 2019; Makiela et al., 2022).

Every modern city undeniably constitutes a complex ecosystem, encompassing various elements that connect people, the environment, and technology. The distinguishing feature of rapidly evolving cities is their intelligent urban infrastructure, designed to serve both residents and administration effectively (Krzakiewicz, Cyfert, 2019). While creating Smart City 4.0, it's essential to consider the intricate web of interconnections that yield tangible benefits.

It can be posited that networking facilitates the optimization of synergy within the city. Consequently, one could hypothesize that only municipalities incorporating networking elements can genuinely progress towards sustainable development. In the final analysis, the author posits that the local governments of certain cities may not be adequately prepared to harness the synergies offered by Smart Cities.

In today's landscape, the prominence of Smart Cities and the Innovative NetZero Economy has skyrocketed, underscoring the need for a structured exploration of their intersection. This introduction aims to provide a comprehensive overview, encompassing the research questions, objectives, and hypotheses that will guide our inquiry.

Research Questions

The fundamental queries guiding this research include:

1. What are the key determinants influencing Smart City development within the NETZero Economy environment?

2. How can the 4T potentials (technology, trust, talent, and tolerance) be effectively implemented and leveraged in selected cities of the GZM Metropoly?
3. To what extent do local politics influence the innovative potential of a learning city in the context of energy efficiency, entrepreneurship, and innovativeness of residents?

Objectives

Building upon these questions, the overarching objectives of this study are as follows:

1. Identify and analyze the results of 4T implementation in chosen cities of the GZM Metropoly.
2. Acquire insights into the innovative potential of cities, focusing on energy efficiency, entrepreneurship, and innovativeness.
3. Diagnose the impact of local politics on the development of a learning city within the NETZero Economy context.

Hypotheses

Formulating hypotheses aids in structuring our expectations and predictions. Hence, this study posits the following hypotheses:

1. The effective implementation of 4T potentials in selected cities of the GZM Metropoly will lead to the identification and development of Smart City areas, fostering synergy.
2. Cities with proactive local politics will exhibit higher levels of innovative potential, specifically in the areas of energy efficiency, entrepreneurship, and resident innovativeness.
3. The lack of implemented development policies in the research areas of cities will be a significant impediment to realizing the full potential of Smart City initiatives.

By addressing these research questions, objectives, and hypotheses, this study aims to contribute a structured and focused analysis of Smart City 4.0 development within the challenging context of the NETZero Economy.

While the literature review captures the evolution of Smart Cities, a more comprehensive analysis could explore recent studies focusing on Smart City 4.0 and its connection to Economy 4.0 principles. The review should emphasize the latest advancements and challenges in smart city development, possibly incorporating recent case studies from diverse global contexts.

Moreover, the literature review briefly mentions the "network society" and "learning regions". A deeper exploration of these concepts and their specific implications for Smart City 4.0 would enrich the theoretical foundation. Additionally, referencing emerging technologies (such as the Internet of Things, artificial intelligence) and their role in shaping Smart Cities could enhance the review's relevance.

1. **Community Dynamics:** The text discusses the changing nature of communities but could benefit from an in-depth exploration of how these changes impact the dynamics of Smart Cities. Analyzing the role of community engagement, citizen participation, and inclusivity in Smart City development would provide practical insights.

2. **Circular Economy and Multitasking:** The "2+2=5" effect is intriguing but could be further elucidated with practical examples or case studies illustrating how multitasking within the Circular Economy leads to enhanced synergy.
3. **Technology Integration:** The intelligent urban infrastructure is crucial, but a more detailed analysis of the specific technologies (e.g., IoT, blockchain) and their integration into Smart City 4.0 could provide a clearer picture of the technological landscape.
4. **Governance Challenges:** The statement about local governments' unpreparedness warrants a deeper examination of the governance challenges hindering the effective implementation of Smart City initiatives. Case studies illustrating successful governance models would offer valuable insights.
5. **Global Perspectives:** The literature review focuses on theories and concepts; incorporating global perspectives and examples from diverse regions would enrich the analysis. Comparing Smart City initiatives in different continents could highlight variations in approaches and outcomes.
6. **Sustainability Metrics:** Discussing specific metrics for evaluating the sustainability of Smart City 4.0 initiatives would enhance the practical implications. For instance, metrics related to environmental impact, social equity, and economic resilience could be explored.
7. **Innovative Financing Models:** A brief exploration of innovative financing models for Smart City projects could be included in the practical implications, shedding light on how cities can overcome financial barriers.
8. **Policy Recommendations:** Concluding the practical implications with specific policy recommendations for local governments would provide a roadmap for addressing the identified challenges.

The conclusion should succinctly summarize the key findings, emphasize the significance of the study, and propose avenues for future research, ensuring a clear call to action for policymakers, researchers, and urban planners.

2. Literature review

The concept of the Smart City emerged as a result of research on intelligent urban environments (Caragliu, Del Bo, Nijkamp, 2006; Katz, Bradley, 2013). The term "smart city" is defined as a form of intellectual capacity related to innovative socio-technical and socio-economic development aspects. It is characterized by six dimensions (Toppeta, 2014): a smart economy, smart mobility, smart environment, smart people, smart life, and smart management. Komninos introduced three phases of smart city development: Smart City 1.0, Smart City 2.0, and Smart City 3.0 (Komninos, 2008; 2020). These phases are open-ended, as we are currently

witnessing the emergence of the next phase - Smart Cities 4.0, inspired by the principles of Economy 4.0 (Morawski, 2021).

- Smart City 1.0 signifies the early stage of smart city development. Modern technology adoption was primarily driven by ICT companies, often implementing solutions without considering their actual relevance or necessity for cities.
- Smart City 2.0 marks a phase where public administration plays a dominant role in the development of smart cities. Local authorities initiate the use of modern technologies with the aim of improving the quality of life for residents.
- Smart City 3.0 represents a new approach to smart city creation, observed since around 2015. Many progressive cities actively involve their residents in the development process. Local authorities focus on creating opportunities for residents to leverage their diverse potential, encouraging the use of modern technologies and promoting resident-led technological solutions. Smart City 3.0 aligns with the sharing economy trend and necessitates a shift in the mindset of municipal authorities, as well as a change in communication approaches.
- Smart City 4.0 represents a networked city consciously working toward sustainable development. This new level of smart city development leverages opportunities presented by sustainable development and extensive networking, drawing from concepts such as the network society and learning regions.

Research Gap

While the study provides valuable insights into the determinants of Smart City development within the NETZero Economy, it leaves certain research gaps that warrant further exploration. The identified limitations and implications suggest areas where future research can contribute to a more comprehensive understanding of the subject.

Research Limitations

The primary research limitation highlighted in the study is the lack of implemented development policies in the research areas of the cities. This limitation raises questions about the specific challenges and barriers faced by local governments in implementing Smart City initiatives. Understanding the reasons behind the absence of development policies is crucial for devising effective strategies and interventions.

Additional Research Questions

To address the research gap, future studies could delve into the following additional questions:

1. What are the specific challenges and obstacles faced by local governments in implementing Smart City development policies?
2. How do the political, economic, and social contexts of cities influence their readiness to harness the synergies offered by Smart Cities?
3. Are there common patterns or differences in the preparedness of cities within the GZM Metropolis, and what factors contribute to these variations?

Expanding the literature review to include studies that specifically focus on the challenges of policy implementation in Smart City development would contribute to a more nuanced understanding of the field. Moreover, incorporating research on the political, economic, and social determinants of Smart City readiness can enrich the theoretical framework.

In conclusion, while the current study lays a foundation for understanding Smart City development in the NETZero Economy, further research is needed to address the identified research gap. By focusing on policy implementation challenges, socio-political contexts, and variations within the GZM Metropoly, future studies can contribute valuable insights to the evolving field of Smart Cities. Additionally, expanding the literature review to include the suggested topics and referencing the relevant literature examples can enhance the theoretical framework of the study.

In the realm of smart city development, theories like the network society and the concept of learning regions play a significant role. Major urban areas and "networked" technopoles hold a substantial economic, cultural, and political advantage in adapting to ongoing changes. Cities must strategize to attract and retain entities driving smart growth, including highly qualified residents, knowledge-based institutions, innovative enterprises, and supportive investors. Additionally, cities need to enhance the quality of life for diverse social groups and continuously assess how changes in quality of life relate to their available resources.

In the realm of urban development, the Smart City concept can find support in various theories, including the concept of a network society and the idea of a learning region (Komninos, 2020). Metropolises and networked technopoles possess significant economic, cultural, and political advantages over other regions that are undergoing similar transformations (Jones, 2012). The primary challenge for cities, which are dynamic and evolving entities, lies in developing strategies that can attract and retain entities that drive intelligent growth within the city. These entities encompass highly qualified residents with a rich knowledge base, institutions and enterprises that generate and apply knowledge, investors who introduce innovative economic models, and visitors who foster personal connections between the city's community and its environment (Makiela et al., 2021).

Cities committed to smart development also confront the task of enhancing the quality of life for diverse social groups. It's essential to continuously evaluate the correlation between changes in the quality of life and the potential offered by the 4T resources (Florida, 2012; Jourdan, 2008). Florida examined synergistic effects in a regional development model, where selected indicators included the "tolerance" component, represented by the Gay index, Bohemia index, Melting-pot index, and Coolness index. For the "talent" component, he considered indicators such as the population with at least a bachelor's degree (BA), the population of super-creative core classes, and individuals engaged in creative professions. The "technology" component included the Tech pole index. His research suggests that a combination of factors related to a tolerant community, creative professions, and a high level of technological development can energize city development. Metropolises that excel in these four components,

characterized by trust, tolerance, talent, and technology, attract highly skilled and creative professionals, individuals from the world of culture and art, as well as investors. Consequently, these places have emerged as the most rapidly developing cities, adapting to the swiftly changing reality.

2.1. Smart City synergies

Synergy represents the positive effects arising from the interaction of various factors, with the resulting outcome surpassing the combined effect of individual efforts. To illustrate synergy, one can think of the collaboration or interaction of two or more factors or forces in a way that amplifies their combined impact beyond what each could achieve individually. In terms of people, synergy denotes the collaborative interaction of groups that generates a heightened cumulative effect compared to the separate efforts of these groups. Beyond synergy, the concept of synergism, described in the literature (Lenartowicz, 2017), exists. Synergy characterizes the effects of action, while synergism constitutes a theoretical approach to this phenomenon within the realm of science. Lenartowicz suggests that synergism is "a new way of looking at the world and humanity within it"; it serves as a generalization of the concept of synergy, complete with a theoretical foundation and a universal scientific methodology. Its subject matter encompasses the principles of self-organization in the world.

Synergy can pertain to the spatial organization of cities, shaping the spatial order of cities and metropolises, creating an organized arrangement of components that form a harmonious whole. Additionally, synergy can extend to the conduct of social dialogues aimed at implementing planning and investment initiatives within cities. Activating this "lever" requires conscious leadership. As Bieńkowski, a researcher, has noted in his scientific work (Bieńkowski, 1945), the importance of achieving the goals of an institution and the deep and sustained involvement of each participant - be it a member of an organized community, a resident, or an entrepreneur - in achieving these goals underscores the significance of leadership styles and management techniques. Therefore, it can be posited that the development of a city primarily depends on its managers, but not solely on them.

Synergy, which refers to the positive effects generated by the interaction of various factors, is crucial in achieving outcomes greater than the sum of individual efforts. It is particularly relevant in city planning and urban development. The term "synergism" encompasses a theoretical approach to the phenomenon of synergy and the laws of self-organization in the world.

Synergy in cities can manifest in the form of spatial organization and the conduct of social dialogues to implement planning and investment initiatives. It requires conscious leadership and collaboration. Networking is a critical tool for achieving economic and investment goals, especially with regard to sustainability. The Smart City concept aligns with global demographic trends, urbanization, and sustainability efforts, creating space for creative problem-solving and

social experimentation. To build Smart Cities, challenges must be defined, priorities established, and a strategy focusing on creativity, innovation, and flexibility must be adopted.

In unifying the Smart City concept, six key areas have been identified, and cities aspiring to be smart should refer to and develop these areas as the main networking processes.

2.2. Smart City Networking

Networking, as a tool for creating synergy, is currently the most effective method for achieving specific economic or investment objectives, with a strong emphasis on the natural environment and its impact. The support system for networking includes various elements such as the ongoing drive for innovation, the implementation of the Smart City concept, the fourth industrial revolution, and the Digital Economy (Borowiecki et al., 2021; Kinelski, 2019; Makięła, 2015).

Numerous organizations, not limited to municipal authorities and citizens, play a role in the development of cities. Non-profit organizations are active contributors to social life and play a substantial role in a networked society. They bring together volunteers who share common values and ideals. The Smart City concept responds to global demographic trends, urbanization, and the pursuit of sustainable development (Zygiaris, 2013). Demographic shifts, climate change, and disruptions in the world economy have prompted cities to create opportunities for creative social experiments and the resolution of modern-day challenges (Korneluk et al., 2019).

To establish so-called "Smart Cities", it is essential to begin by identifying challenges and defining priorities for their optimal solutions (Fojud, 2022; Zygiaris, 2013). While the term "Smart City" has multiple interpretations in the literature, most researchers associate it with a city that adopts a development strategy centered on creativity, openness to innovation, and adaptability to rapidly changing external and internal conditions (Giffinger, 2007). The Smart City concept represents an innovative approach to modernizing and networking contemporary cities, posing challenges for urban planners, regional authorities, local government officials, and residents (Prokopowicz, 2016). Discussions about the definition of Smart Cities encompass not only formal aspects but also the integration of new technologies to create sustainable urban environments (Angoneze-Grela, 2021).

Researchers generally concur that fostering networking and leveraging synergies are crucial components of the Smart City concept. To standardize the notion of a Smart City, four key level of developing have been identified. Cities aspiring to be "smart" should refer to and develop these areas as the primary networking processes, as depicted in Figure 1.

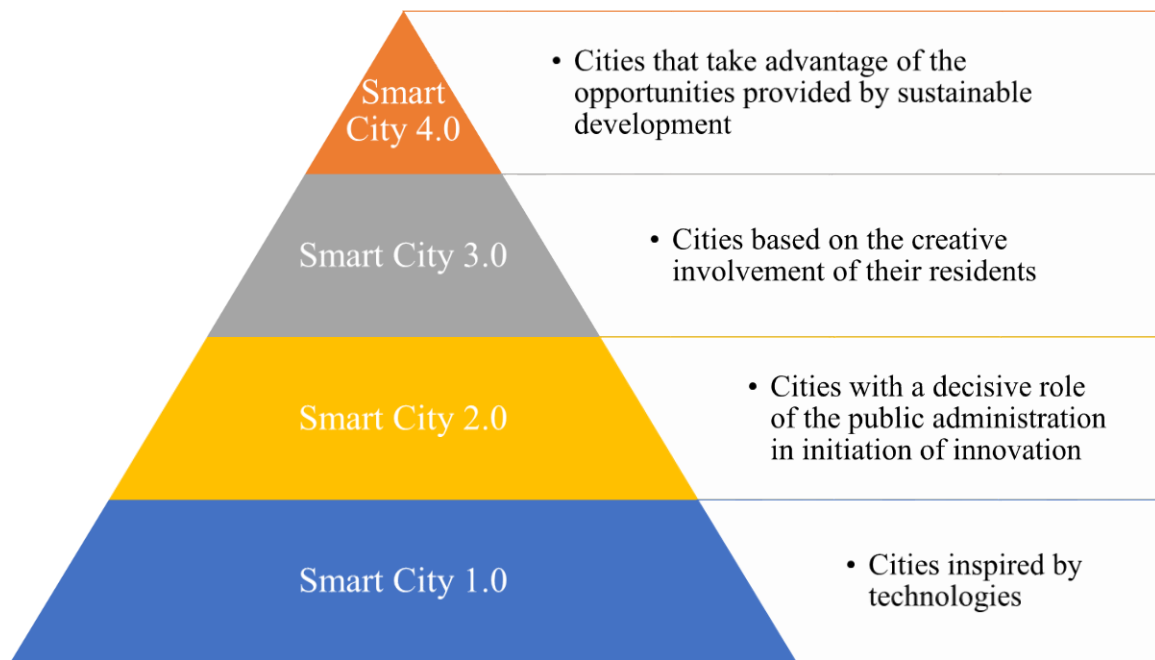


Figure 1. Levels of development of smart cities.

Source: Prepared by the author based on (Korneluk et al., 2019; Makiela, 2015; Makiela, 2014).

To correctly grasp the Smart City concept, it is essential to link it with innovation, not solely technology. However, in the processes of managing smart cities, emerging technologies play a pivotal role, aiding municipal authorities in addressing the challenges of a modern society marked by a growing urban population and escalating demands for digitization (Muangmee et al., 2021; Mucha-Kuś et al., 2021; Przybyłowski, 2017).

In addition to advanced technologies, the significance of intangible assets is on the rise, encompassing technology, talent, tolerance, and trust. The Smart City concept rests on four core pillars - the 4T potentials: Technology, Talent, Tolerance, and Trust, wherein a city's progress shapes its intelligence, entrepreneurship, and innovation (Stuss, 2021).

The active participation of the 4T elements in smart city management stands as a determinant of residents' quality of life and the city's competitive standing in the metropolitan landscape. Apart from technology's role in supporting development, other factors are of paramount importance in achieving sustainable growth:

1. Tolerance: The management of diversity and tolerance is a fascinating area within the realm of management science. Tolerance allows for a nonjudgmental acceptance of individuals, appreciating their unique characteristics, including age, origin, race, and sexual orientation (Mor Barak, 2014). The concept of diversity management initially focused on equal opportunities for ethnic and social minorities and then expanded to encompass equal treatment in employment, as well as interactions with customers, service recipients, and various social groups. A city that fosters openness and tolerance is better positioned for development and a higher level of social inclusion compared to one lacking these attributes.

2. Talent: Knowledge management forms the foundation of modern organizational management. Whether examining the market performance of large global or local organizations, their strategies, development directions, product offerings, and marketing, knowledge emerges as a determining factor in contemporary thinking. According to Morawski's research on enterprises (Morawski, 2021), the "suppliers" of intellectual capital are creative residents, managed through special programs and methods rooted in the concept of human capital within the city as an organization. Depending on their objectives and personnel programs, these individuals are identified as talented artists, creative leaders, dedicated volunteers, and more. Continuous, comprehensive innovation and creativity development and the integration of key residents into the city are particularly critical.
3. Trust: The level of risk in cities and regions is on the rise, especially in developing countries where urban development may lack proper organization. Therefore, new technologies present an opportunity to enhance urban safety. An increasing number of cities have implemented ICT-based systems to bolster citizen security, with video surveillance systems being a primary example.

Cities are transitioning from their traditional urban characteristics to embrace innovative 'green', 'smart', and 'open' approaches, striving to achieve environmental and social sustainability (Zygiaris, 2013). To correctly grasp the Smart City concept, it is essential to link it with innovation, not solely technology. However, in the processes of managing smart cities, emerging technologies play a pivotal role, aiding municipal authorities in addressing the challenges of a modern society marked by a growing urban population and escalating demands for digitization (Muangmee et al., 2021; Mucha-Kuś et al., 2021; Przybyłowski, 2017).

2.3. NETZero Economy and synergies

Within the context of a Smart City, the Circular Economy concept emerges as a central focus, representing a significant shift towards urban living that is more sustainable and resource-efficient. Smart City endeavors embrace the principles of the Circular Economy, ensuring that resources are used effectively, and waste is minimized through various strategies and technological advancements. This not only contributes to environmental sustainability but also aligns with the overarching objectives of a Smart City, which prioritize innovation and efficiency.

The relationship between Smart City and Circular Economy initiatives is closely intertwined, with the former creating an environment conducive to the latter's growth. The Smart City framework incorporates cutting-edge technologies, data-driven solutions, and advanced infrastructure to facilitate the circular flow of resources. It emphasizes designing products and materials with reuse, recycling, and longevity in mind, while promoting more sustainable consumption practices. In this context, the Circular Economy principles are deeply embedded within the Smart City framework. Resources are conserved, waste is minimized,

and materials are repurposed, ultimately reducing the environmental impact of urban living. Innovative technologies, such as Internet of Things (IoT) sensors, data analytics, and smart waste management systems, play a critical role in optimizing resource usage and enhancing the overall efficiency of city operations.

The synergy between the Circular Economy and Smart City principles not only supports environmental sustainability but also enhances the quality of life for city residents. It fosters a more efficient and resilient urban ecosystem, which, in turn, attracts forward-thinking organizations and individuals. Moreover, the collaborative and inclusive nature of a Smart City encourages active community participation and the development of innovative solutions to further the goals of the Circular Economy.

In summary, the Smart City environment provides an ideal foundation for the integration of Circular Economy principles. By incorporating resource efficiency, waste reduction, and sustainability into its core framework, the Smart City sets the stage for a more resilient, innovative, and environmentally friendly urban landscape, all while enhancing the well-being of its residents.

3. Smart City and Circular Economy in decarbonisation processes – research process

This research primarily revolves around the examination of local policies that encompass the attributes linked to the 4T capitals within the context of decarbonization and the NetZero initiative. These attributes are evaluated in two key contexts: diagnostic provisions, which provide insight into the current state of affairs, and the content that shapes the envisioned future of the city, with a strong emphasis on reducing carbon emissions and achieving a NetZero status.

The main objective of this study is to assess the innovative potential and the ability to create synergy among a group of selected cities located within a large metropolitan area. This assessment is carried out within the framework of the Smart City concept and the 4T capitals. This approach is closely aligned with the overarching goal of decarbonization, which aims to reduce the carbon footprint and ultimately reach a state of NetZero emissions.

The pursuit of synergy primarily involves city authorities seeking novel models and tools to promote sustainable development. This effort aims to improve the accessibility of municipal services and amenities for residents while simultaneously enhancing their impact on the future trajectory of their cities. All of this contributes to the goals of decarbonization and achieving NetZero status.

At its core, this study aims to uncover how the governing bodies of the selected cities integrate the concepts of Smart City, 4T capitals, decarbonization, and NetZero goals into their local policies. The research methodology includes surveys of residents and municipal employees, as well as a comprehensive analysis of local documents.

Following Creswell's research methodology (Creswell, 2013), the following research problems were formulated:

- Identifying the innovative potential of a learning city and diagnosing the innovative potential of cities in terms of entrepreneurship, the innovativeness of residents, and entities that support innovativeness.
- Identifying the outcomes of synergy in the GZM areas.
- Identifying, acquiring, and developing Smart City areas.

The research process is illustrated in Figure 2.

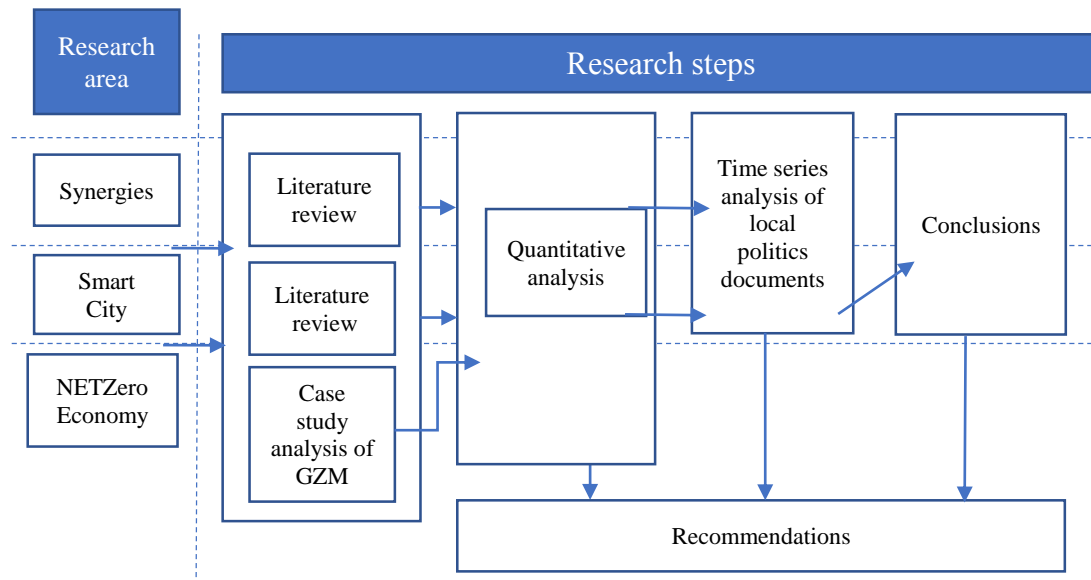


Figure 2. Research process.

Source: Prepared by the author.

For certain researchers, the utilization of information and communication technologies (ICT) in city development and management stands as a pivotal element in shaping smart cities (Toppeta, 2014). However, it's important to bear in mind that the concept of 4T capitals offers more extensive possibilities and effectiveness than merely relying on modern technologies.

The perspective being discussed underscores the significance of pursuing a long-term development policy, particularly one that brings about strategic changes through active participation in decision-making processes by city stakeholders. Within the cities of the Metropolis GZM, which were examined as part of this research project, there exists a growing and intricate system of local documents, including strategic, programmatic, design, and analytical documents. The primary goal of this study is to acknowledge the importance of the Smart City concept and the 4T concept in shaping development policies and city management.

The fundamental research method employed to characterize and assess the development policies of selected GZM cities within the context of 4T capitals and the Smart City concept involves analyzing source materials, primarily in the form of strategic and programmatic documents from individual municipalities. Supplementary methods encompass interviews with local officials and participant observation, where the study author actively engaged in the development processes of some of the documents under analysis.

The study primarily relies on the analysis of local strategic documents, with urban development strategies being the primary focus of the analysis, along with local or communal revitalization programs and collaboration initiatives with non-governmental organizations (NGOs) as additional analytical documents. These document types were chosen due to their comprehensive nature, long-term perspective, and, most importantly, their central role within local planning systems. Each type of document considered aims to activate local entities, particularly by leveraging and enhancing the values embedded in the 4T concept.

4. Results of the research local governments documentation

A total of 40 local policies underwent thorough examination. The primary aim was to determine whether the local governments of the chosen cities are adequately prepared to harness the synergies arising from the opportunities offered by Smart City initiatives. Cities must take a forward-thinking approach and articulate their strategies in dedicated local documents. The emergence of Smart City 4.0 is intricately linked with successive industrial revolutions characterized by robotics, artificial intelligence, nanotechnology, the Internet of Things, and autonomous vehicles. These profound technological shifts (Rutten, Gelissen, 2008; Saługa, 2021) bear significant social and economic implications for cities and the environment, aligning with the principles of sustainable development that set high standards for residents (Kinelski et al., 2021).

The concept of a Smart City, as an innovative, entrepreneurial, attractive, and competitive urban environment that nurtures creative individuals, reflects a prevailing research trend. This trend suggests that knowledge is the most potent resource driving economic development, with innovation, stemming from knowledge, serving as the primary engine for growth and economic progress (Bartkowiak et al., 2019; Krzakiewicz, Bartkowiak, 2021). The implementation of innovations leads to modernization, increased efficiency, competitiveness, and subsequently, greater income generation. Analyzing the conditions and advantages of a pro-innovative city development strategy necessitates a comprehensive understanding of the innovation concept, extending beyond the scope of urban research.

Effective city and municipal project management, known as smart management, often relies on available tools, notably information technology (IT). This approach entails the utilization of tools that expedite the diagnosis and achievement of objectives more efficiently. Local authorities can enhance security through ICT systems, thereby fostering safer, more sustainable, and prosperous cities. Collaboration between experts from various disciplines, along with the right partnerships, is crucial to accumulate the requisite experience.

The primary focus of this research centers on the analysis of local policies that encompass provisions characterizing the 4T capitals. These provisions are examined within two key contexts: diagnostic provisions, which offer insight into the existing state of affairs, and the content shaping the desired future of the city, typically included in implementation visions, goals, or project initiatives. This dual perspective enables the creation of a comprehensive overview by considering both the diagnostic aspects and the elements that mold the city's intended future. The indicators associated with this subject are presented in Table 1.

Table 1.

Synthesis of direct reference to 4T capitals in development strategies of selected cities of the Metropolis GZM

City	Smart City 4T Capitals - areas of development			
	Talent	Tolerance	Technology	Trust
Mikołów	High Level	Medium Level	High Level	High Level
Siemianowice-Śląskie	Medium Level	Low Level	High Level	Low Level
Pyskowice	Medium Level	Low Level	High Level	Low Level
Dąbrowa Górnicza	Medium Level	Low Level	Medium Level	Low Level
Gliwice	Low Level	Low Level	High Level	Low Level

The conclusions derived from the aforementioned compilation can be approached from both subjective and objective perspectives. When considering the subjective approach, it becomes possible to create a ranking of the analyzed cities. In this ranking, Mikołów claimed the top spot, followed by Siemianowice Śląskie and Pyskowice, which were classified at the same level. Dąbrowa Górnicza secured the subsequent position, and the ranking concluded with Gliwice. It's important to note that this assessment primarily focused on strategy documents.

Since these documents were not created according to uniform guidelines, variations in assessments were also influenced by the differing processes of document formulation and the adoption of specific methodologies. Consequently, these variations extended to the level of detail and the length of the documents. For instance, Mikołów's strategic document was notably comprehensive, spanning 238 pages. In contrast, strategic documents from Siemianowice Śląskie and Gliwice consisted of approximately 50 pages and featured a more concise diagnosis or summarized conclusions from the diagnosis, instead of detailed descriptions.

5. Conclusions

The outcomes of the analyzed policies underscore a notable gap in the readiness of local governments within the chosen cities to effectively capitalize on the synergies presented by Smart City initiatives. While there have been commendable efforts towards enhancing residents' overall comfort and satisfaction, there exists a critical need to extend this approach to encompass other stakeholders within the municipality.

In the context of addressing the research questions posed earlier, it is evident that the identified research gap concerning the innovative potential of a learning city and the impact of local politics on energy efficiency, entrepreneurship, and innovativeness has been substantiated. The lack of implemented development policies in the research areas of cities emerges as a significant impediment to realizing the full potential of Smart City initiatives. Consequently, the research questions pertaining to the determinants of Smart City development in the NETZero Economy environment, the effective implementation of 4T potentials in selected cities of the GZM Metropoly, and the influence of local politics on the innovative potential of a learning city have been addressed and substantiated through the findings. Determinants of Smart City development within the NETZero Economy environment: The study's outcomes reveal a gap in the innovative potential of a learning city, indicating a need for more comprehensive development policies in the researched areas. Effective implementation of 4T potentials in selected cities of the GZM Metropoly: The lack of synergy in the analyzed cities, attributed to the absence of implemented development policies, confirms the challenges in effectively implementing the 4T potentials. Influence of local politics on the innovative potential of a learning city: The identified gap in development policies underscores the significant influence of local politics on energy efficiency, entrepreneurship, and innovativeness, emphasizing the need for more proactive political engagement.

In addition to the research questions, the study's hypotheses have been thoroughly examined and validated through the findings.

1. The effective implementation of 4T potentials in selected cities of the GZM Metropoly will lead to the identification and development of Smart City areas, fostering synergy. The research substantiates this hypothesis by showcasing the existing gap in implementing development policies, indicating a lack of synergy in the analyzed cities.
2. Cities with proactive local politics will exhibit higher levels of innovative potential, specifically in the areas of energy efficiency, entrepreneurship, and resident innovativeness. The study's findings support this hypothesis by highlighting the lack of implemented development policies in the research areas of cities, underscoring the influence of local politics as a significant impediment.

3. The lack of implemented development policies in the research areas of cities will be a significant impediment to realizing the full potential of Smart City initiatives. This hypothesis is strongly supported by the research outcomes, demonstrating a clear association between the absence of development policies and the unpreparedness of local governments to leverage the possibilities offered by Smart City initiatives.

A pivotal aspect of the development process, as highlighted in response to the identified research gaps, is the reliance on a competent and skilled workforce with a modern mindset and a commitment to growth. Empowering employees with suitable tools and work flexibility is identified as vital for maximizing their expertise, addressing the lack of preparedness in implementing the politics of development in the cities under study. The interconnected networks, both in terms of socio-economic and environmental-spatial dimensions, emerge as crucial elements for societal progress and efficient management, substantiating the importance of talent, tolerance, technology, and trust in Smart City development.

As part of the research limitations, it is acknowledged that the lack of consistent references to Smart City and 4T in analyzed documents from Polish municipalities has shaped the conclusion. This limitation also contributes to the proposal for further research. To enhance the understanding of Smart City concepts and 4T capitals, a suggested avenue for future research involves an indirect analysis focused on the 4T capitals through factors and provisions that specify and elaborate on them. In the pursuit of NetZero objectives, the research highlights the multidimensional nature of further exploration. This includes an in-depth examination of strategic documents, investigation into revitalization and collaboration programs with non-governmental organizations, and addressing challenges in talent management within the public sector. The senior management's active support for talent identification initiatives is emphasized as crucial for competitiveness with the private sector, aligning with the broader research objectives. A critical factor in the success of resident engagement and the realization of synergistic effects lies in fostering a civil society within the community involved in the project. Direct interactions among individuals who share common values, trust each other, and exhibit a high level of tolerance are identified as essential components. These interactions enhance citizens' awareness of their rights and responsibilities, actively participating in shaping their immediate and broader surroundings. The engagement of civil society is recognized as integral to the synergy of management, design, construction, and user activities.

While technology plays a prominent role in the development goals of the analyzed cities, the identified gap in addressing issues related to trust and tolerance suggests a need for a more comprehensive approach. The lack of correlation between the extent to which the surveyed municipalities address the 4T aspects and their size, character, or potential indicates a complex challenge in translating Smart City concepts into operational documents. Given the current geopolitical landscape, the research proposes an additional area of exploration focusing on security. The intricate link between security and trust emerges as a crucial element in the Smart City equation, further underscoring the importance of trust and security in the pursuit of Smart

City and NetZero objectives. Trust and security are recognized as pivotal considerations for the success of Smart City initiatives in the evolving urban landscape.

In summary, the identified research gaps have been effectively addressed and substantiated through the study's findings, providing valuable insights into the challenges and opportunities for Smart City development within the NETZero Economy context. The hypotheses formulated at the outset of the research have been rigorously examined and confirmed, contributing to a more comprehensive understanding of the factors influencing Smart City initiatives in the analyzed cities. The research has not only filled the existing research gap but also paved the way for future investigations into the dynamic and evolving landscape of Smart City development.

References

1. Angoneze-Grela, E. (2021). Porto alegre sustainable innovation zone – The strategy of smart city development as exemplified by the Brazilian city in relation to poznań (Poland). *Space&FORM*, 48. Szczecin, 105-128.
2. Azkuna, I. (2012). *Smart Cities Study: International study on the situation of ICT, innovation and Knowledge in cities*. The Committee of Digital and Knowledge based Cities of UCLG, Bilbao (Innovation and Knowledge in cities).
3. Bartkowiak, P., Rutkowski, I.P., Bartkowiak, A. (2019). A model approach to the maturity and the level of risk in the product innovation process. *Studia i Prace WNEiZ*, 55. Szczecin, 129-142.
4. Bieńkowski, S. (1945). *Psychologia kierownictwa, Vol. I*. Kraków: Instytut Naukowy Organizacji i Kierownictwa.
5. Borowiecki, R., Siuta-tokarska, B., Maroń, J., Suder, M., Thier, A., Żmija, K. (2021). Developing digital economy and society in the light of the issue of digital convergence of the markets in the European Union countries. *Energies*, 14(9).
6. Caragliu, A., Del Bo, C., Nijkamp, A. (2006). *Smart cities in Europe*. Amsterdam University, Faculty of Economics, Business Administration and Econometrics.
7. Creswell, J. (2013). *Projektowanie badań naukowych. Metody jakościowe, ilościowe i mieszane*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
8. Florida, R. (2012). *The rise of the creative class. Richard Florida – Revisited*. Toronto: University of Toronto - Rotman School of Management.
9. Fojud, A. (2022). *Dlaczego smart city warto tłumaczyć jako użyteczne miasto?* <http://smartcityforum.pl/artykul/dlaczego-smart-city-warto-tlumaczyc-jako-uzyteczne-miasto/>, 26.08.2022.

10. Giffinger, R. (2007). Smart cities Ranking of European medium-sized cities. *Urban and Mobility Services, Vol. 16, Issue October*. Vienna: Research Institute for Housing.
11. Han, J. (2019). *Research on Talent Agglomeration in the Background of Knowledge Economy*. Fourth International Conference on Economic and Business Management (FEBM 2019). Dordrecht: Atlantis Press, 237-242.
12. Jones, D.S. (2012). *Masters of the Universe: Hayek, Friedman, and the birth of neoliberal politics*. Princeton University Press, 418.
13. Jourdan, S. (2008). *Richard Florida, Cities and the creative class. Méditerranée*. New York/London: Routledge, 198.
14. Katz, B., Bradley, J. (2013). *The Metropolitan Revolution: How Cities and Metros Are Fixing Our Broken Politics and Fragile Economy*. Washington, D.C.: Brooking Institution Press.
15. Kaufman, J.C., Beghetto, R.A. (2013). Do People recognize the four Cs? Examining layperson conceptions of creativity. *Psychology of Aesthetics, Creativity, and the Arts, APA, 7(3)*. Washington D.C., 229-236.
16. Kinelski, G. (2019). *Competitiveness and Efficiency Management Through Cognitive Technologies in the Digital Economy*. Toruń: Adam Marszałek.
17. Kinelski, G., Stęchły, J., Sienicki, A., Czornik, K., Borkowski, P. (2021). Application of smart technologies in metropolis GZM to reduce harmful emissions in district heating systems. *Energies, 14(22)*. Basel.
18. Komninos, N. (2008). Intelligent cities and globalisation of innovation networks. In: *Intelligent Cities and Globalisation of Innovation Networks*.
19. Komninos, N. (2020). *Smart Cities and Connected Intelligence Platforms, Ecosystems and Network Effects*. London: Routledge Taylor Francis Group.
20. Korneluk, K., Bielawska, M., Zygadło, S., Dominiak, B., Kruczek, A. (2019). *Human Smart City Przewodnik dla samorządów*. Warszawa: ThinkIt Consulting Sp. z o.o., Ministerstwo Inwestycji i Rozwoju, 8-9.
21. Krzakiewicz, K., Bartkowiak, P. (2021). *Imitation as a Competitive Strategy*. Proceedings of the International Scientific Conference Hradec Economic Days 2021, Hradec Kralove, 11.
22. Krzakiewicz, K., Cyfert, S. (2019). Strategic orientations of the organization - entrepreneurial, market and organizational learning. *Management, Sciendo, 23(1)*.
23. Lee, J.H., Hancock, M.G., Hu, M.-C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change, 89*, 80-99.
24. Lenartowicz, K. (2017). Synergetyka a planowanie urbanistyczne i projektowanie architektoniczne. *Budownictwo i Architektura, 16(1)*. Lublin.

25. Makiela, Z.J., Stuss, M.M., Mucha-Kuś, K., Kinelski, G., Budziński, M., Michałek, J. (2022). Smart City 4.0: Sustainable Urban Development in the Metropolis GZM. *Sustainability, Vol. 14(6)*. Basel, 3516.
26. Makiela, Z. (2015). *Entrepreneurship and Innovation as a Factor in the Competitiveness of Local Authority Units. Development, Innovation and Business Potential in View of Economic Changes*. Kraków: Foundation of the Cracow University of Economics, 47-55.
27. Makiela, Z., Stuss, M.M., Borowiecki, R. (2021). Sustainability, technology and innovation 4.0. In: *Sustainability, Technology and Innovation 4.0*. London: Routledge.
28. Morawski, M. (2021). *Gospodarka 4.0 na przykładzie przedsiębiorstw w Polsce*. Warszawa: Oficyna Wydawnicza Politechniki Warszawskiej.
29. Muangmee, C., Dacko-Pikiewicz, Z., Meekaewkunchorn, N., Kassakorn, N., Khalid, B. (2021). Green entrepreneurial orientation and green innovation in small and medium-sized enterprises (SMEs). *Social Sciences, 10(4)*. Basel, 136.
30. Mucha-Kuś, K., Sołtysik, M., Zamasz, K., Szczepańska-Woszczyna, K. (2021). Coopetitive Nature of Energy Communities—The Energy Transition Context. *Energies, 14(4)*. Basel, 931.
31. Prokopowicz, A. (2016). Walka o mądre i inteligentne miasta. *Inteligentne Miasta i Regiony, 1*. Warszawa, 34.
32. Przybyłowski, A. (2017). Miasto przyszłości w aspekcie równoważenia mobilności. *Studia KPZK*. Gdynia: PAN, 177.
33. Rutten, R., Gelissen, J. (2008). Technology, talent, diversity and the wealth of European regions. *European Planning Studies, 16(7)*. London, 985-1006.
34. Saługa, P.W., Zamasz, K., Dacko-Pikiewicz, Z., Szczepańska-Woszczyna, K., Malec, M. (2021). Risk-adjusted discount rate and its components for onshore wind farms at the feasibility stage. *Energies, 14(20)*. Basel.
35. Stuss, M.M. (2021). *Zarządzanie talentami. Koncepcje, modele i praktyki*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
36. Toppeta, D. (2014). *The Smart City Vision: How Innovation and ICT Can Build Smart, "Livable", Sustainable Cities*. Report of The Innovation Knowledge Foundation (2010). Milan: The Innovation Knowledge Foundation.
37. Zygiaris, S. (2013). Smart City Reference Model: Assisting Planners to Conceptualize the Building of Smart City Innovation Ecosystems. *Journal of the Knowledge Economy, 4(2)*, Portland: Springer, 217-231.