COLLECTION OF PAPERS
NEW ECONOMY
Volume 3, No. 1, 2025

IMPLEMENTATION OF SMART IOT TECHNOLOGIES ON THE BULGARIAN MARKET - AN INNOVATIVE APPROACH FOR ECONOMIC SUSTAINABILITY AND ENVIRONMENTAL BENEFITS

Nikolay Vankov[1], Vasil Lukarev[1*]

Received 02.04.2025. | Send to review 13.04.2025. | Accepted 22.07.2025.

Original Article

[1] University of National and World Economy, Business Faculty, Department of Entrepreneurship, Bulgaria

***Corresponding Author:**
Vasil Lukarev

Email: vasil.lukarev@unwe.bg

JEL Classification:
A1, I3, R1

Doi: 10.61432/CPNE0301101v

UDK: 502.131.1:004.4(497.2)

ABSTRACT

The article presents opportunities for implementing an innovative entrepreneurial model, based on IoT technologies in the context of the Bulgarian urban environment. The focus is on "smart poles" that use existing urban infrastructure (street lighting), additionally equipped with smart modules and sensors. The presented approach considers economic sustainability and environmental benefits such as reducing energy costs, optimizing urban processes and creating new opportunities for entrepreneurial activity, without significant initial investments in new infrastructure.

The article examines in detail the theoretical context of IoT technologies and the specifics of the Bulgarian market, and highlights the potential economic benefits, improved efficiency in infrastructure management and opportunities for new business models. Environmental benefits include a significant reduction in carbon footprint, optimization of energy and resource consumption.

Key potential customer segments have been identified, including city administrations, public and private organizations responsible for infrastructure and utility management, smart building companies, utility providers, and private technology entrepreneurs. The proposed model is distinguished by its flexibility, making it suitable for both large urban municipalities and smaller settlements striving for sustainable development.

An empirical study is proposed, including a quantitative method, which aims to assess market needs, readiness for technology adoption, and expected benefits.

The scientific novelty of the study lies in the development of an entrepreneurial IoT business model adapted for Bulgaria, which provides concrete solutions for sustainable urban development and economic improvement, while at the same time addressing current global environmental challenges.

Keywords: *Internet of Things (IoT) Business Model, Smart city infrastructure, Sustainable urban development*

1. INTRODUCTION

Urbanization is a global phenomenon that also affects Bulgaria, with nearly 77% of the country's population living in urban areas. This process leads to population concentration, which poses serious environmental and economic challenges. Among the most significant of these are air pollution, high energy costs, difficulties in mobility and insufficient efficiency in managing urban resources and infrastructure. These problems have a negative impact on the quality of life of the residents and the sustainable development of cities.

The aim of this article is to present an innovative entrepreneurial model based on the Internet of Things (IoT), with a focus on the implementation of the so-called "smart poles". These intelligent solutions use the existing urban infrastructure by equipping it with modules and sensors to improve energy efficiency, optimize traffic flows and monitor air quality. The working hypothesis of the study is that the integration of the IoT technologies into urban infrastructure not only improves the economic sustainability by reducing operational costs, but also contributes significantly reducing the ecological footprint, providing long-term benefits for society and the business. The article will examine theoretical propositions and empirical evidence supporting this hypothesis.

1.1. THEORETICAL FRAMEWORK AND LITERATURE REVIEW OF IOT TECHNOLOGY, SMART CITIES AND BUSINESS MODELS IN THE CONTEXT OF IOT

1.1.1. ESSENCE AND APPLICATION OF IOT TECHNOLOGIES

The Internet of Things (IoT) refers to a complex ecosystem where physical devices embedded with sensors, communication modules, and intelligent software interact via internet, creating a data-driven environment capable of autonomous decision-making and optimization (Gubbi et al., 2013). The foundational elements of IoT include hardware sensors, wireless networks, data processors, and automation platforms.

Within urban areas, the implementation of IoT can transform public services and infrastructure by enabling solutions such as adaptive traffic management, real-time environmental monitoring, smart lighting, and automated public safety systems (Zanella et al., 2014). For instance, “smart poles” — streetlight structures equipped with sensors and communication devices — offer functionalities such as pollution monitoring, emergency communication, and surveillance integration. These systems often rely on existing urban infrastructure, reducing capital investment requirements and accelerating deployment.

In Bulgaria, one of the most promising IoT technologies is the concept of “smart poles”, representing modernized street lighting poles equipped with intelligent modules and sensors. They provide opportunities for energy-efficient lighting, monitoring of air quality, traffic and weather conditions, as well as integration of safety systems such as video surveillance and SOS buttons for emergencies (Kakizhanova et al., 2025). The advantage of this technology is that it is based on existing infrastructure, which significantly reduces the need for initial investments in new urban infrastructure.

Urban areas globally consume nearly 60% of the world’s energy and produce over 70% of greenhouse gas emissions, making them prime candidates for IoT-enabled sustainability strategies (Cocchia, 2014). By leveraging sensor data, municipalities can optimize traffic flow, monitor environmental changes, and automate public utilities for greater efficiency and reduced ecological footprint.

The benefits of implementing IoT technologies are multifaceted: reduced operating costs for electricity and maintenance, increased efficiency of urban services and infrastructure management, creation of new entrepreneurial opportunities and business models, as well as a significant improvement in environmental sustainability and the quality of life of the urban population. Thus, the implementation of IoT solutions can provide significant added value for both the public and private sectors, becoming an important driver for the development of modern smart cities in Bulgaria.

1.1.2. IOT AND SMART CITIES

Smart cities rely heavily on digital transformation strategies where IoT technologies are deployed to optimize resource management, increase citizen engagement, and support environmental sustainability. Core elements include data-driven governance, real-time service delivery, and automated infrastructure control (Bibri, 2021).

Smart poles serve as a key example of this transformation (Priambodo et al., 2025). Modernized or newly constructed lighting poles with integrated technology can support urban monitoring systems, traffic management, wireless coverage, and environmental sensing - all while using pre-existing urban installations (Zanella et al., 2014).

Notably, global cities such as Barcelona and Amsterdam have successfully integrated IoT solutions to enhance urban mobility and energy management. In Barcelona, intelligent lighting and traffic control have led to measurable efficiency gains, while Amsterdam’s smart transport infrastructure has significantly improved air quality and congestion management (Cocchia, 2014).

In the Bulgarian context, the introduction of IoT solutions such as "smart poles" has the potential to achieve similar results, solving the specific environmental and economic challenges associated with the urbanization. The proposed technology allows for effective data collection and analysis, which in turn helps to make informed management decisions in the field of urban mobility, environmental management and public safety. This provides real opportunities for Bulgarian cities to significantly improve their economic, social and environmental indicators, becoming more attractive, both for living and for business and investment.

1.1.3. ENTREPRENEURSHIP AND BUSINESS MODELS IN THE CONTEXT OF IOT

IoT fosters innovation in entrepreneurial ecosystems through multiple business models — product-centric, service-based, platform-oriented, and data-driven approaches (Westerlund & Rajala, 2014). For example, product innovation in IoT includes developing devices such as air quality sensors and smart surveillance units. Cities can modernize existing streetlight infrastructure with these technologies, transforming them into multifunctional "smart poles" with minimal additional investment.

Smart poles benefit from proximity to roads, existing power sources, and wide urban distribution. By embedding IoT components into these structures, municipalities gain access to real-time data on traffic, weather, noise, and pollution - useful for both immediate urban operations and long-term planning.

Such platforms may include 5G or Wi-Fi hotspots, CCTV systems, emergency alert buttons, EV charging points, and digital displays. Their modular design allows for scaling and adaptability based on specific urban needs.

In terms of monetization, municipalities or businesses can adopt one-time purchase models, subscription services for infrastructure management, or data commercialization strategies (Westerlund & Rajala, 2014). In Bulgaria, such monetization strategies can be tailored to local governance and market dynamics to foster sustainable entrepreneurship.

In the Bulgarian context, applicable monetization mechanisms include:

- Platform model, in which municipalities or organizations purchase hardware and software for "smart poles" once and manage the platform with their own resources.
- Subscription service model, in which the provider offers comprehensive infrastructure support, with the client paying a regular fee for operation, monitoring and maintenance.
- Monetization through the sale of anonymous data collected by the IoT devices, which can be used for urban planning, marketing analyses or scientific research.

In the case of "smart poles", the possibility of generating revenue from both the sale of the IoT devices and infrastructure themselves and the provision of cloud services for management and maintenance of the infrastructure, with monthly or annual subscription models, is being considered.

This spectrum of innovation opportunities and monetization models provides significant potential for entrepreneurship development and economic growth, especially when these models are adapted to the specific needs and conditions of the Bulgarian market.

2. RESEARCH METHODOLOGY

2.1. RESEARCH APPROACH AND DESIGN

This research utilized a quantitative approach, employing structured surveys directed at municipal administrations and potential business partners. Results were analysed using statistical methods to interpret numerical data and uncover patterns, relationships, or trends with data visualization charts. The survey was conducted online, through the "Google Forms" platform to collect direct responses and opinions from participants working in state/municipal institutions and a few people, engaged in private sector serving large facilities that could be interested from the "smart pole" platform. For this purpose, a questionnaire including 39 questions was developed, 134 respondents took part in filling out the survey. The core objective was to explore awareness, expectations, and the level of preparedness regarding the adoption of IoT technologies and "smart pole" platforms in Bulgaria's urban environment. The questionnaire included various segments: understanding of IoT and smart poles; anticipated societal and economic benefits such as cost savings and pollution reduction; infrastructure readiness, workforce capacity, and data governance (Westerlund and Rajala 2014).

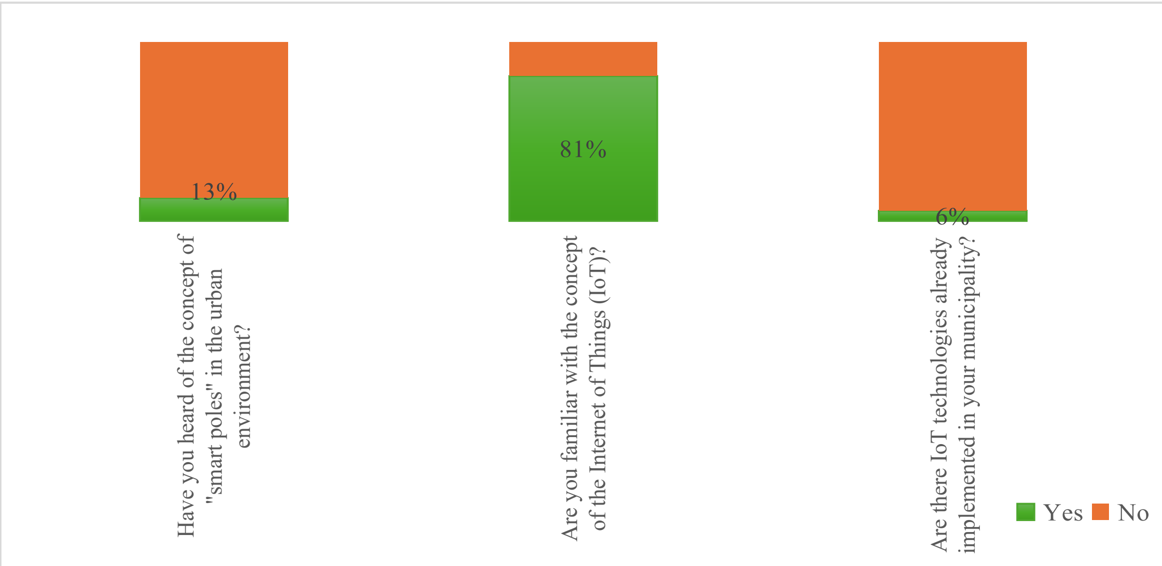
Respondents were prompted to evaluate economic and environmental implications, identify driving motivations for implementation, and suggest potential public-private collaboration strategies. The survey also integrated demographic profiling to contextualize the insights and trends observed across different stakeholder groups. Some of the more interesting results of the study are presented below.

2.2. ANALYSIS AND INTERPRETATION OF DATA

The survey responses reflected region-specific characteristics and revealed limited awareness of the smart pole concept, despite the general familiarity with IoT. This represents both a challenge and an opportunity - awareness campaigns could facilitate broader adoption. As seen in the responses, participants recognized the advantages of the proposed system in reducing energy consumption, enhancing urban planning, and supporting local economies (Zanella et al. 2014).

In “General Questions and Awareness” answers we can see that majority of the participants are familiar with the IoT technology but not with the “smart pole” concept. This can be a challenge and will need additional effort to build awareness, but at the same time adoption of IoT technology is very low and this can be considered as and good opportunity to grow the demand.

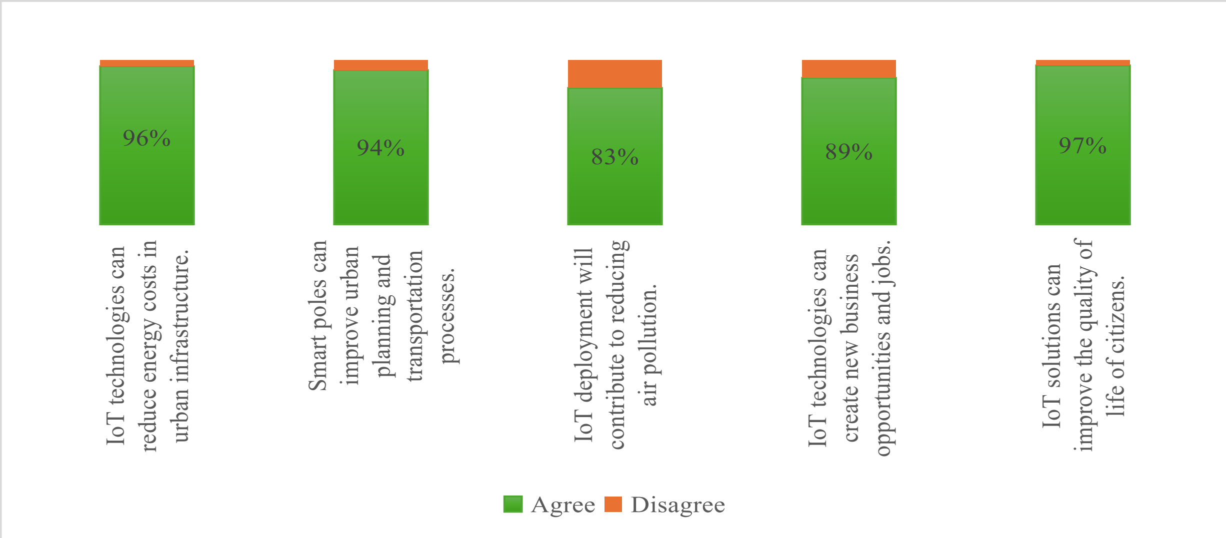
Figure 1. General Questions and Awareness



Source: Created by the author

“Potential benefits” answers (figure 2) clearly shows that the IoT and “smart poles” platform can bring significant advantages to the entire urban ecosystem like reducing energy costs, improving planning and traffic flows, reducing air pollution, and at the same time create new jobs and business opportunities. All these combined will improve the quality of life.

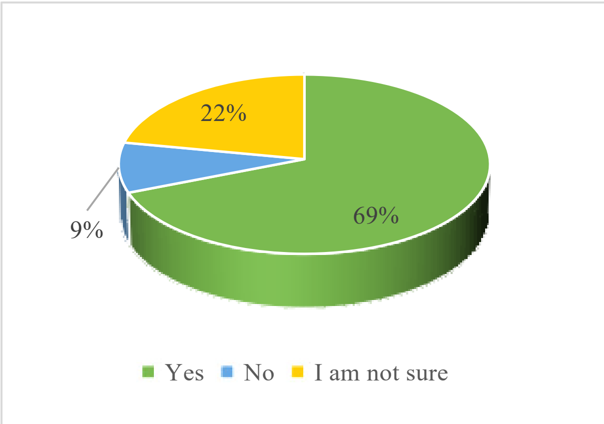
Figure 2. General Questions and Awareness



Source: Created by the author

In the "Assessment of needs and market interest" and "Are you interested in implementing smart poles in your municipality/organization?" questions we received positive answer from 2/3 from the participants. There is also not a small group of people that cannot decide.

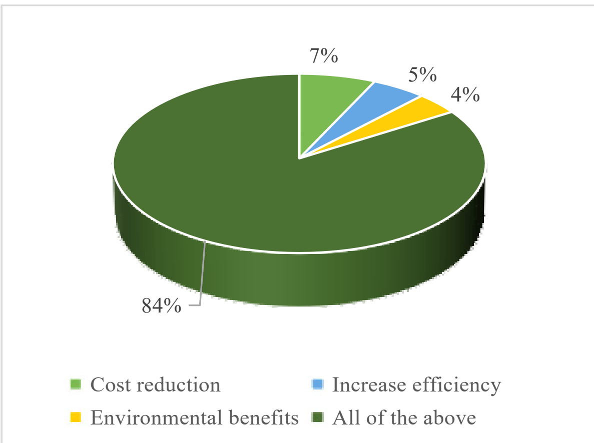
Figure 3. Are you interested in implementing smart poles in your municipality/organization?



Source: Created by the author

On the "What is the main factor that would motivate you to implement IoT?" question, most of the participants expressed opinion that implementing and using IoT technologies will be driven by multiple factors related to cost reduction, increase efficiency and environmental benefits.

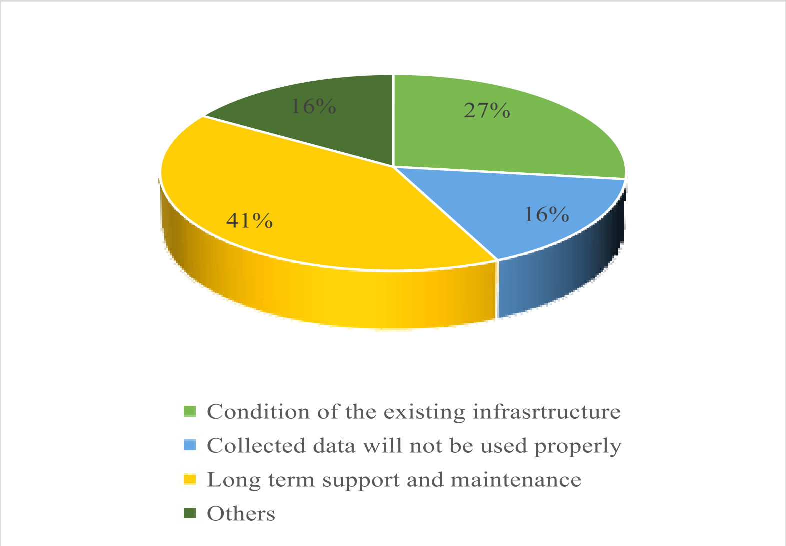
Figure 4. What is the main factor that would motivate you to implement IoT?



Source: Created by the author

In the "Technological aspects and challenges" and "What are the main technological barriers you see to the implementation of smart poles?" questions worth to mention the top 3 answers. Participants identified as the main hurdle the long term support and maintenance, and this is a valid concern. Very often in Bulgaria there are great initiatives completed and after some time left unattended without proper maintenance. Will need to put special attention on this topic in the "smart pole" service with at least 5 years operational time where maintenance will be incorporated. The other two challenges are also important and should not be neglected – how the collected data will be used (whether will be used at all) and the condition of the existing infrastructure that in most of the cases is old and not serviced regularly.

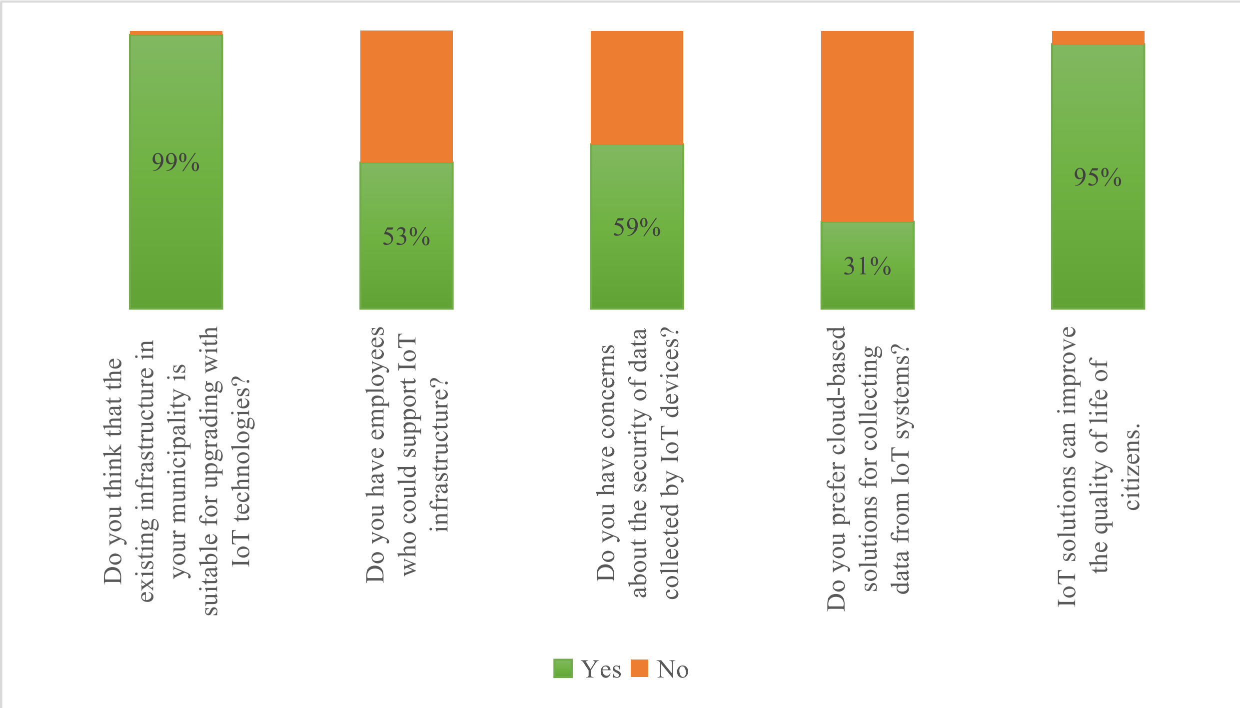
Figure 5. What are the main technological barriers you see to the implementation of "smart poles"?



Source: Created by the author

In the other questions from the "Technological aspects and challenges" section we received the following answers, stating challenges with the availability of trained people to support IoT infrastructure, data security and using the public clouds to host the service. While the struggle with the prepared people can be relatively easily resolved, with additional specialized trainings or outsourcing to 3th party vendors, the security of the data will need special attention. Security in the IoT infrastructure is always a challenge due to the need of a distributed sensor architecture. Security is also not cheap so we need to find the right balance. "smart pole" platform relies on security industry standards/protocols and best practices that are followed to guarantee acceptable security level. Also regular updates are considered to prevent vulnerabilities. Related to concerns with the usage of public clouds we can always use on-prem infrastructure but this will be more expensive to be setup and maintained.

Figure 6. Technological aspects and challenges



Source: Created by the author

Approximately two-thirds of respondents expressed interest in implementing smart poles, though a notable portion remained undecided. Cost efficiency, service automation, and environmental sustainability were highlighted as key motivators. However, long-term maintenance, underdeveloped infrastructure, and data utilization remain significant concerns.

The study also exposed challenges related to the availability of trained personnel and the reliability of public cloud infrastructures. While workforce limitations could be mitigated via specialized training or outsourcing, ensuring robust data protection requires adherence to recognized security standards and continuous system updates (Bibri 2021).

Based on the data collected from the survey, we can draw the following conclusions and recommendations regarding the market readiness for adoption of the IoT technologies and "smart" pole platform:

- Bulgarian market has good potential for adopting new IoT technologies and "smart pole" platform.
- Building more awareness on the "smart" pole concept – platform and service will be needed. Having the first reference customer implementation will be a key milestone.
- Addressing technological challenges is essential for the success of the platform adoption with focus on security, data processing and work force readiness.
- Initially need to focus more on marketing and platform potential benefits with priority on service and long-term relationship – working as partners with customers.
- Utilizing EU funding

Overall, the results emphasize the Bulgarian market's receptiveness to IoT adoption, contingent upon enhanced awareness, structured support for infrastructure upgrades, and targeted communication of long-term benefits. EU funding may serve as a critical enabler for initial deployments and cross-sector partnerships.

3. RESEARCH RESULTS AND BUSINESS MODEL

3.1. ENVIRONMENTAL BENEFITS: REDUCTION OF CARBON FOOTPRINT. IMPROVEMENT OF AIR QUALITY AND OPTIMIZATION OF RESOURCES.

The implementation of a "smart pole" platform provides significant environmental opportunities aligned with the ESG (Environmental, Social, and Governance) frameworks. From an environmental standpoint, reducing carbon emissions and energy consumption are priorities, but additional attention must also be given to the full lifecycle impact of the platform - from production and deployment to maintenance and recycling (Bibri 2021).

IoT devices are designed for low energy consumption, utilizing energy-efficient SoCs (System-on-Chip) and LED-based lighting systems with adaptive control. Integrating renewable energy sources such as solar panels may further decrease reliance on grid electricity, albeit with implications for lifecycle carbon footprint. Data centers powering platform operations also contribute to the total energy use and must be factored into environmental assessments.

The adoption of OTA (Over-the-Air) software updates extends device usability, supporting sustainability goals. Hardware end-of-life must comply with EU regulations, including Directive 2012/19/EU and Bulgaria's Waste Management Act.

Smart poles, constructed with recyclable metals, enhance urban sustainability through energy savings, emissions reductions, and improved public service efficiency. By collecting real-time data, municipalities can optimize traffic, public safety, and urban planning, thereby enhancing residents' quality of life while creating entrepreneurial opportunities.

The use of the "smart pole" platform will lead to the improvement of urban infrastructure, reduction of carbon footprint, increase of energy efficiency, as well as save time, public resources and reduction in environmental pollution. With the help of the collected data, the city administration will be able to make informed decisions about limiting pollution, optimizing transport flows, including public transport, and generally improving the quality of life of the residents. The "smart pole" platform will also bring economic benefits and increased business opportunities with the creation and use of various software applications for the end users. As an example, we can point to an application that shows in real time the free parking slots in a given urban area or street(s). This will save time (no need to drive around, looking for a parking space), reduce pollution (less traffic), as well as improve health and safety for both residents and travelers. Also, the data collected by the platform can be used to create new products and services or to sell anonymized data to third parties for various purposes.

3.2. MARKET ANALYSIS AND KEY STAKEHOLDERS IN BULGARIA

Bulgaria's IoT market is poised for steady expansion through 2030, driven by technological advancement, increased sectoral adoption, and favourable policy frameworks. Major contributing segments include hardware components (sensors, processors), software platforms (data analytics, monitoring, security), and managed services (Zanella et al. 2014).

As the main trend, we can define the stable growth of the IoT devices in Bulgaria. The number of connected IoT devices continues to grow, with a significant increase expected in the coming years. Technologies such as LPWAN (Low-Power Wide-Area Network) and LEO (Low Earth Orbit) satellite communications will play an important role in the development of the market. Dominant technologies such as Wi-Fi, Bluetooth, and cellular IoT connections are the main that drive the market today, but this could change in the near future. The adoption of new standards such as Wi-Fi6/Wi-Fi6E also improves the efficiency and reliability of the IoT communications that can influence the market. There are a few components that play a key role to the IoT market:

- IoT components. Include processors, connectivity integrated circuits, memory, sensors, and logic devices. The demand for these components is due to their critical role in the overall functioning of the IoT devices. There is no local production in Bulgaria, and almost all significant global vendors are represented and components are available for local ordering.
- Software solutions. The IoT software solutions market in Bulgaria is segmented into data management, real-time streaming analytics, network bandwidth management, remote monitor-

ing, and security solutions. These solutions are essential for managing and protecting the vast amounts of data generated by IoT devices. In the last years Bulgaria is positioned as an IT hub in Europe with many, well prepared and skilled software developers. From one side this is good if you want to create new software solutions but makes very strong competition and at the same time is very challenging if you want to get significant market share.

- Platforms. IoT platforms in Bulgaria are categorized into device management, application management, and network management, providing the necessary infrastructure for the implementation and maintenance of IoT applications.
- Services. Professional and managed services are vital for the implementation and ongoing operation and maintenance of the IoT systems, ensuring that businesses can effectively use IoT technologies.

3.3. MARKET SEGMENTATION

IoT applications are widely adopted in various sectors, such as: (Lasse Lueth)

- Healthcare. The implementation of IoT in healthcare improves patient monitoring and improves the efficiency of healthcare services.
- Automobiles and transport. IoT is fundamental to the advancement of intelligent transport systems and automotive innovation.
- Building and construction automation. IoT solutions are used to optimize energy consumption, improve security in the buildings, reduce operating costs, and improve productivity. Smart sensors and RFID tags help identify potential risks and optimize resources.
- Production. Smart manufacturing processes are driven by the IoT technologies, increasing production efficiency and reducing costs.
- Retail. IoT is transforming the retail sector through improved inventory management and personalized customer experience.
- Agriculture. Smart farming solutions help increase agricultural productivity and sustainability.
- Energy. IoT solutions help monitor and manage energy resources, resulting in more efficient energy use and reduced carbon dioxide emissions.

3.3.1. COMPETITIVE ENVIRONMENT AND CHALLENGES

The Bulgarian IoT market is competitive, with several key players contributing to its growth. These companies focus on technical and operational benchmarking to stay ahead in the market. Strategic recommendations include investing in research and development, expanding the offered services, and increasing customer engagement to maintain a competitive advantage. IoT market in Bulgaria provides many opportunities, especially in the fields of smart manufacturing, smart transportation, smart energy, and connected healthcare. Some of the companies in Bulgaria that are actively developing IoT solutions are listed below.

- “A1 Bulgaria” **-** A1 is the first telecom in Bulgaria that offers mobile Narrowband-IoT (NB-IoT) solutions. The company have multiple projects, including water consumption monitoring, waste management, smart city lighting, and smart parking.(A1)
- “Smart IT” **-** MFG’s technology hub, Smart IT, is working on various IoT projects, including the development of software products in a variety of fields. These projects include features such as remote access and control of various sensors and devices.(SmartIT)
- “Techno Logica” **-** This company has many years of experience in the IT sector and works on projects and solutions aimed at Bulgarian society and economy.(TechnoLogica)
- “DataArt” **-** With own inovative project, they won an award in the category “Internet of Things Smart City” at the IoT Adventure Awards. The project includes smart elevators that use IoT technologies to improve efficiency and safety.(DataArt)
- “Devision” **-** This company develops cloud-based IoT software for a leading international company in the field of smart home & building automation. Projects include intelligent management of private homes and business buildings.(Devision)

It is also worth mentioning some successful startups that are developing innovations in the field of the IoT:

- "Melissa Climate" - This company is known for its smart home climate management solutions. They offer devices that allow remote control of air conditioners and other appliances through a mobile application.(Mclimate)
- "Shelly" - Known for their Shelly products, which include smart relays and sensors for home automation. Their devices are popular both in Bulgaria and on the international market.(Shelly)
- "Develiot" - Develops IoT solutions for air and water quality monitoring. Their products are used to collect real-time data and provide analytics to improve the environment. (Develiot)
- "Bosch Startup Harbour" - The Bosch.IO program in Bulgaria supports numerous startups, including Efemarai and QuarkXR, that work in the field of machine learning and augmented virtual reality.(Bosch-digital)

These companies demonstrate how Bulgarian companies can be innovative and compet on the Bulagruan and international markets. Overall, the IoT market in Bulgaria is set for significant growth, driven by technological advancements and growing adoption in various sectors. Businesses and stakeholders need to focus on innovation and strategic planning to harness the full potential of the IoT in Bulgaria.

3.3.2. IOT TECHNOLOGY MARKET - REVENUE AND VOLUME

The revenue in the Internet of Things market market in Bulgaria is projected to reach $764.31million in 2025 where the automotive IoT sector dominates the market with a projected market volume of $206.17 million in 2025. It is expected that the revenue will show an annual growth rate (CAGR 2025-2029) of 9.06%, resulting in a market volume of $1.08billion by 2029. Bulgaria is emerging as a key player in the Internet of Things market with its growing number of tech startups specializing in IoT solutions. (IoT Bulgaria)

Significant growth is expcted also across varoius segments with expected Consumer IoT projected to reach $169.85 million in 2025, with a compound annual growth rate (CAGR) of 8.30% from 2025 to 2029 (Consumer IoT). Smart Cities expected to generate $56.54 million in revenue by 2025, growing at a CAGR of 8.46% from 2025 to 2029 (Smart Cities) and other IoT segemtn anticipated to reach $9.03 million by 2025, with an annual growth rate of 11.39% from 2025 to 2029. Overall IoT market volume in Bulgaria is also expanding rapidly and is expected to to reach $684.40 million in 2024 and rise to $1,081 million by 2029, with an annual growth rate of 9.57%. (Other IoT)

The growth is driven mainly by the proliferation of smart devices, sensors, and connected appliances. Along with devices, the market for IoT platforms and services is expanding rapidly. Companies are investing in platforms that offer device management, analytics, and security solutions that are essential for managing the growing volume of IoT devices. Improvements in connectivity (such as 5G), data analytics, and AI enable more complex IoT applications, which in turn are driving market growth.

The IoT market in Bulgaria is experiencing increasing growth, both in terms of revenue and the number of connected devices. The expansion of the market is supported by technological advancements and growing adoption in various sectors. The positive outlook implies continued investment and innovation in IoT technologies in the coming years.

3.3.3. KEY CUSTOMER AUDIENCE

Determining the key customer audience for IoT products and the "smart poles" in this case is a key step for the successful implementation and marketing. We need to perform the following steps: demographic analysis, psychographic analysis, creation of user personas, market segmentation, competition research and feedback collection.

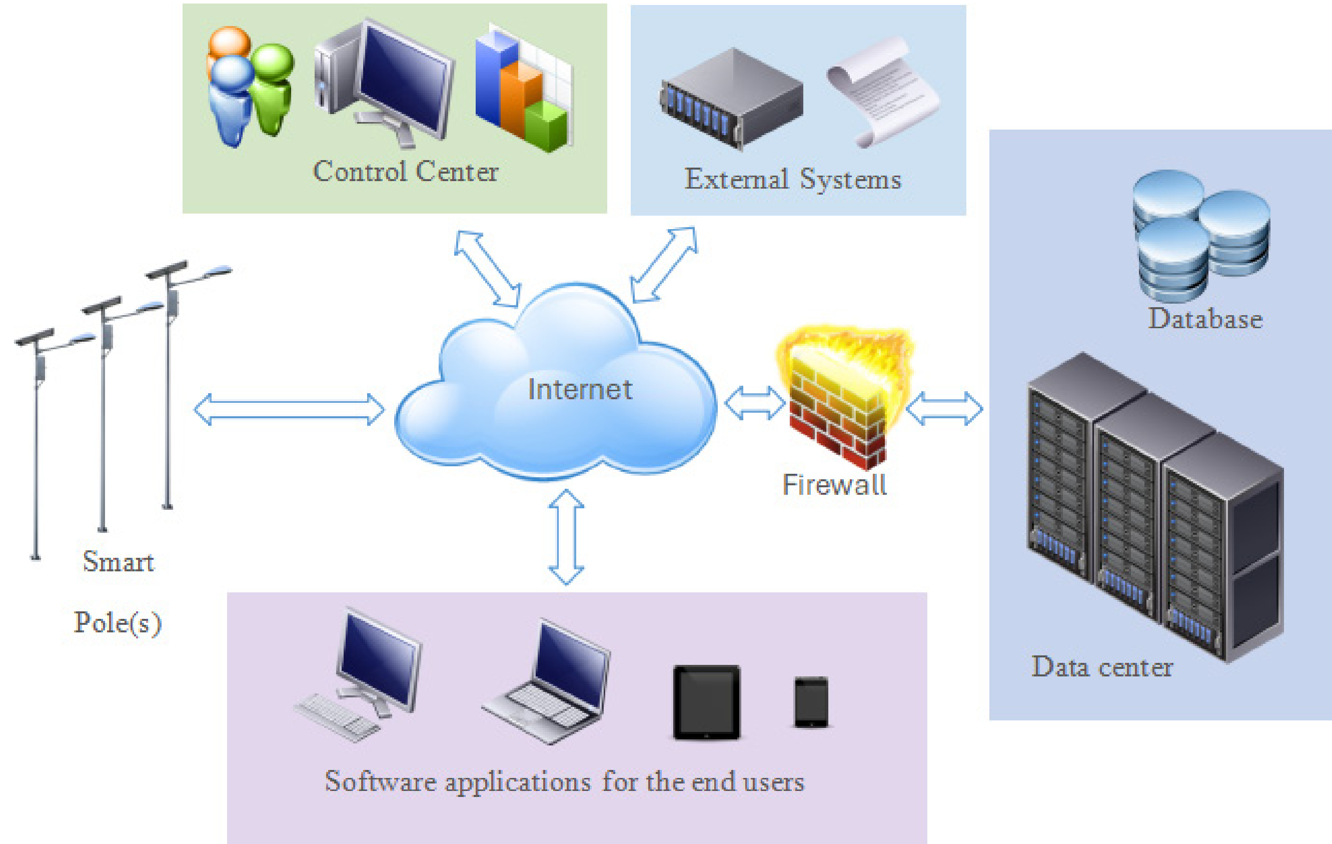
Due to the specifics of our platform/product/service, we have a specific, strictly limited target audience – state/municipal institutions, such as direct end users/clients or we can work with partners enabled to deliver the platform to their end customers. In limited cases, customers can be also private organizations or private companies serving facilities for public events, private parking lots, large factories, smart buildings or similar. We will focus only on competition research and collecting feedback and conducting surveys, interviews with our target audience to get direct feedback from our potential customers.

3.4. SMART POLE TECHNICAL ARCHITECTURE AND BUSINESS MODEL

3.4.1. TECHNICAL IMPLEMENTATION

The "smart pole" ecosystem is composed of five integrated subsystems: physical infrastructure, centralized data center, operational control center, external system interfaces, and user-facing applications. Each pole is equipped with modular components including sensors for air quality, lighting, traffic monitoring, and emergency communication (Figure 7).

Figure 7. Smart pole platform architec



Source: Created by the author

Table 1 presents the key smart pole modules.

Table 1. Key Smart Pole Modules

Module	Main Function
Control Module	Manages all pole functions and modules; supports communication and system health monitoring
Communication Module	Connects the pole with the data center via WiFi, 4G/5G, or LoRAWAN
Power Supply Module	Supplies electricity to all modules and monitors power consumption
Lighting Module	Automatically and remotely controls street lighting based on ambient light or schedule
Audio Module	Plays preloaded audio messages for emergencies, public info, or ads
Video Module	AI-enabled cameras for surveillance, object counting, parking management, and license plate recognition
Display Module	Displays video messages or ads using various types of screens
Meteorological Module	Measures temperature, humidity, pressure, and optionally wind speed
Air Quality Module	Monitors air pollution levels; visualized via color indicators or digital display
SOS Module	Emergency button for immediate audio connection to the Control Center

Source: Created by the author

The data center aggregates and processes information through a secure, scalable architecture that can be hosted on public clouds (AWS, Azure) or private infrastructure. Access to data is governed through custom APIs, ensuring role-based segmentation and data integrity (Gubbi et al. 2013).

The control center provides 24/7 monitoring, lifecycle management, and diagnostics. Through proprietary software, responisble staff can manage assets, respond to incidents, and generate insights. End-user apps deliver urban data (e.g., air quality, free parking spaces) via mobile and web interfaces, enhancing public transparency and civic engagement.

As any other IoT system "Smart pole" platform comply with the General Data Protection Regulation (GDPR) and manage data securely. The platform is designed with privacy and security at its core following the industry's best practices. Platform is not user centric and will not require collection of personal data. All data collected from the IoT devices will be available and accessed by the users without explicit registration. Users will give clear, informed consent before any personal data is collected (like agreeing to share their current location, for better user experience) and only will collect the data when is strictly necessary for the application(s) to function. Users will be informed what data is being collected and why with the possibility to access, correct, or delete their data, including withdraw consent at any time. Communication between the IoT devices and the data center is encrypted and not accessible eternally. Regular IoT firmware and software updates are considered to avoid vulnerabilities. In cases where public cloud is used partners should be also GDPR compliant. If a data breach occurs, will notify the relevant authority within a predefined period.

3.4.2. MONETIZATION AND BUSINESS MODEL

The "smart pole" platform will be offered in two main models – *as a platform and as a service*. It is possible also to have a combination between the two models, depending on the requirements and needs of the market and the customers. For example, the installation of the poles infrastructure is covered by the customer and the management/maintenance part is covered by the platform vendor. Both models have their advantages.

Smart pole "Platform" model

The customer pays one-time for the delivery of:

"Smart poles" – the price is determined depending on the number and functions of the poles (new or modernized existing poles).

Right of Use, license covering software for "Data Center", "Control Center", "External Systems", "Software Applications for the end users".

Licensing is based on the number of poles with a predefined step for "Control Center" (100, 200, 500, 1000+ poles), and the license for "Software applications for the end users" is based on application and number of subscribers. The license includes a warranty period (2 years), software updates (1 time per year), limited technical support (software and spare parts supply) during normal business hours, with a predefined response time.

In this model, the client takes over the construction of the entire infrastructure, the installation and management of the software, the provision of the necessary personnel for the operation and maintenance of the system.

Additionally, for a fee, staff training and the opportunity to develop custom functionalities on behalf of the customer (new modules, applications, optimizations, applications for end users, etc.) can be provided.

Smart pole "Service" model

When used as a service, the customer receives the entire platform of "smart poles" (including infrastructure), software, staff for operation and maintenance of the system directly ready for use, paying a subscription annual fee. With this model, customers get more value and more quality for their investment. The minimum term for using the service is 5 years

These hybrid deployment models accommodate different budget cycles and operational capacities, enabling broader adoption of smart urban infrastructure. (Table 2).

Table 2. Monetization and business model comparison

Component	Platform	Service
Smart pole infrastructure – installation & setup	Performed by the client	Included
Infrastructure Software	Provided by the client	Included
Software / Data Center	Licensed per number of poles	Included
Software / Control Center	Licensed per number of poles	Included
Software / External Systems	Licensed per number of clients	Included
Software / End-user applications	Licensed per functional module and number of clients	Included
Smart pole support	Limited. Spare parts during working hours	Full, 24/7
Software support	Limited. Remote assistance during working hours	Full, 24/7
Software updates	Once a year	2+ times a year
Adding new functionalities	Upon request, based on client assignment (charged separately)	Upon request, based on client assignment (charged separately)
Personnel using the platform	Provided by the client	Included
Personnel training	10 people	Not required
Licensing	One-time (perpetual license)	Annual fee

Source: Created by the author

Before the platform becomes operational and stable, the focus will be on the "Service" monetization model and building the fist reference customer. For this case "smart pole" platform with 100 smart poles is considered, ready to use with the related software applications. Estimated costs are listed in (Table 3).

Table 3. Estimated cost for building and operationalize "smart pole" platform

Expense Category	Cost Estimate (€)
Initial development and productization (software, IoT modules, practice – installation and maintenance, tests)	200 000 (one time)
Rent & Utilities	3 000 (per month)
Equipment for maintenance staff and developers	15 000 (one time)
Public data center (5 VPS, 1000€ per VPS/year)	5 000 (per year)
Marketing	1 000 (per month)
Staff Salaries and spare part management service	30 000 (per month)
Miscellaneous	2 000 (per month)
Smart poles installation, setup, configuration, acceptance	55 000 (one time)
Maintenance, upgrade, parts replacements	5 500 (per year)
Inflation, salaries adjustments	8000 (per year)
Total:	
Total Startup Cost (for the first year)	712 000 €
Total Yearly Cost (after the first year, one customer)	450 000 €

Source: Author`s calculations

Estimated revenue is calculated based on annual fee for 5 years where the "smart pole" platform is provided ready to use plus additional income from selling anonymized data collected from the IoT devices. At this first stage additional partnerships, 3th party software revenue is not considered due to adding of additional complexity without clear and reliable income predictions. Two customers are considered under the same conditions, and the second customer will be engaged from the second year. Estimated revenue is listed in (Table 4).

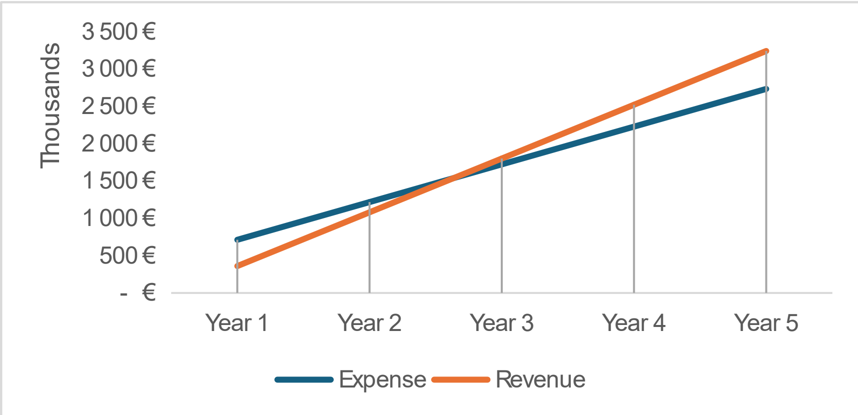
Table 4. Estimated Revenue

Revenue Category	Revenue Estimate (€)
Annual fee for one year (per customer)	350 000 (per year)
Selling anonymized data, collected from the IoT device (per customer)	10 000 (per year)

Source: Author`s calculations

Break-even is in the middle of the 2nd year, when the revenue equals costs. It is vital to have the second customer as early as possible to be sustainable (Figure 8).

Figure 8. Break-even chart



Source: Author`s calculations

Profit margin for the scenario described is 22% and can be considered as decent for some industries, like service-based businesses, retail, and manufacturing. For software companies and specialized consulting firms, usually the target is higher (above 30%). If we can start and operate with 3 customers at the same time under the same conditions, Profit margin will increase to 48%. If our business consistently reaches 15% profit margin, it can be considered as a stable that allows reinvestment.

4.CONCLUSION

The conducted research on the implementation of smart IoT technologies - particularly the concept of “smart poles”- in the Bulgarian urban environment confirms the initial working hypothesis: that the integration of IoT solutions into existing infrastructure contributes not only to economic sustainability by reducing operational costs but also to environmental improvement and long-term urban resilience. The empirical study reveals a substantial readiness and interest in adopting smart city technologies, albeit with certain reservations regarding infrastructure and maintenance.

The analysis clearly demonstrates multiple economic benefits. Among the most cited by respondents were reductions in electricity consumption due to smart lighting control, increased efficiency in urban services, and the creation of new entrepreneurial opportunities through data monetization and platform-based business models. Furthermore, the ability to modernize existing lighting infrastructure without large-scale investment makes the solution both cost-effective and scalable, especially in the context of constrained municipal budgets.

From an environmental perspective, the “smart poles” platform offers significant positive outcomes. These include lower carbon emissions, improved air quality monitoring, and optimization of traffic and energy flows. The modular design, energy-efficient hardware, and integration of renewable energy sources (e.g., solar panels) further reinforce the ecological value of the system. Additionally, the ability to collect and process environmental data in real-time equips city administrations with powerful tools for data-driven governance and sustainable planning.

Despite these advantages, several challenges remain. The research identifies critical barriers such as the lack of trained personnel for the IoT system maintenance, concerns about data privacy and cybersecurity, and the outdated state of much of the existing urban infrastructure. Addressing these obstacles will require a coordinated effort involving public authorities, private technology providers, and academia. In particular, the establishment of training programs, strategic partnerships, and regulatory frameworks supporting secure and ethical data usage will be crucial for sustainable deployment.

The validation of the working hypothesis opens avenues for future research and practical implementation. One promising direction involves the development of specialized pilot projects in mid-sized Bulgarian cities to further evaluate the real-world performance, maintenance demands, and community acceptance of smart poles. These pilot initiatives can serve as testbeds for innovation, generating valuable feedback for optimizing both the technology and business model. Additionally, longitudinal studies are recommended to monitor the environmental and socio-economic impact of IoT adoption over time.

Another future research direction lies in the expansion of the IoT platform's functionalities through integration with artificial intelligence (AI) and machine learning (ML). Predictive analytics could enhance the value of collected data, supporting advanced urban planning scenarios such as predictive maintenance, dynamic traffic rerouting, and emergency response optimization. Moreover, the development of open APIs for third-party developers will foster the creation of complementary services and applications, stimulating innovation and entrepreneurial ecosystems.

At present the platform is available as prototype running most of the use cases with selected hardware vendors, communication protocols, over-the-air upgrades, compliance with data privacy and security standards. To make it ready for commercial use will have to establish public-private partnerships for funding, finalize development for control center and the end user applications, draft contracts with clear governance terms, get ops personnel, pilot deployment and tests, gather user feedback and refine system. Once this is done, we can proceed with onboarding of commercial customers and full-scale rollout. After the platform is fully operational will go in Monitoring/Optimization and Innovation/Expansion phases, with adding new modules and features, explore monetization and scale to other customers and regions.

In conclusion, the implementation of smart IoT technologies in Bulgaria represents a realistic, innovative pathway toward more sustainable, intelligent, and economically vibrant cities. The "smart poles" initiative serves not only as a technological advancement but also as a strategic opportunity to reimagine urban living. Through informed policy decisions, stakeholder collaboration, and continuous research, Bulgaria can position itself as a regional leader in smart city innovation, aligning national development with global environmental and digital transformation goals.

REFERENCE LIST

Atzori, Luigi, Antonio Iera, and Giacomo Morabito. 2010. The Internet of Things: A Survey. *Computer Networks* 54(15), 2787–2805. https://doi.org/10.1016/j.comnet.2010.05.010

Bibri, Simon Elias. 2021. Smart Sustainable Cities of the Future: The Untapped Potential of Big Data Analytics and Context-Aware Computing for Advancing Sustainability. *Sustainable Cities and Society 74*, 103130. https://doi.org/10.1016/j.scs.2021.103130

Borgia, Eleonora. 2014. The Internet of Things Vision: Key Features, Applications and Open Issues. *Computer Communications* 54, 1–31. https://doi.org/10.1016/j.comcom.2014.09.008

Caragliu, Andrea, Chiara Del Bo, and Peter Nijkamp. 2011. Smart Cities in Europe. *Journal of Urban Technology* 18 (2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Chourabi, Hafedh, et al. 2012. Understanding Smart Cities: An Integrative Framework. *In Proceedings of the 45th Hawaii International Conference on System Sciences*, 2289–2297. https://doi.org/10.1109/HICSS.2012.615

Cocchia, Alessandra. 2014. "Smart and Digital City: A Systematic Literature Review." *In Smart City, edited by Renata Paola Dameri and Camille Rosenthal-Sabroux*, 13–43. Springer. https://doi.org/10.1007/978-3-319-06160-3_2

Giffinger, Rudolf, and Gudrun Haindlmaier. 2010. "Smart Cities Ranking: An Effective Instrument for the Positioning of the Cities?" *ACE: Architecture, City and Environment* 4 (12), 7–26. https://doi.org/10.5821/ace.v4i12.2483

Gubbi, Jayavardhana, Rajkumar Buyya, Slaven Marusic, and Marimuthu Palaniswami. 2013. "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions." *Future Generation Computer*

Systems 29 (7): 1645–1660. https://doi.org/10.1016/j.future.2013.01.010

Hashem, Ibrahim Abaker Targio, et al. 2016. "The Role of Big Data in Smart City." *International Journal of Information Management* 36 (5): 748–758. https://doi.org/10.1016/j.ijinfomgt.2016.05.002

Hollands, Robert G. 2008. "Will the Real Smart City Please Stand Up?" *City* 12(3), 303–320. https://doi.org/10.1080/13604810802479126

Kakizhanova, T., Utepkaliyeva, K., Zeinolla, S., Aben, A., and Ilyashova, G. (2025). Impact of Digitalization, Economic Growth and Birth Rate on Female Labor Force: Evidence from Kazakhstan. *Economics - innovative and economics research journal*, 13(2), 95–110. https://doi.org/10.2478/eoik-2025-0032

Komninos, Nicos. 2013. What Makes Cities Intelligent? *In Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation*, 77–86. River Publishers. https://doi.org/10.1007/978-3-642-20898-0_31

Lee, Jooho, and Heejin Lee. 2014. "Developing and Validating a Citizen-Centric Typology for Smart City Services." *Government Information Quarterly* 31, S93–S105. https://doi.org/10.1016/j.giq.2014.01.010

Nam, Taewoo, and Theresa A. Pardo. 2011. "Smart City as Urban Innovation: Focusing on Management, Policy, and Context." *In Proceedings of the 5th International Conference on Theory and Practice of Electronic Governance*, 185–194. https://doi.org/10.1145/2072069.2072100

Neirotti, Paolo, et al. 2014. Current Trends in Smart City Initiatives: Some Stylised Facts. *Cities* 38, 25–36. https://doi.org/10.1016/j.cities.2013.12.010

Priambodo, A., Anwar, N., and Suharno, S. (2025). Does Digital Literacy Mediate the Relationship Between ICT and Regional Own-Source Revenue? *Economics - innovative and economics research journal*, 13(2), 203–222. https://doi.org/10.2478/eoik-2025-0037

Westerlund, Mika, and Risto Rajala. 2014. "The Role of Business Models in the Development of Smart Cities." *IEEE Software* 31(6), 52–56. https://doi.org/10.1109/MS.2014.77

Zanella, Andrea, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, and Michele Zorzi. 2014. Internet of Things for Smart Cities. *IEEE Internet of Things Journal* 1(1), 22–32. https://doi.org/10.1109/JIOT.2014.2306328

Zanella, Andrea, and Michele Zorzi. 2015. The Role of Smart City Data in Urban Applications. *In Smart Cities: A Data-Driven Approach*, 27–44. Springer. https://doi.org/10.1007/978-3-319-27753-0_2

Zhang, Yunchuan, et al. 2017. "Smart City and the Applications of Internet of Things in the Construction Industry." *In IEEE International Conference on Smart Cloud (SmartCloud)*, 1–6. https://doi.org/10.1109/SmartCloud.2017.27

Lasse Lueth, Knud, IoT market segments – Biggest opportunities in industrial manufacturing, 2014, https://iot-analytics.com/iot-market-segments-analysis/

A1, https://www.a1.bg/en

SmartIT, https://mfg.bg/companies/smart-it

TechnoLogica, https://technologica.com/en/

Dataart, https://www.dataart.team/

Devision, https://www.devision.com/

Mclimate, https://mclimate.eu/

Shelly, https://www.shelly.com/

Develiot, https://www.linkedin.com/company/develiot

Bosch-digital, https://www.bosch-digital.com/

IoT Bulgaria, Statista Market Forecast, Jun 24, https://www.statista.com/outlook/tmo/internet-of-things/bulgaria

Consumer IoT Bulgaria, Statista Market Forecast, Jun 24, https://www.statista.com/outlook/tmo/internet-of-things/consumer-iot/bulgaria

Smart Cities – Bulgaria, Statista Market Forecast, Jun 24, https://www.statista.com/outlook/tmo/internet-of-things/smart-cities/bulgaria

Other IoT – Bulgaria, Statista Market Forecast, Jun 24, https://www.statista.com/outlook/tmo/internet-of-things/other-iot/bulgaria