TUZLA SMART CITY– CITY OF THE FUTURE

Energy Transition and Digitalisation

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1. INTRODUCTION

A smart city utilizes digital technologies so as to enhance the productivity and cost-efficacy of daily activities. It is a city offering better services to its citizens, creating a suitable ground for new investments, economic growth, but also a better and more attractive life.

Cities are pillars of human and economic activity. With a potential for synergies that create vast development opportunities for their residents, they can, however, also generate a wide range of problems difficult to solve. Cities are also places where inequalities are more prominent and, if not managed properly, the negative effects can outweigh the positive ones.

A poorly developed city or a city with outdated infrastructure is one hardly any town's mayor would like to manage. In this regard, the development of smart city technologies and orientation towards a technologically advanced future should be the goal of every city administration [1]. In fact, by 2050 as much as 70% of the world population will live in cities, namely: 64.1% in developing countries and 85.9% in developed countries, which points to the conclusion that cities must become as sustainable and self-sufficient as possible in order to provide its citizens quality of life[2]. Cities cover only 3% of the Earth's surface, but they are the driving force for development, quality of life and sustainability. This is essential for the construction of quality and sustainable urban concepts through the stabilization, construction and sustainability of smart cities [3]. The global reference for determining a society's value creation is the UN Program for Sustainable Development 2030. It sets out 17 Sustainable Development Goals to end poverty, protect the planet and ensure prosperity for all.

A city with free wireless Internet access in all public areas. A city where children learn how to program applications in elementary school. A city where you can shop online and have things delivered within hours. A city with functional street lighting. A city that uses smart sensors to tell drivers where to park in the city center. A city that knows when waste should be collected, and that has open data-access. A city that uses smart algorithms to coordinate hospital and vaccination capacities. A city that is moving towards improving urban energy and planning concepts. Such a city is called a "smart city" and it undertakes actions in all these areas based on a strategic and integrated approach to planning and a comprehensive and high-quality IT infrastructure [1].

Thus, cities are the fastest growing form of settlement worldwide, which implies a growing demand for space for buildings, infrastructure and food, water, and energy supply. Various initiatives, as

well as funds and legislation, are being launched all over the world so that modern cities can cope with these challenges, that is, to become “smart cities”. However, population growth, migration and urbanization create problems in the form of pollution, lower resilience and inadequate infrastructure. The solution lies in following trends in technological development [1].

The term “smart city” has emerged fairly recently. In the last two decades, many new words to modify cities have entered the scientific register and political discourse, such as: “sustainable”, “green”, “digital”, “smart”, “intelligent”, “informational”, “eco”, “low carbon”, “knowledge cities”, etc. Even combinations such as “low-carbon eco-cities” and “ubiquitous eco-cities” are used, which creates even more conceptual confusion. By looking at numerous texts, it can be concluded that the term “sustainable city” has mainly been replaced by the term “smart city” since 2010.

There is no finite definition of a smart city, due to the amount of technologies that can be incorporated into a city to be considered a smart city. From the definition given by Husam Al Waer and Mark Deakin [1] in their research publication “From Intelligent to Smart Cities”, the factors that contribute to classifying a city as smart are:

1. Application of a wide range of electronic and digital technologies among communities;
2. Use of information and communication technologies to improve the living and working environment within the region;
3. Installment of information systems in government systems;
4. The localization of the introduction of information and communication technology (LICT) contributes to innovation and improvement of the community.

For a city to become smart, devices, data and algorithms are not enough. A cultural transformation and beyond is necessary to make the vision a reality. It is vital that there is a unique strategy that will unite all individual efforts and ensure the sustainability of the entire concept behind everything. Otherwise, individual smart projects will be just sparks that will fade without leaving any significant trace. Smart technologies include Internet-of-Things (IoT), artificial intelligence, social media, low energy lighting and many other related new technologies.

A smart city is one that uses information technologies to meet market demands. Community involvement in the process is vital. A smart city would, therefore, be a city that not only has ICT technology in certain areas, but has also implemented this technology in a way that positively affects the local community. Digital technology should be embedded in all functions of the city, and includes: smart management, smart energy, smart construction, smart mobility, smart infrastructure, smart technology, smart health care, and smart citizens. A smart city is a concept of rethinking city development in terms of sustainability and efficiency with the help of ICT. Experience so far shows that it is necessary to launch as many initiatives as possible that will contribute to the sustainability and efficiency of resource use. This is the task of all parties: primarily the city administration, but also the business sector, non-governmental organizations, and most of all the citizens themselves.

The most common terms and ideas currently used in connection with the goals of the “smart city” concept are:

- General improvement of urban energy and planning concepts,
- Sustainability of the environment (sustainable use of resources),
- Social sustainability (achieving inclusion of different categories of the city’s population in public services, democratization with cultural and social progress),
- Better quality of life through technical improvements in telecommunications infrastructure, administration, mobility, etc.
- Economic development and efficiency,

- Integrating the private sector, business-oriented urban development,
- High-tech and creative industries in long-term growth,
- Social/human capital in the development of the city,
- Adaptability.

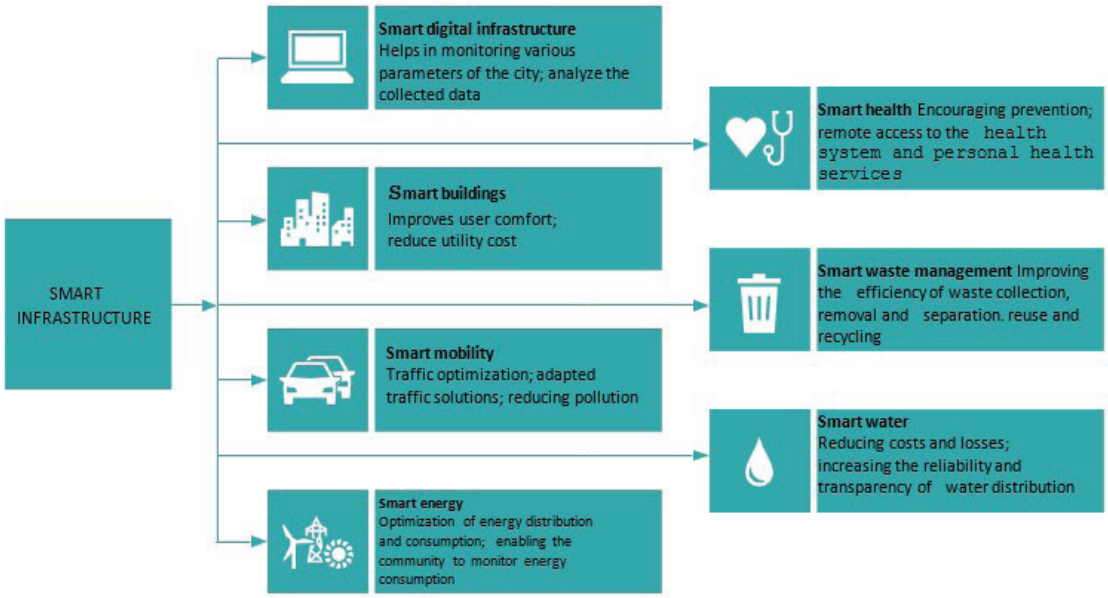


Figure 1.1. Concept, participants and possible impact of the "smart city" [1]

A wide range of terms and ideas that go with the concept of a "smart city" are presented today at the theoretical level and classified into six functions [2,3]:

- Smart economy (competitiveness),
- Smart population (social and human capital),
- Smart management (participation),
- Smart mobility (transport and ICT),
- Smart environment (natural resources),
- Smart living (quality of life).

The Development Strategy of the city of Tuzla for the period until 2026 is a key development document adopted by the City Council of the City of Tuzla at its 4th session (September 19, 2013). At that time, it was stated that the City of Tuzla, with its proactive approach and full engagement of available resources, almost completely achieved the goals from the Tuzla Municipality Development Strategy until 2015. Noting that most of the strategic goals from the long-term development strategy of the municipality of Tuzla for the period 2003-2015 have been realized, the Tuzla Municipal Council adopted a conclusion accepting the initiative of the Mayor to create a new development strategy that will cover the period until 2026.

The Development Strategy of the municipality of Tuzla until 2026 is compatible with the EU Development Strategy until 2020, which prioritizes the development concept based on smart, sustainable and inclusive development. In this approach, smart growth implies the development of an economy based on knowledge and innovation, sustainable growth implies the development of a more efficient, cleaner and competitive economy, and inclusive growth foresees the strengthening of the economy with high employment, social and territorial cohesion. These three development priorities will promote and encourage employment, productivity growth and social integration. The

development model conceived in this way focuses on the achievement of goals related to employment, innovation, education, social inclusion and energy efficiency.

The vision of the municipality/city of Tuzla was set from the defined framework for creating the Strategy, which reads: "*Tuzla is a city of continuity of culture, creative innovation, healthy and pleasant life; a city that enables the participation of its citizens in all aspects of urban life; a city that ensures economic and social attractiveness, development and quality of life for citizens and all people who live, invest and create in it.*" The vision is complementary to the mission and states: "*Joint dedication to the satisfaction and happiness of citizens, improvement of the environment for actors of economic and social life, while preserving the cultural, historical and natural heritage of the city*."

A more detailed consideration of these questions and topics prompted the preparation of this Study: "The Smart City of Tuzla - The City of the Future", which can be a good basis for the creation of the Tuzla Smart City Strategy. This Study will elaborate and explain the Smart City concept, acts and practice at the EU level, present the projects that have been implemented so far, which are connected to the development of the Smart City concept, as well as guidelines for the 6 mentioned key areas (economy, citizens, public management, mobility, environment and lifestyle).

DIGITAL TRANSFORMATION

2. DIGITAL TRANSFORMATION

2.1. Smart City development as a concept

Based on all data available, cities are generators of economic and social development, in particular, they are centers for new investments and the application of new development models. In this sense, the term Smart City has been used since the 90s to emphasize the need for the application of high-quality technological solutions that will contribute to the quality of life in urban areas. Moreover, some authors [2] believe that the concept of a Smart City is attributed to human characteristics. In any case, the term Smart City is inextricably linked to technological development.

The concept of Smart Cities was developed precisely because of the need to achieve a more organized, high-quality, energy-efficient, environmentally friendly, economically better place for people to live. "The development of smart cities with its technological improvements through the use of ICT should be open to the emotional, social and spiritual side of man. The goal of smart cities should be to exploit the benefits of life in large communities, and to suppress its negative consequences for each individual [2]". Although the concept of a smart city developed out of necessity, cities do not actually become smart by accident or out of necessity, but rather they become smart systematically, taking into account the sustainability of the proposed solutions.

The executive government branch will strive to improve the city it manages, its destination, and direct it to a certain competitive advantage and ensure the smooth operation and functioning of its local self-government. Ultimately, poor public transport, constant traffic jams, bad city administration, lack of technology, poor health services and education, weak security, lack of concern for the environment, non-transparency of city decisions and procedures force residents and entrepreneurs to choose other

locations for living and working. Residents who move for these reasons are primarily part of a more mobile population, highly educated and with higher average incomes. The loss of such a population can be disastrous for cities because, in the long term, the development and innovative component of the workforce is lost, which is the bearer of growth, development and adoption of new technologies, which is a prerequisite for the creation of new jobs.

The need to develop the concept of Smart Cities also lies in the fact that for the first time in most developed countries and developed cities, more and more people live and work in cities, which creates constant pressure on local politics, infrastructure and local development. "In the world's cities, 80% of the world's gross national product is produced and two-thirds of the world's total energy consumption is consumed." "70% of the world's total greenhouse gas emissions annually ensues from them into the atmosphere, and a million people die every day as a result of air pollution in cities." "About 3.5 billion people live in cities today, more precisely more than 50 percent of the Earth's population." On the other hand, population growth also enables the development of individual local communities, especially attracting investments for the sustainability of the city's urban structure. "This also creates logistical problems, in terms of delivery, treatment of waste and waste-water, education, health, safety, mobility and employment of the population, emancipation of the population in the management of the city."

Cities and their infrastructure are elaborate complexes, which need to keep up with the times and progress and grow at the same speed in order to meet the needs of citizens every day. Some cities are more successful at this than others. Whichever Smart City concept is used, it is always aimed at smarter and more sustainable solutions so as to add to better economic opportunities and quality of life.

Environmental protection, energy efficiency, savings on public lighting, controlled use of natural resources, the availability of smart tools for easier navigation and communication with the city's administrative apparatus, technology and simple traffic solutions - these are all parts of a large puzzle that needs to be shaped and assembled in such a way that provides better results with the aim of a better managed, ecologically sustainable, energy efficient, safe and technologically advanced city.

A Smart City is a global concept developed under the influence of technological development, and especially under the influence of large companies that develop integrated technological solutions applicable in various sectors. The concept of integrated technological solutions is developing at a high speed, and their application, changes the needs and habits of users of public services. Although there is no single definition, the term Smart City can be most simply defined as a systemic (strategic) approach to city development through the use of ICT. The development of technology imposes new trends, so we should talk about the Internet of Things technology, 3D printing and cloud computing. However, Artificial Intelligence and Blockchain technology are also developing.

The Internet of Things, for which the abbreviation IoT (Internet of Things) is used, represents the general concept of the ability of network devices to sense and collect data from the world around us, and then share this data over the Internet, where it can be processed and used for various interesting purposes. 3D printing or three-dimensional printing is a way of quickly creating prototypes, i.e. objects through direct printing from a 3D CAD program. Cloud computing can be imagined as a large set of computing resources that are easily available. These resources can be, for example, computer networks, servers, data storage systems, applications and various other services. The end user just connects to the cloud and uses the resources he needs, not caring how they are created, and pays for the amount of resources he consumes.

In addition to the above, a more massive use of unmanned aerial vehicles (drones) has begun for commercial purposes related to the surveillance of inaccessible areas, dusting of surfaces, geodesy, tourism and entertainment. Also, the first projects using artificial intelligence and machine learning

in the form of virtual assistants that answer user questions (through online channels or customer service) are underway. Software solutions that convert text or voice into digital form (OCR –Optical Character Recognition, or VRT –Voice Recognition Technology) are certainly interesting. At the global level, the application of technology related to the use of various types of virtual currencies (Cryptocurrency) based on the application of the so-called Blockchain technology, which in the future will certainly become a platform for the democratization and decentralization of traditional value exchange systems. Also, at the same time, it promotes an innovative approach in financial projects (fintech project).

The trend of a significant drop in prices largely helps the popularization of the use of technologies. So, for example, the price of unmanned aerial vehicles (drones) has been reduced up to a hundred times in six years, while the price of industrial robots has been reduced up to thirty times in seven years.

The Smart City concept implies management based on data that is contextually transformed into information and knowledge about the observed system. Data is collected in different ways, and IoT technologies enable their mass collection from remote locations through a network of installed sensors. This way of collecting data leads us to the fact of having huge amounts of data at our disposal, which enables better management of different systems.

In the said way, via IoT, a significant amount of data (Big Data) is collected every day, which needs to be analyzed and properly used through the Data Center (Data Center) which consolidates the collected data. At the same time, it should be emphasized that the Data Center can be owned by a business entity or the Data Center services can be used through Computer Clouds. Based on the analysis of the collected data, it is possible to observe various phenomena in the urban environment and to plan new measures to improve the situation in the urban environment.

A Smart City integrates ICT and IoT solutions in order to safely and efficiently manage city assets, which achieves the integration of various public services such as lighting, traffic, energy production, ecology and more. This way, the efficiency of public services is increased, costs are reduced and communication between subsystems is accelerated, and most importantly, the significant reduction of CO2 emissions is achieved. One of the prerequisites for the development and use of ICT and IoT solutions is digitisation. The term digitisation is used for the process by which different forms of information such as text, sound, image or analog signal are converted into a unique binary code, i.e. a digital discrete form that can be processed by a computer.

*Figure 2.1. The relationship between projects, initiatives and cities **

When we talk about a Digital City, it should be emphasized that this term is sometimes used as a synonym for a Smart (intelligent) City. At the same time, through this term, an attempt is made to define the concept of a Digital City as a social information infrastructure for improving the quality of city life in all segments. However, in this study we will use the term Smart City, which emphasizes meeting the needs of all citizens within the urban area, while the term Digital City emphasizes the use of technologies. So, although both terms are associated with technological development, a Smart City respects the real needs of all categories of citizens, and therefore this approach is more suitable for us. Also, the term Smart City includes planning and managing changes based on data, information and knowledge, public participation and openness to cooperation with partner institutions. The application of

integrated technological solutions changes the needs and habits of users of public services and creates a digital society. Digital society means a modern, advanced society formed as a result of the adoption and integration of ICT at home, at work, in education and in free time.

From the abovementioned, it can be concluded that the Smart City concept is based on the digital possibilities of urban development, emphasizing the need to develop a technological platform for networking of all participants. Therefore, in a technological sense, the Smart City concept is increasingly focused on connecting different sensory technologies via the network, always with the aim of improving the quality of life for citizens, improving business for entrepreneurs, and enabling the public sector to communicate on multiple levels, with everyone to whom the public service provides service.

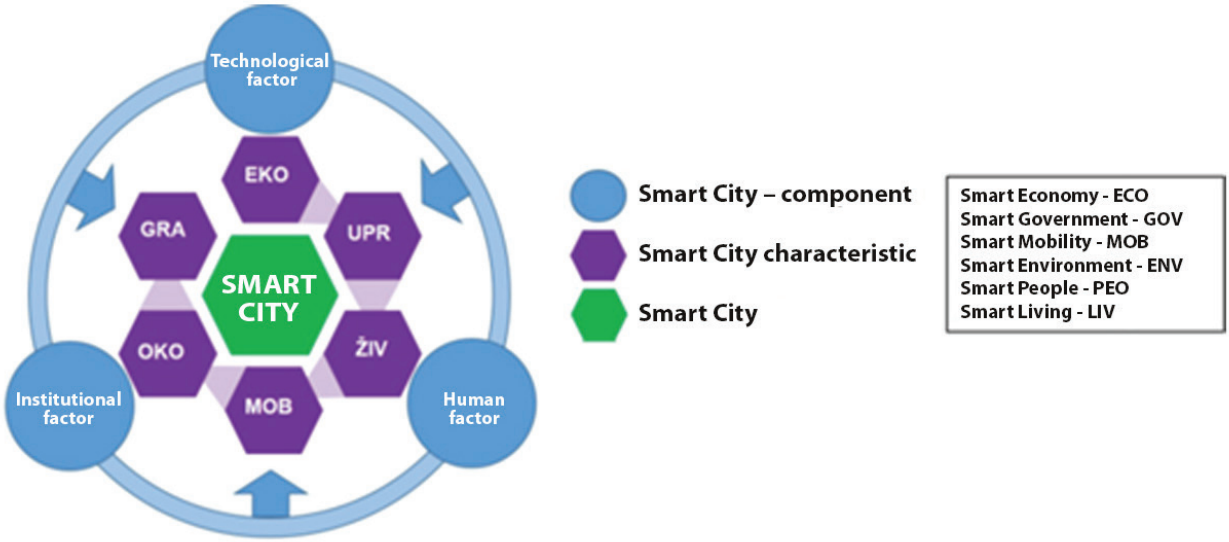


*Figure 2.2. The relationship between components and aspects of Smart Cities**

However, aside from the technological part, it is also about a complete urban digital transformation that is realized in cooperation with a whole range of participants, the public and private sector, citizens, non-governmental organizations, business community, entrepreneurs and scientific research institutions.

In addition to technological development, the Smart City concept also has an innovative component that indicates the development of human and organizational capacities. Certain smart projects from, for example, mobility, connected to the public transport system can certainly be considered projects from the field of Smart Environment due to energy consumption. In the development of the Smart City concept, local specificities and needs should be taken into account, which differ from city to city, and each one within a certain area determines its own priorities. In all cities, traffic is a topic that deserves a lot of attention, and in this sector, technology can be used to improve the public transport service, improve the management of traffic systems, but also significantly contribute to air quality, i.e. achieve positive environmental impacts.

Green economy is an important driving force behind a large number of initiatives. The results of observing the principles implemented by the green economy have an enormous impact on improving the quality and standard of living. In order to create Smart Cities, it is necessary to use certain technologies. Given the increased use of technology, one might expect that it is not possible to respect the principles of the green economy, but the concept of Smart Cities does imply the application of a green economy. Smart Cities are based on sustainability and optimal use of resources. This means that the idea of Smart Cities overlaps with the idea of a green economy. In the future, it is expected to

raise the quality of life, which is also part of the ideas of the green economy. Quality and sustainable use of resources will help create Smart Cities. Green economy and Smart Cities are similar in that their ideas are focused on the future. By focusing on the future, new values are created in the present, and the creation of a Smart City always includes the ideas of green economy. Green economy ideas are in fact part of a Smart City.

2.2. Framework for the development of Smart Cities

2.2.1. The framework of Smart Cities in the world

According to data for the year 2021, the US government, through the United States Department of Transportation, is investing approximately 177 million USD in traffic solutions for smart cities. Of the stated amount, 114 million USD are funds from public sources, and the rest are various sources of financing aimed at technological development.[1]

Asia, which accounts for 60% of the world's population, is emerging as a dynamic region in the world in terms of economic and technological growth. It's no surprise that Asian cities are also recognized as leaders in designing Smart Cities that use digital information to improve operational efficiency. In Asia, there is a great emphasis on issues of urbanization and e-governance. The policy of the People's Republic of China is certainly interesting, which solves the problems of rapid urbanization by developing the concept of Smart Cities, but also encourages Chinese companies to develop projects that must provide new technological solutions for accelerated urban development. At the same time, the Ministry of Housing and Urban-Rural Development is particularly active, encouraging smart projects throughout the country. Also interesting is the example of the Republic of India, which, through the Ministry of Urban Development, encourages the development of 110 Smart Cities with the aim of sustainability and quality of life. The development of Smart Cities in India began in 2015 and was aimed at the comprehensive development of infrastructure and increased economic growth that will improve the quality of life, create more jobs and increase incomes for everyone, especially poor citizens. India is poised to become the most populous country in the world by 2030. It is predicted that the so-called megacities generate about 80% of economic growth with the application of modern technologies and infrastructure [2]. By 2050, approximately 843 million people will live in cities in India, and this requires smarter ways of managing urban development. Therefore, the Smart Cities vision, set by Prime Minister Narendra Modi, plans to build 100 smart cities across India.

The mentioned Smart Cities will be a training ground for new technological solutions in India, but also in the global market. It is interesting to note that the Indian authorities are also creating new economic corridors in cooperation with neighboring countries that want to offer their companies new investment opportunities [2]. In Japan, the national government has selected 13 sites for its Eco-Model Cities scheme. This includes four major cities - Kitakyushu, Kyoto, Sakai, Yokohama - plus 9 other small and medium-sized cities.

2.2.2. The framework of Smart Cities in the EU

In Europe, the emphasis is placed on the fight against climate change. European cities are hubs for all kinds of activities – a pathway for study opportunities, jobs and services because of their key infrastructure and economic activity. More than three quarters of the EU population live in urban areas and this number is expected to rise to almost 85% by 2050.

1 US Department of Trasportation (2021). Agency Financial Report: Fiscal Year 2021. available at: https://www.transportation.gov/ sites/dot.gov/files/2021-12/FY%202021%20DOT%20AFR_508-Compliant_updated.pdf

Due to the high number of population, urban areas also consume the highest amounts of energy and have the highest greenhouse gas emissions. As the fight against climate change increasingly involves the application of solutions at all levels and the participation of citizens, cities are well positioned to show leadership in the clean energy transition and can achieve significant benefits through the early adoption of policies aimed at achieving climate neutrality. To this end, the European Commission is putting Smart Cities at the forefront of its efforts to achieve the goals of the European Green Deal and to make Europe climate neutral by 2050.

Several EU policies, proposals and initiatives that promote more sustainable and competitive urban areas already exist. This includes the implementation of smart technologies in buildings to increase their energy efficiency, the promotion of research and innovation efforts to transform the EU's energy system into a low-carbon one, and the development of expert networks for the implementation of EU climate and energy goals in cities.

The Smart Cities Marketplace was launched as the European Innovation Partnership Market on Smart Cities and Communities in 2012 and since then aims to improve the quality of life of citizens, increase the competitiveness of EU cities and companies and help achieve the EU's energy and climate goals. This initiative provides information on the introduction of sustainable solutions for smart cities using its integrated "Explore-Shape-Deal" process, which enables an exchange between project promoters and members of the financial community by gathering and shaping smart city knowledge into profitable projects. In order to effectively encourage the process of finding partners, the platform brings together cities, industries, small and medium-sized enterprises, investors, banks, researchers and other actors in areas such as sustainable urban mobility, districts and the built environment, focus on citizens and integrated infrastructures and processes in energy, information and communication technologies and transport. The main areas of cross-sectoral action of the Marketplace include: sustainable urban mobility, sustainable areas and the built environment, integrated infrastructures and processes in energy, information and communication technologies and transport, focus on citizens, policies and regulations, integrated planning and management, knowledge sharing, fundamentals , performance indicators and metrics, open data management, standards and business models, procurement and financing.

Also, the European Commission has developed another initiative focused on Smart Cities called the Intelligent Cities Challenge (ICC), which supports 136 cities in using cutting-edge technologies to lead an intelligent, green and socially responsible recovery. ICC cities and their local ecosystems will be engines for the recovery of their local economies, creating new jobs and strengthening civic participation and well-being. The ICC is part of a wider EU support system that recognizes the importance of fulfilling the promises of the European Green Plan, the digital strategy and other EU policies. It seems to be moving towards a more digital, service-based and low-carbon economy, supported by a knowledge-based society, which enables circular economy systems through "local value loops", evidence-based retraining and sustainable investments.

At the global level, the EU lags behind the production and application of technologies related to the concept of Smart Cities. In the last few years, activities aimed at a faster development of digitisation have been undertaken. The EU recommends the development of Smart Cities through a series of documents and conclusions. As part of the Europe 2020 strategy, on May 19, 2010, the European Commission published a statement containing an initiative called the Digital Agenda for Europe (DAE). In March 2013, the European Council invited the European Commission to prepare a Report on the implementation and key obstacles to the completion of the single digital market by 2015. The Group of High Representatives is responsible for monitoring the implementation of the Digital Plan

for Europe. The overall goal of this initiative is to achieve sustainable economic and social benefits on a single digital market based on fast and ultra-fast Internet and interoperable applications. DAE determines 101 measures grouped into seven priority areas of activity at the EU level:

1. Creation of a single digital market,
2. Improving the interoperability of information and communication products and services,
3. Encouraging trust and safety on the Internet,
4. Ensuring the provision of significantly faster Internet access,
5. Encouraging investment in research and development,
6. Improving digital literacy, knowledge and e-inclusion
7. Application of information and communication technologies in solving key challenges of society, such as climate change, increase in health care costs and population aging.

The Management Development Institute and Singapore University of Technology and Design have ranked cities in their Smart City Index. In the Smart Cities Index for 2021, among the top ten smart cities in the world, Singapore was the first, followed by Zurich, Oslo, Taipei City, Lausanne, Helsinki, Copenhagen, Geneva, Auckland and Bilbao, three of which are in Switzerland.

2.2.3. Smart Cities in the EU

The EU and its member states at all levels of governance, together with civil society, businesses and researchers collaborate to create a city that is constantly changing and adapting to tomorrow. European cities will continue to be attractive to citizens and will offer increasing employment opportunities, quality of life and social services. To ensure successful coexistence, European cities collaborate with actors in a participatory manner at all levels in areas such as housing, energy, mobility, water, climate policy, poverty eradication, inequality, circular economy, resilience and security. European cities will become Smart Cities, in which traditional networks and services using digital and telecommunication technologies will become more efficient for the benefit of their citizens and businesses.

Smart specialization, partnership between cities, social inclusion and participatory politics (e.g. collaborative city management, multi-stakeholder platforms), sustainable plans for urban mobility, socially responsible business/responsible business behavior, crowdfunding and other forms of innovative financing, digitisation, artificial intelligence and new technologies, collaborative economy, low-emission public transport, active mobility (walking and cycling) and appropriate infrastructure, research and innovation, low-emission buildings, urban agriculture, urban green areas are some of the possibilities , that is, the initiator of positive movements.

At the EU level, which included 28 member states in 2014, an expert study entitled “Mapping EU Smart Cities” (hereinafter referred to as the Study) [2 was considered by the European Parliament in January 2014. The Study points out that in 2011, 240 out of 468 EU-28 cities with at least 100,000 inhabitants, or 51% of them, have at least one characteristic of a Smart City and can therefore be classified as a Smart City. The study points out that there are more small Smart Cities than large ones, but there are Smart Cities in all size categories and in most EU-28 countries. The largest absolute number of Smart Cities is found in Great Britain, Spain and Italy, while the countries with the largest share of Smart Cities are Italy, Austria, Denmark, Norway, Sweden, Estonia and Slovenia. According to this Study, most Smart City initiatives are still in the early stages of development, but larger cities tend to be the most mature (with at least one fully launched or implemented initiative). The most common of the six characteristics that will be presented in the next part of the Study and that are most represented in the implementation of a Smart City are related to pan-European issues of public goods - Smart Environment and Smart Mobility, present in 33% and 21% of initiatives, respectively. Each of the other

four characteristics (governance, economy, people and life) is addressed in approximately 10% of Smart Cities, reflecting specific local strengths or weaknesses. The study points out that the size of the city has a clear positive correlation with the number of required characteristics through Smart City initiatives. Initiatives for the concept of smart living exist across the EU-28, while initiatives focusing on other areas are less evenly distributed. Smart Governance projects are mainly implemented in Northern Europe (e.g. France, Spain, Germany, Sweden and the UK) and Italy. Initiatives for smart mobility are relatively well represented in the non-Nordic North of Europe, Spain, Hungary, Romania and Italy, but insufficiently represented in the Nordic member states. Some characteristics are likely to be found in combination with others, such as Smart People and Smart Living.

The Smart Cities concept is implemented in various projects that respond to specific urban challenges. Of course, every city is different, which is a consequence of historical circumstances, the current situation and the dynamics of development. According to European documents and practices, the following areas are understood under Smart City: Smart Economy, Smart Mobility, Smart Environment, Smart Citizens, Smart Living and Smart Administration [14].

The Smart Economy area includes projects related to business improvement through innovation. At the same time, the emphasis is on strengthening entrepreneurship, as well as relations with consumers. Projects from the field of Smart Economy result in an increase in productivity, but also in the recognition of local companies on the domestic and international markets.

Projects in the area of Smart Mobility contribute to a sustainable, innovative and safe transport system, especially the public transport system. The development of information and communication infrastructure significantly affects the management and organization of all types of traffic in cities, including idle traffic (parking system).

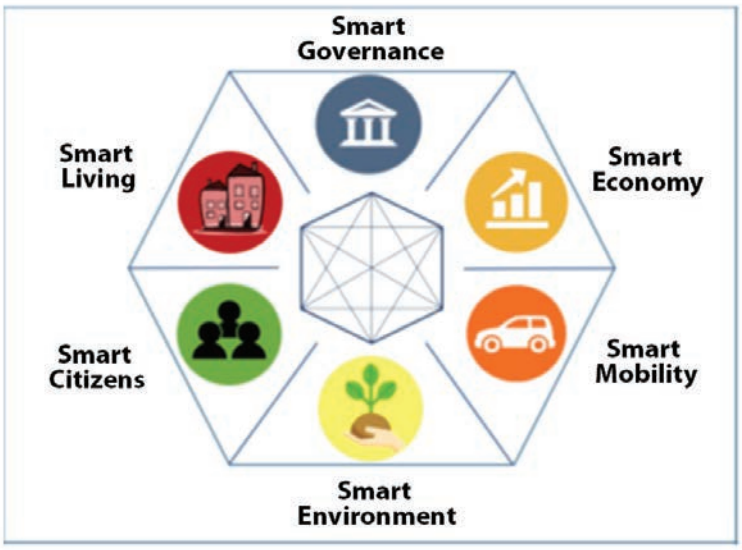
Smart Environment projects refer for the protection of water (rivers and lakes), sea, air, soil, and all natural resources. Sustainable management of natural resources is achieved by introducing new technological solutions. This is particularly prominent in energy consumption, waste disposal and management, and construction or renovation of buildings.

Projects in the field of Smart Citizens are related to education, but also specific forms of education for citizens of all age groups. There is a special emphasis on educational programs that develop the digital skills of citizens. In addition to the above, it is a concept of lifelong learning that encourages creativity, social and ethnic pluralism. All of the above results in greater participation of citizens in the local community, which contributes to the quality of life.

Smart Living includes projects related to improving the quality of life. It mainly is about improving the health culture and quality of health of all age groups. However, the projects are also related to increasing the quality of life in other different areas - housing, education, security, social inclusion, culture, sports and recreation, and sustainable tourism.

Smart Administration refers to projects that make public government transparent, and public and social services more accessible to all citizens. The prerequisite for the aforementioned is the education of public administration employees (strengthening of administrative capacities). However, the availability of various databases and the creation of an information service for communication with citizens is also important. It is also about projects that encourage citizens' participation in decision-making, and the inclusion of citizens in the processes of creating strategies, plans and other documents important for the local community.

The study indicates that the success and realization of the Smart Cities concept requires quality projects and measurement of the effects of each project and concept as a whole. The Study also



Figue 2.3. Smart City Areas [14]

lists the most successful smart cities: Amsterdam (Netherlands), Barcelona (Spain), Copenhagen (Netherlands), Helsinki (Finland), Manchester (UK) and Vienna (Austria). Analysis of the projects listed in the Study shows that 50% of the projects in smart cities are oriented towards the challenges of sustainable development through energy-efficient buildings and urban traffic.

Europe 2020, the EU strategy for the period from 2014 to 2020, includes the promotion of the concept of Smart Cities and the need to invest in ICT. In this way, the achievement of the European goals of smart, sustainable and inclusive growth by 2020 is supported. Europe 2030, the strategy for the period up to 2030, is a new EU strategy for which Ursula von der Leyen, the president of the European Commission, emphasized: "The green transition is making its way across Europe right now. But there is always a need for pioneers, who set themselves even higher goals. These cities show us the way to a healthier future. We will support them in that! Let's get to work today."

Cities Mission will receive EUR 360 million in funding from Horizon Europe for the period from 2022 to 2023 in order to launch innovations towards climate neutrality by 2030. Research and innovation activities will deal with clean mobility, energy efficiency and green urban planning, and offer the possibility of building joint initiatives and strengthening cooperation in synergy with other EU programs, which will certainly accelerate the development of Smart Cities in the EU.

2.3. Digital Transformation in Bosnia and Hercegovina

Digital technologies significantly affect the way of life, work, networking and social interaction of a growing part of the population. Digital transformation (DT) refers to profound changes that occur in all sectors of the economy and society, as a result of the introduction and integration of digital technologies into every aspect of human life.

Considering the importance of digital transformation for the competitiveness of companies and the economy as a whole, it is one of the major priorities of the EU. The European Parliament helps shape policies that will strengthen capacities in the implementation of new digital technologies, opening up new opportunities for businesses and consumers, developing people's digital skills and training workers and digitizing public services, and intensively monitors the digital transformation of business in member countries.

On the other hand, in Bosnia and Herzegovina (BH) there is no relevant report that would present the state of digitisation of business. The Chamber of Foreign Trade of BH (FTCBH) has set digital transformation as one of the priorities in the coming period, as it is a prerequisite for increasing the competitiveness of the economy, but also for improving a number of other processes that are crucial for BH on its path to European integration. As it is estimated, digitisation in the chamber system will significantly contribute to the improvement of services to members and facilitate their business.

Bosnia and Herzegovina is one of the most complex organized countries in the world. It consists of two entities: the Federation of Bosnia and Herzegovina (FBH) and the Republic of Srpska (RS), as well as the administrative unit Brčko District of Bosnia and Herzegovina (BD). Additionally, the FBH entity is divided into 10 cantons. BH is characterized not only by the complex organization of the state, but also by vaguely defined competences for certain areas, e.g. where laws defining the same

legal matter are passed both at the state level and at the entity level, including BD. For instance, it can be seen that the laws defining the use of electronic signatures and electronic documents were passed at the level of BH, but also at the level of the entities and BD.

By adopting the Policy for the Development of the Information Society of BH for the period 2017-2021, and the Policy for the Management of Information Security in the Institutions of BH for the period 2017-2022, BH clearly defined its strategic commitment to the development of the information society and the improvement of information security on the territory of BH. Although structurally a very complex country, Bosnia and Herzegovina has passed a certain number of laws and strategic documents aimed at the promotion and improvement of electronic business. It is necessary to emphasize the fact that the implementation of the aforementioned strategic documents and laws is very slow, which significantly limits the digitisation and electronic business of small and medium-sized enterprises.

Furthermore, during the research of legal regulations in BH, one can come to the conclusion that the register of enacted regulations is quite complex and the analysis of legal regulations from any field requires a lot of time, and as such can be assessed as inadequate. Searching for relevant regulations is very complicated, while determining the list of valid regulations for a company that intends to start operating on the territory of Bosnia and Herzegovina can be a real challenge. Simplifying the work of companies clearly requires the unification of all regulations in Bosnia and Herzegovina into a single database, regardless of the level of government, which could then be searched online.

The strategic documents at the BH level are:
- Policy for the development of the information society of BH for the period 2017-2021 ("Official Gazette of BH", no. 42/17)
- Information security management policies in BH institutions, for the period 2017 - 2022 ("Official Gazette of BH", no. 38/17)
- eSEE Agenda + (Directorate for Economic Planning, Council of Ministers of BH, 2015)
- Strategic Framework for BH (Directorate for Economic Planning, Council of Ministers of BH, 2015)
- Law on Electronic Signature of BH ("Official Gazette of BH" No. 91/06)
- Law on Electronic Legal and Business Transactions ("Official Gazette of BH ", No. 88/07)
- Law on Electronic Documents ("Official Gazette of BH", No. 58/14)

The by-laws governing this area are:

a) At the BH level:
- Rulebook on the payment of indirect taxes and other revenues and fees charged by the Directorate for Indirect Taxation ("Official Gazette of BH ", No. 21/20 of April 30, 2020);
- Decision on determining the price of services for issuing and using qualified electronic certificates ("Official Gazette of BH ", No. 78/20 of 04.12.2020).

b) At the FBH level:
- Rulebook on the procedure for submitting tax returns ("Official Gazette of FBH", no. 66/02, 54/03, 74/04, 38/09, 7/11, 53/12 and 87/20);
- Rulebook on the application of the Law on Profit Tax ("Official Gazette of FBH", no. 88/16, 11/17, 96/17, 94/19 and 87/20);
- Rulebook on submission of applications for enrollment and changes to enrollment in the unified system of registration, control and collection of contributions ("Official Gazette of FBH", no. 73/09, 38/10, 77/10, 9/11, 1/13, 83/ 14, 1/15, 48/16, 25/17, 53/19 and 93/19).

c) At the level of RS:
- Rulebook on the procedure for registration and identification of taxpayers ("Official Gazette of RS", No. 94/2017).

In addition to policies and strategies, as well as legal and by-law regulations for which the competent authorities at the state and entity levels are responsible, there are other projects and activities that include digitisation or digital transformation in BH, especially those initiated by international organizations. The main goal of the projects is to improve the level of digitisation of companies and public administration in Bosnia and Herzegovina.

The UNDP (United Nations Development Program) actively participates in this field, and one of the projects implemented by the UNDP is "Digital Transformation in the Public Sector in Bosnia and Herzegovina

(2020-2024)". The goal of the project is to provide support to the BH authorities on their way to a digital future by promoting new opportunities and utilizing technologies and innovations for more efficient and inclusive management and provision of public services. This project has three main goals: to improve the legal and political environment that accelerates digital transformation in the public sector, to inclusively advance e-government and people-oriented e-services, and to increase capacity and open innovation in the public sector through knowledge exchange and networking.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH takes an extremely active part in the field of digitisation, and in the last two years has contributed to the greatest extent to the development of digital transformation in BH through the project "Innovations and digitisation in small and medium-sized enterprises in BH". With its activities, the project raises awareness of the possibilities of digitisation and develops the innovative spirit of SMEs, especially in traditional sectors such as sales, metal and wood processing, agriculture and tourism.

The Chamber of Foreign Trade of BH (FTCBH) contributed through work on the development program of the information society of BH with the aim of promoting domestic economy and support in approaching modern business and work flows, both in the EU and in the world. In cooperation with GlobalGPS NJ d.o.o. the Tiimiss conference was held, which consisted of 13 thematic units, which presented what is a priority for society and its digitalization.

The company Datalab BH organized a panel discussion on the topic "The state of digitisation and the vision of the digital future of Bosnia and Herzegovina's economy", and the panelists agreed that this process is an important step towards better service in all segments of BH society, and that digitisation achieves better service in medicine, education , judiciary, public administration, media, police and every other area of life.

It can be concluded that the state of digitisation - that is, digital transformation in Bosnia and Herzegovina, is such that we lag behind both the EU countries and the countries in the region. Although digital technologies are transforming the global economy, Bosnia and Herzegovina has not yet experienced all the developmental benefits of digital technologies, such as inclusive and sustainable growth, as well as improved management and fast delivery of services. Bosnia and Herzegovina is faced with the risks of slow or poor adoption of these innovations, which can have bad consequences for the economy, the government sector and individuals, that is, the country as a whole. A faster and better reaction from regulators and all state and entity levels is expected, in order to stimulate, rather than slow down - that is, stop technological progress. The legislator should make additional efforts and work on improving the regulations related to the application of digital signatures, use of cloud services, protection of personal data, access to data registers and the like, all with the aim of harmonizing the regulatory framework with global trends.
Figure 2.4 shows the DESI indicator of the integration of digital technologies taken from the report of the European Commission for the year 2020. According to the aforementioned report, the most successful are Ireland, Finland, Belgium, the Netherlands, Denmark and Sweden with a score of more than 55 points. At the other end of the scale are Bulgaria, Romania, Hungary, Poland, Greece and Latvia with a rating of less than 35 points, well below the EU average of 43 points. If BH were included in the analysis, it would be before or after Hungary or Poland. This is only an estimate based on data from 2019 and 2020, given that the analysis for the EU was based on data from 2020, and not all data for this year is available for BH (so for some indicators, data from 2019 was observed).

The presented data for BH indicate that the situation in BH, when it comes to the digital transformation of business operations, is at a very low level compared to other European countries. Together with Poland, Hungary and Romania, Bosnia and Herzegovina is at the very bottom of the business digitisation scale. The situation with SMEs is particularly unenviable. One of the main obstacles to the digitisation of SMEs is the gap in digital knowledge, which is caused by the low level of digital literacy among owners, managers and employees (European Commission, 2020). The European Commission (European Commission, 2020) emphasizes that there is a big difference in the integration of digital technologies by companies depending on the size and sector. Before the pandemic, companies were becoming increasingly digitized, especially large companies. 38.5% of large companies already relied on advanced cloud services, and 32.7% used big data analytics. However, the vast majority of SMEs have still not taken advantage of these technologies, with only 17% using cloud services and only 12% using big data analytics. Furthermore, the report states that there is a significant gap between large companies and SMEs not only in the application of advanced technologies in business, but also in basic digital solutions, such as software packages for enterprise resource planning (ERP) and e-commerce. In this regard, a special priority of digitisation efforts should be directed at small and medium-sized enterprises.

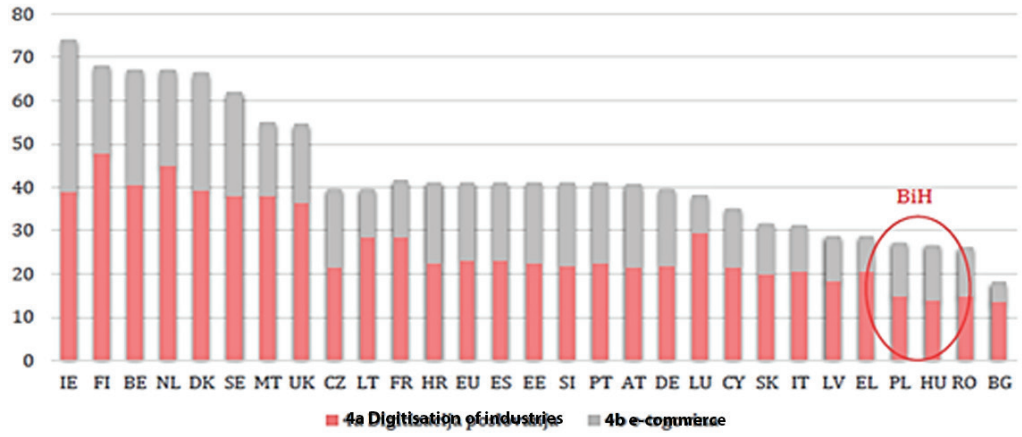


*Figure 2.4. The integration of digital technologies (DESI indicator) **

The level of digital transformation in BH can be assessed as low to moderate. Companies face different challenges in all areas that are defined as drivers of digital transformation: digital infrastructure, supply and demand of digital skills, entrepreneurial culture, investment and access to finance and e-leadership. According to most indicators, BH is below the EU average and at the bottom of the table. Taking into account the complexity of the organization of Bosnia and Herzegovina, governments at different levels are trying to define measures to achieve digital transformation of the country, but the results are hardly visible. The projects of international institutions and organizations that are quite active in this field have a significant impact on improving the state of digital transformation.

3.1. Background and History of the City of Tuzla

The city of Tuzla occupies an area of 303 km² and is located at an altitude of 231 m/asl. Tuzla is surrounded from the northwest by the mountain range of Majevica (Medvednik 843 m2), from the southwest by the mountains Ozren, Konjuh and Javornik. The area of Tuzla belongs to the Peripannonian region, i.e. the contact zone of the Dinarides of the Pannonian Plain. The valley area is located on the southern side of the ridge of Majevica and the separate ridge towards Obodnica. It consists mainly of long transverse stream valleys and hairpin bends that end in the Jala river valley. The terrain is slightly inclined to the south. Hotel Mellain, with a height of 100 meters, is the tallest building in Tuzla Canton. Neighboring municipalities of Tuzla are Srebrenik and Lopara from the north and northeast, Kalesija from the southeast, Živinice from the south and Lukavac from the west. The basic watercourse network consists of the Jala river with its tributaries, the largest of which are Solina and Joševica, as well as Požarnička river, Grabov and Mramorski potok. The Jala springs in the area of Majevica, at an altitude of 700 m. The total length of the main stream from the source to the confluence in Spreča is 37 km. The wider Tuzla area is mostly made of geologically young sediments (Neogen), important from an economic point of view (coal, table salt, quartz sand, etc.). The creation of the Tuzla basin is related to several phases that followed each other after the Mesozoic, which resulted in the creation of different depositional conditions. In joint action with polyclimatic characteristics, diverse and specific sedimentary formations were created.

According to the official census from 2013, the number of inhabitants of the City of Tuzla is 110,979, although it is estimated that due to development trends, this number is even higher. Of that number, 80,774 (72.8%) are Bosniaks, 15,396 (13.9%) Croats, 3,378 (3.0%) Serbs and 11,431 (10.3%) Others. 74,457 (67.1%) of the population live in the urban part of the city, while 36,522 (32.9%) live in the rural part. The average age of both the urban and rural population is 41 years. The average population density is 357.0 inhabitants/km², while in the urban part of the city it is 1,537.9 inhabitants/km², and in the rural part it is 147.6 inhabitants/km².

* *US Department of Trasportation (2021). Agency Financial Report: Fiscal Year 2021. available at: https://www.transportation.gov/ sites/dot.gov/files/2021-12/FY%202021%20DOT%20AFR_508-Compliant_updated.pdf*

III TUZLA CITY – BASIC INFORMATION AND CURRENT SMART CITY STATE ANALYSIS

3. TUZLA CITY – BASIC INFORMATION AND CURRENT SMART CITY STATE ANALYSIS

3.1. Background and History of the City of Tuzla

The city of Tuzla has the characteristics of a moderately continental climate. Certain peculiarities are caused by the local relief, the general position in relation to the dominant regions in the surroundings (the central Bosnian mountain massif on the one hand, and the Pannonian plain on the other), air currents of tropical and polar air masses and cyclonic activities. The main characteristics of the climate refer to the clear expression of all four seasons, relative humidity and cloudiness, maximum precipitation in the warmer part of the year, and minimum at the end of winter. The average annual temperature in the last half century is 10.1 C°. The coldest month is January with an average temperature of 0.6°C, and the warmest is July with 19.4°C. In this series, the highest temperature was measured in August 1971 and was +38.4 C°, and the lowest was -25.8 in January 1963. The average number of days in a year with negative temperatures, i.e. frost, is 91, and there are 20 per year days when the temperature exceeds 30 degrees. There are 80 days of the year with a temperature higher than 25 degrees. Daily periods with rain are 135, with showers 19, with thunder 37, with the appearance of fog 69, with snow and with snow cover 52 (the maximum height of the snow cover measured in February 1984 was 97 cm). There are an average of 127 cloudy and 63 clear days per year. The average amount of precipitation is 908.6 l/m2, air humidity is 79%, and atmospheric pressure is 980.2 hPa. Climatic factors are favorable, because they are characterized by the predominant normality of meteorological parameters, and a smaller influence of temperature inversions.

Tuzla is one of the oldest settlements in Europe with continuity of life. The oldest Sojenica settlement in Europe was found in Tuzla, which dates back to the Neolithic (younger Stone Age), unlike other Sojenica settlements found in Europe, which date back to the Iron Age. A large number of objects from the Neolithic era were also found in Tuzla, and among them salting vessels, i.e. vessels for producing salt from salt water, occupy a special place. These archeological finds confirm that the Neolithic inhabitants exploited the salt springs in this area. The oldest European cultures that used salt were dated to the Copper Age, which means that the Neolithic finds in Tuzla move the limit of knowledge and use of salt in human nutrition from the Eneolithic to the Neolithic. It should be noted that a Neolithic settlement was found in the very center of the present-day city of Tuzla, which is a unique case and proof that this settlement was the beginning of the continuity of living in the area of the present-day city, throughout all historical periods, from the Neolithic to the present day.

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Tuzla has a special geological past. The people of Tuzla say that Tuzla is “a city on a grain of salt”. That “grain of salt” is millions of tons of rock salt, which was left behind by the old Pannonian Sea, when, more than ten million years ago, it retreated from these areas. The name of the city has always, throughout its existence and in the languages of all travel writers, cartographers, historians, conquerors, been linked to salt. The river Jala, which flows through Tuzla, has a name derived from the Greek word Jalos, which means salt, while the city throughout its history has been called: Castron de Salenes, the city of salt pans (Greek), Salenes (Greek), Ad Salinas (Latin). , Soli (South Slavic), Memlehatejn (Arabic), Memleha-i Zir (Persian), Tuz (Turkish)... up to today’s name Tuzla, which means salt pan in Turkish. A more organized exploitation of salt in Tuzla began during the time of the Ottomans

The production of salt and the income from it was a key factor that established Tuzla as a kasaba. The organized production and sale of salt came about with the digging of the salt well in today’s Salt Square in 1476 and the declaration of Tuzla as an “Imperial Has” in 1477. The method of salt

Figure 3.1. Archaeological artifacts from the Neolithic era

production can be seen from the very names that these saltworks were called after the arrival of the Ottomans: Saltworks on wood, (Agac Tuzla, Memleha-i cob), which emphasizes the difference between these saltworks and sea saltworks.

In Salt Square there were up to 80 pans in which salty water from the salt well was boiled. In the beginning, modest amounts of salt were produced, and over time it increased. The reason for this is not so much technical-technological progress as the increase in the population of Tuzla, which was related to the production of salt. The Tuzla salt was also known outside the Bosanski Ejalet. In the 17th century, the French king Louis XIV procured salt from Tuzla for his court through his merchants. Proof of this is a French coin with the image and name of Louis XIV, found in the area of Tuzla. Salt connected different countries, cultures and civilizations of that time. Tuzla salt was one of the basic items with which the Bosnian Ejalet presented itself at the International Economic Exhibition in Philadelphia in 1876.

One of the main goals of the annexation of Bosnia and Herzegovina by the Austro-Hungarian monarchy was the exploitation of natural resources, and Tuzla salt occupied a special place among them. The first salt factory, built in the suburbs of Tuzla, in Simin Han, in 1885, represented the beginning of industrial salt production in Tuzla. Soon after, the city began to sink, as a result of the uncontrolled leaching of brine from the rock salt deposits on which the city is located. Sinking reached its peak in the 70s of the last century, when the city was left without several thousand residential, commercial and cultural buildings. Salt is the fate that built and destroyed Tuzla, but also culturally determined its uniqueness.
The story of Tuzla is timeless and supranational. At every critical moment in Europe, the Balkans and BH, the citizens of Tuzla thought “with a grain of salt” (“Cum grano salis”). In the Second World War, on October 2, 194, Tuzla was the largest liberated city in Europe, enslaved by Hitler. In the last war, from 1991-1995 in the territory of the former Yugoslavia, the citizens of Tuzla did not divide nationally. They had a mission according to which the best way to defend against the violation of human rights is to protect them, against hatred with love, against nationalism with anti-nationalism, against fascism with anti-fascism and against division with common life. Thus Tuzla, in the midst of massive violations of human rights caused by the war, became a symbol of the protection of human rights and freedoms.

Tuzla is the administrative seat, as well as the economic, cultural and educational center of Tuzla Canton, the most populated and one of the most developed cantons in Bosnia and Herzegovina. About 16,500 students study at the University of Tuzla. Numerous young people from Tuzla have confirmed their talents and creativity in almost all spheres of life. From victories at mathematical Olympics and competitions of young musicians, to scientific and technological discoveries, victories at sports and art competitions - young talents from Tuzla have reached stellar moments, made it to podiums and world stages, entered the chronicles of the best, not only at national but also and at the international level.

In an effort to preserve this greatest asset of ours, the City of Tuzla, in cooperation with other institutions and partners from the country and abroad, launched a series of initiatives to support programs for young people and tie this enormous energy to Tuzla and Bosnia and Herzegovina. Among these initiatives, a project realized with the help of the Government of Norway stands out. The Business Innovation and Technology Center was built, the aim of which is to provide support to young people from the region and beyond, so that they can develop and realize their talent and knowledge in their city and in their country, and at the same time be connected with the international labor and knowledge market.

The organizational scheme of the City of Tuzla is very complex due to the large number of responsibilities. Administrative bodies are organized through: expert services and administrative services, the secretary of the civil service, and the institute for urban planning. The city has organized 11 administrative services and two professional services and one administrative organization, the Bureau of Urbanism. The city of Tuzla is the founder of 21 public companies and public institutions that are engaged in activities of interest to the normal functioning and development of the city and city infrastructure, as well as the fields of health, culture, sports, preschool education and social activities.

As part of this Study, an analysis of the possibility of applying modern solutions from the aspects of economy, mobility, environment, citizens, lifestyle and public administration in the city of Tuzla was carried out. In order to see the benefits that can be expected from the implementation of these solutions, a cross-section of the current situation in the city of Tuzla is given, followed by measures and opportunities for improving the current situation with the aim of achieving the desired effects regarding the implementation of the smart city concept.

3.2. Examples of Tuzla Smart City Projects

The city of Tuzla, together with public enterprises and public institutions, has for many years been continuously implementing activities related to the basic pillars of the development of Smart Cities and sustainable development goals. This approach is based on the Development Strategy of the Municipality of Tuzla until 2026, which sets the vision of development: "Tuzla is a city of continuity of culture, creative innovation, healthy and pleasant life; a city that enables the participation of its citizens in all aspects of urban life; a city that ensures economic and social attractiveness, development and quality of life for citizens and all people who live, invest and create in it." From the vision, strategic and sectoral goals defined in this way, it is evident that they are directly connected with the basic areas of a Smart City, namely: smart environment, smart mobility, smart economy, smart citizens, smart administration and smart living, as well as with the UN the goals of sustainable development, namely: industry, innovation and infrastructure, a safe, inclusive and functional city, a place of healthy and pleasant life.

In this connection, a mapping of the processes implemented in the area of the city of Tuzla by the public administration, public companies, public utility companies and public institutions, which are directly related to the implementation of the smart city concept, was carried out. In the next part, we list the realized activities that contribute to the city of Tuzla becoming a Smart City:

- Public lighting
  - October 2017, contractors for LED lighting have been introduced
  - in 2018 –80 LED park lights were installed
  - in 2019 – 100 LED park lights were installed
  - in 2020 –230 LED park lights were installed
  - in 2022 –375 LED park lights were installed
- Tuzla Wireless City
  - Since 2008, a free wireless Internet system has been in operation in the city center
  - o In 2017, the service was improved:
    - Increased number of access points
    - Extended coverage zone (pedestrian zone + Slana Banja)
    - Increased internet access speed
- Video surveillance of public areas
  - Since 2010, 11 surveillance cameras have been in operation
  - In 2020, the system was significantly expanded with 13 more cameras at the Slana Banja location

- Smart parking
  - In operation since 2022
  - The mobile application enables:
    - parking payment,
    - overview of available parking lots and their price lists,
    - use as navigation to the parking lot.
- Chronological development of the information system, remote monitoring and management of the district heating system of the city of Tuzla:
  - in 1986,first remote monitoring and management activities on Project 24 stations based on PLC and SCADA (10 for the network and 14 for thermal substations). The control and monitoring center was the process industrial computer "TRIGLAV", and the programmable stations were of the DIPS type. Program support realized through the QNX operating system and the RSX11 programming language.
  - In 1991, the first computer network based on a PC, type 386 as a server, and a WISE type terminal was acquired and developed. Everything was supported by the UNIX operating system. The network was primarily intended for data processing and was set up on the UNIX-COBOL platform.
  - In 1995, the remote monitoring system was innovated and transferred to the PS platform with the QNX operating system and the Real Flex program with a graphical display of the obtained data. The built-in system used part of the DIPS of the time ("Iskra-Delta"), while at five significant points on the network, a PLC of 'Allen Bradley' USA industrial design was installed. Systems of this type are constantly being upgraded, and the data obtained in this way are of inestimable value both for analysis and for the management of the district heating system of the city of Tuzla.
  - In 1998, a new UTP network was created, a server, PC workstations and a package of financial modules with a specially created module for calculating the delivered thermal energy were purchased. All based on the DOS-Clipper platform.
  - In 2000, Internet connection was established. The first website was created. A connection with a remote location - toll booth in Slavka Mičića Street was realized.
  - In 2002, a new Scada Eltec Mulej system was installed for the control and management of compact substations. The system enables complete monitoring and management of substations from the dispatch center and is connected to the existing computer network. The selected substations are interconnected by a UTP cable. Continuation of the development of the computer network in the remote facility in Slavka Mičića Street, which is connected to the server at the company's headquarters via a rented PTT pair. The reconstruction and automation of hot water substations managed by Centralno grijanje d.d. was launched. Tuzla, which also created the conditions for the expansion of supervision over hot water thermal substations after the installation of electronic regulators that are equipped with a device for connecting to the SCADA system.
  - In 2004, the Canopy Wireless system was installed and 5 locations were connected by a personal aerial network. The transmission speed is about 5 MBits per second, which partially meets its needs. This method transmits data from compact substations and data from parts of the local network installed in the premises of S. Mičić, Kula G and B. Kidrič. By the end of 2004, a total of 26 compact substations and 16 computers were connected via Wireless. With this merger, we managed to partially solve the communication with our remote locations, we achieved the connection of compact substations on Scad Eltec Mulej, we did not lease a single new line from PTT, but we canceled some lines. Previous experience with this type of communication has proven to be quite good for smaller amounts of data flow, otherwise this was intended as a transitional solution to the optical connection of individual locations.
  - In 2005, all software modules were created on the Windows platform. Lotus Notes document management software on the Lotus Domino platform was acquired.
  - In 2006, the directorate in Krečanska No. 1 was connected with the location in Slavka Mičića with an optical cable, which achieved gigabit communication and significantly accelerated the operation of the network. Barcode readers were installed at toll booths.
  - In 2007, the TERMIS project phase was launched. A static model of the software for techno-

economic optimization of the system was installed and system calibration was started. The installation of the new version of Scada Eltec Mulej was completed. Halcom Corporate E Bank internet banking was installed. Along with these activities, all direct (mixing) hot water thermal substations were replaced with indirect (exchanger) hot water thermal substations with electronic regulators with the possibility of connection to the SCADA system. In 2009, the K-5 chamber near the Tuzla Grammar School was connected with an optical cable to the location in the toll booth in Kula G, which enabled Gigabit communication and significantly accelerated network operation, and at the same time enabled the connection of new substations to the SCADA system.

– 1st phase of implementation of the program for techno-economic optimization TERMIS March-April 2009. Calibration results in TERMIS based on real measurements:
  Scenario A: possible operations at TE TUZLA (Tuzla Thermal Power Plant),
  Scenario B: possible measures to regulate substations owned by Tuzla Canton,
  Scenario C: planned expansions of the SDG network until 2011 and risk analysis.
  In 2011, an additional 5 km of optical network was laid in the eastern part of the city. By connecting the endpoints, the necessary data for the functioning of the TERMIS II program was obtained. At the location of the toll booth in Kula G, a fiber optic cable hub with a new modular Switch has been installed, where it is planned to complete the other fiber optic cables that will be laid in the eastern part of the city.
  In 2012, the TERMIS software was upgraded to a dynamic version. Completed installation of the necessary measurement and regulation equipment in the Tuzla Thermal Power Plant and enabled supervision on the Scada system. Procurement and complete installation of the communication network within the directorate was completed. Cables that support data transfer speeds of 10 Gb were used during the execution, which represents a good basis for the use of devices with the latest technologies. With this, we have created a network that should meet the needs of our processes in the 10 years or so to follow. During the planning and implementation of the network, we paid attention and carefully predicted the maximum number of workplaces in each office, the most precise position of the desks inside the office, etc. Along with these works, an electrostatic floor was made in the server room and a new cabinet for active equipment was installed and completed. i.e. switch, servers, storage, firewall, etc. In this way, we separated active and passive network equipment in two cabinets.
– 2nd phase of implementation March 2011 - May 2012:
  • Economic management of the system in real time: TERMIS Operation,
  • Economical control of temperature in thrust: TERMIS TO.

  The purpose and goal of the 2nd phase of the implementation of the TERMIS program tool were: reduction of heat losses, quality and reliability of heat energy supply, achievement of competitive prices, optimal planning and design of the system, reduction of CO2 emissions, increase in the level of supervision over the operation of the system and increase in the level of knowledge.
  The Data Editor is responsible for the transmission of process data on the state of production and distribution of heat, consumer locations and weather forecasts in the system for economical management of the district heating system. It checks all data and at the same time detects errors, such as missing or incorrect data. The data editor also takes care of transferring data from the SDG economic management system to SCADA packages. We can monitor the current flows, pressures and temperatures in the pipe network, we can predict the future condition and sense problems in operation and distribution before they occur.
  In 2013, a SCADA 3 system was installed, which enabled faster communication and a larger number of measurement points. The activity planned through Scenario B using the TERMIS program too was initiated and realized in the following years: reconstruction of the primary hot water substations owned by the Tuzla Canton in the next few years (schools, faculties, student dormitories).
  In 2014, a new DMS (document management system) system, infoDMS, was created. Care was taken to ensure that all collected documents in the existing Lotus Notes document management are available, and at the same time that the new application relies on the existing database in order to use all available data for analysis and reporting in the future as best and rationally as possible. The new application was created on the Web platform so that it is also available in

remote locations, which was practically implemented in the Info Desk opened by the Service for Communal Activities of the City of Tuzla. This application was also acquired as an executable version, i.e. we received a license for its use.
The reconstruction of substations with the aim of installing correct automatic regulation, replacement of exchangers, flow regulators (replaced old three-way control valves with transient control combi valves) and all necessary measuring equipment continued in the following years, and all substations managed by Centralno grijanja d.d. Tuzla were reconstructed. In this reconstruction, inefficient circulation pumps were replaced with frequency circulation pumps, which significantly reduced the consumption of heat and electricity at all reconstructed substations.
In 2018, an information application, MIS - Management Information System, was created for the needs of management and sector managers. It is planned that the reports will be available to users at any time and in any place where there is an Internet connection.
In 2019, a GIS system was created, which consists of the acquisition of licenses, data centralization, tools for customer mapping, geocoding, base maps, tools for drawing and maintaining the distribution network of central heating, tools for mapping all interventions on the distribution network (connection of a new customer, information, damage, ...), establishing a connection to the central database (technical data base) and other data sources (which the user already has in digital form or which he receives from the outside), the possibility of creating various statistical reports and, most importantly, customizing the interface of the desktop application user needs.
In 2021, a new version of the Movicon SCADA system was installed and training was carried out, given that there is no option to download settings from the SCADA 3 system, and further improvement and development activities continued.

- Water supply network
  - In 2017, equipment was acquired to improve measurement and fault detection
  - In 2017, 415 radio relay water meters were supplied
  - In 2017, a leak detection device with accompanying equipment was acquired
  - In 2018, the SOKOP Mal system was implemented for the electronic submission and processing of small value cases
  - In 2018, 1,349 radio relay water meters were supplied
  - In 2018, equipment for the microbiological laboratory was supplied
  - In 2018, computers and servers were supplied
  - In 2019, 1,075 radio relay water meters were supplied In 2019, a business information system was implemented with 14 interconnected modules (Water reading and calculation, Finance and accounting, Cashiers, Personnel, Payroll, Work orders, Dispatchers, Laboratory and FVC, DMS, MIS, Payments, GIS, Material and Transportation)
  - In 2020, the installation of the main distribution control cabinet in Sprečko polje was carried out
  - in 2020, 1,961 radio relay water meters were supplied
  - in 2021, the installation of the main distribution control cabinet was carried out on the main supply pipeline Stupari + PS Spreča
  - in 2021, 1,257 radio relay water meters were supplied
  - In 2021, the acquisition and installation of a frequency regulator for the fine control of electric motor pumps was carried out, which ensured energy savings of 15-30%
  - In 2021, electromagnetic water flow meters were purchased - as part of the Main Supply Pipeline, Stupari-PS Spreča project, a total of 5 electromagnetic flow meters were purchased, all with the aim of more accurate measurements and reducing losses
  - In 2021, Ozone System membranes and software were supplied at the Cerik reservoir
  - In 2022, worn-out electrical cabinets were replaced

- Public administration
  - 2011 The Register of Self-Employed Activities
  - 2012 e-Land books was implemented
  - 2012 e-Cadastre was implemented
  - 2012 Unified civil registry
  - 2013 “Ethical line” application introduced

- 2013 “Centar 72” application introduced
- 2013 E-register of administrative procedures
- 2015 Recordings of City Council sessions on the City website
- In 2017, the Disaster Risk Analysis System - DRAS was introduced
- 2018 DMS was introduced
- 2018 The Diaspora Module was introduced
- 2019 E-registrar application introduced
- 2019 An application for the registration of business premises was introduced
- 2022 Module for service information was introduced
- 2022 The event calendar module was introduced
- 2022 Comand-D application was introduced – an IT platform for disaster risk assessment

3.3. Assessment of the current state of smart services in the city of Tuzla

Another aim of this Study is to assess the state of maturity in which the city of Tuzla is currently in. A SWOT analysis of Tuzla was first carried out, through which the strengths and weaknesses, as well as opportunities and threats were analyzed with regard to the current state and capabilities, in order to determine the gap between the current state and what needs to be implemented in order for the city of Tuzla to become a “Smart City”. Also, a maturity assessment analysis was made in the context of smart services using the diagnostic tool “Maturity model” in the context of the “Smart City”, which serves to identify readiness and the current state of development, set goals for reaching the desired level of maturity and identify gaps between the current and the desired state.

3.3.1. SWOT analysis in the context of Tuzla as a Smart City

Through the analysis of the current situation and the identification of citizens’ needs through interviews and surveys, data were obtained, which were further elaborated in a SWOT analysis, for the purpose of identifying a number of citizens’ needs and the potential of the city of Tuzla. The main purpose

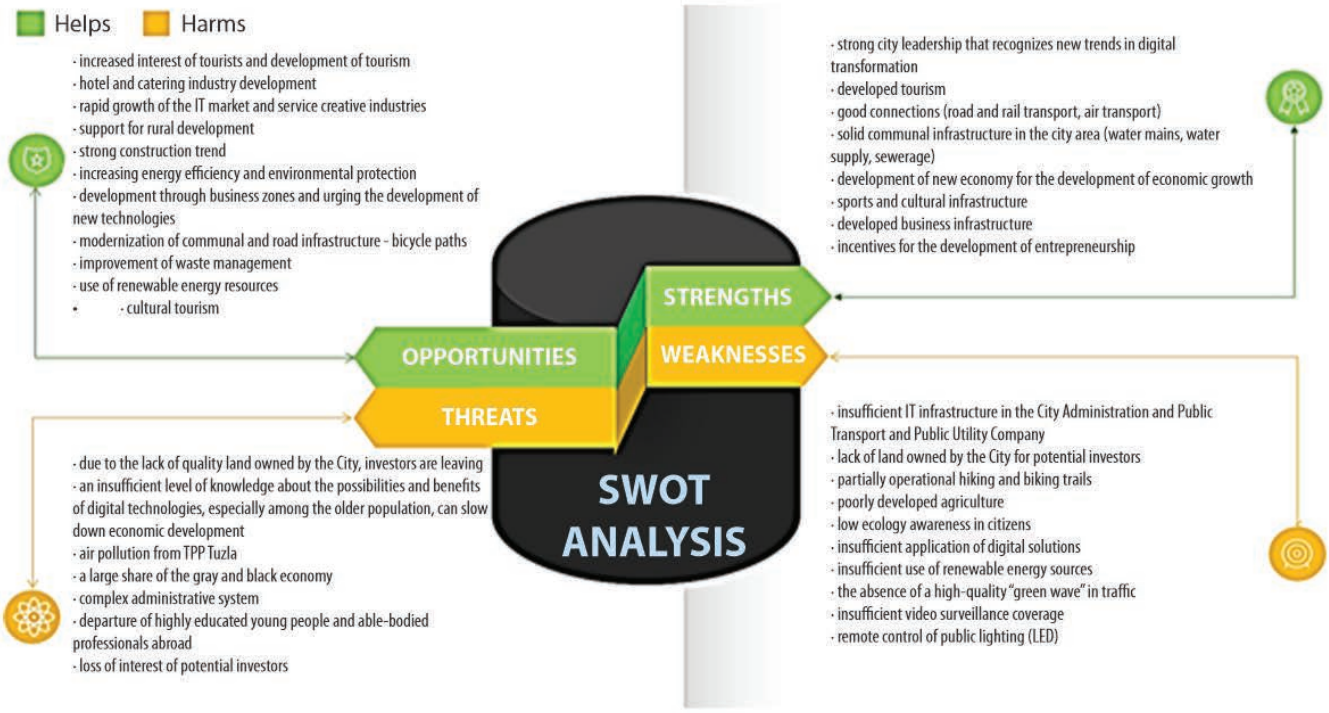


Figure 3.2. SWOT analysis in the context of Tuzla Smart City

Figure 3.3. Assessment of the current state of smart services in Tuzla

of the SWOT analysis is to briefly determine and present strengths, weaknesses, opportunities and threats. The goal of the SWOT analysis is to clarify the information obtained from the analysis of the situation, with a clear indication of the assessment of the main strengths and weaknesses of Tuzla in the context of the development of the "Smart City", as well as the opportunities and threats essential for the development of the "Smart City of Tuzla - the city of the future".

3.3.2. Evaluation of the maturity of Tuzla in the context of a Smart City

Analyzing previous research, the Smart City Maturity Model can be followed through five stages of maturity, namely: information dissemination, service optimization, service replication, service integration and related services. Some authors also call these levels of maturity: beginning (1), development(2), competent(3), advanced(4) and transformed(5). Figure 3.3 shows the assessment of the current state of smart services in Tuzla by monitoring the phases through the assessment of: strategic management and leadership, data, technologies and resources, management and service delivery models, focus on participants and their involvement, and the organization itself.

Using the diagnostic tool "Maturity Model" on the example of the city of Tuzla, a lower level of maturity was established in the context of the application of the "Smart City" concept, whereby the components "Data" and "Technology and resources" were evaluated as initially developed, and all other components: Strategic management and leadership, Focus on stakeholders and their involvement, Management and service delivery model, and Internal work organization are characterized by a moderate level of maturity. Significant individual efforts and initiatives for the application of "Smart City" models and solutions have been identified, but until this Study was made, there was no integrated and comprehensive application of the "Smart City" concept. However, it must be pointed out that significant projects were implemented within the framework of the environmental protection and energy efficiency component, as well as the improvement of the management of parking lots and pedestrian and recreational zones. So, it can be said that the city of Tuzla is currently in the second phase of Smart City development, and that if it continues at this pace of development, it may soon reach the third stage of maturity, which is where most European cities are.

A Smart City is formed from six development areas that represent elements of urban development management. According to the aim of this Study, and European documents and practices, the application of smart technologies will be shown through these areas of the Smart City, namely:

- Smart economy,
- Smart mobility,
- Smart environment,
- Smart citizens,
- Smart living, and
- Smart management.

IV DEVELOPMENT AREA OF THE SMART CITY

4. DEVELOPMENT AREA OF THE SMART CITY

4.1. Smart economy and new technology

“Smart economy” describes all activities aimed at transforming and strengthening the economy of municipalities and cities. The most important goals of the smart economy relate to the improvement of the overall business climate, the attraction of the city for start-up companies, investors, businesses and new (highly qualified) talents, as well as the development of the economy in an innovative and sustainable way in order to increase competitiveness.

The use of (digital) technology and intelligent approaches lead to economic prosperity, which in turn creates stable and favorable conditions for all interested parties. From the government’s perspective, “smart economic development” is an important tool for actively exploiting opportunities and providing conditions that support the creation and growth of enterprises, as well as new jobs.

The economic development of Smart Cities is based on the creation of an overall and comprehensive environment that enables and encourages innovation and the creation of new business models. The city of Tuzla has significant potential that would lead to a stronger development of economic activities based on knowledge and modern business models. The strategic goal of this area is to create a basis for the development of innovative business models and enable the transition of companies towards a newer, more innovative and more competitive approach to the market. This process includes digitization and enhanced integration of new service models, adapted to changes in client requirements.

The city of Tuzla has a system of business incubators (Entrepreneurial Development Center Tuzla – incubator Lipnica, BIT Center Tuzla) and business zones (Kreka sever, Šići, Poljana), but the entire business infrastructure in the coming period must be more focused on reducing unemployment, especially among young people. In this regard, the City of Tuzla will additionally develop

entrepreneurial programs in cooperation with competent state bodies and institutions and with financing from EU funds. The development of new technologies at the University of Tuzla and within the aforementioned entrepreneurial infrastructure must be available to Tuzla entrepreneurs, and primarily to the processing industry that is focused on the global market (pharmacy, food industry, etc.). The basic prerequisite of a successful and competitive economy is the transfer of knowledge from the academic community to the economy and vice versa. At the same time, it is important to determine which scientific research resources of the University of Tuzla are aimed at creating new knowledge and technologies. It is equally important to establish the real needs of the Tuzla economy and tourism related to the application of new knowledge and technologies.
The development of creative industries, a sector of the economy that has not yet been statistically defined in an appropriate form, but which the EU recognizes as a very significant application of new technologies (architecture, design, development of new media, etc.), can be a significant part of city projects in culture, but also influence further development of the local economy. The development of Tuzla on the basis of new knowledge and technologies is directly related to the strengthening of Europe's global competitiveness, based on the same examples. In the future, we can see Tuzla as a developed university city that will generate new types of technologies and new knowledge aimed at the development of Tuzla's economy and economy. This will realize the well-known phrase "knowledge economy" and/or "knowledge society", which in this case could be called "knowledge city".

According to the data of the Federal Institute for Development Programming, basic economic and financial business indicators indicate that in 2021, according to the latest published data, there was an increase in economic activities in the city of Tuzla compared to the previous period. This continued the positive business trend of entrepreneurs and businessmen from Tuzla. Thus, the number of registered business entities increased by 0.4% in 2021 compared to 2020, and by 1.4% compared to 2019, while the number of employees increased by 2.7% compared to 2020. year, and by 3.5% compared to 2019. The number of employees compared to 2017 recorded an increase of as much as 12%. It is important to point out that in the observed period there was also a decrease in the number of unemployed persons, by 2% compared to 2020, and by 7.4% compared to 2017. According to the level of development, in 2021, Tuzla was ranked 9th out of 79 municipalities in the Federation of BH, which is a big jump compared to 2017, when it was ranked 15th. It is especially necessary to emphasize the growth of income/IG per inhabitant in Tuzla, so that it amounted to 317 KM in 2021, which is 11.6% more compared to 2020 and 61.7% more compared to 2017. a year. This income is higher than the average of the Tuzla Canton in 2021 by 65.1%, and compared to the average of the Federation of Bosnia and Herzegovina in 2021, it is higher by 29.4%.

In addition to the above data, it should certainly be emphasized that Tuzla entrepreneurs (1,013) made a total profit of 226 million KM in 2021, which is an increase of 22.4% compared to 2020.

Within the field of Smart Economy, innovative projects aimed at improving the operations of city enterprises have been registered, which is stated in chapter 3.2. of this Study. On the other hand, projects that increase the availability of the database to citizens, entrepreneurs and visitors in various ways are united under the field of Smart Administration. According to research within the EU, publicly available data significantly improves the situation in the local economy because it provides innovative entrepreneurs with the opportunity to identify new business opportunities, and thus the development of new products and services.

4.1.1. Background and challanges

The economic development of Tuzla should be based on economy and tourism. They represent key levers in the development of a city, and that is why it is important in the context of the use of digital technologies to think about how and in what way to stimulate development in these two segments, essential for development of the city. Economic development, in addition to making the

city alive and to providing jobs, directly and indirectly affects the budget. Tourism can be a good addition to the development of the economy if the contents are cleverly designed and there are natural predispositions, such as in the city of Tuzla. Nowadays, utility companies use the advantages of digital technologies and data processing in order to be more efficient and provide quality service to their users.

In the next part, a list of potential activities for the economy segment will be presented:

- Development and monitoring of the work of currently active companies
- Municipal economy (traffic, parks and greenery, water supply, drainage, waste disposal, environmental protection)
- Development of entrepreneurship
- Encouraging the growth of start-up companies
- Development of the entrepreneurial climate
- Development of companies in the field of new technologies

The development of digital technologies in the function of economic development is possible through the center for digital technologies. The goal is to improve the business environment and competitiveness, and attract innovators and mostly young people to open businesses or companies based in the City of Tuzla, through the development of adequate business infrastructure and the so-called "coworking" (joint work in a common space, which includes mentoring), and other incentive measures. By improving the conditions for attracting investors, investments in the economy will be greater. A large number of key projects have been implemented in this area, e.g. the BIT Center Tuzla was opened in 2005. BIT Center is a place for the development of companies in the field of Information and Communication Technologies (ICT). There are three types of companies / projects in the BIT Center, namely "Idea Development" (projects), "start-up" companies and companies with growth and development potential, and at the moment most of them are start-up companies. BIT Center has several components: ICT Incubator, ICT Training Center, ICT Research Center. The BIT center in five office buildings with about 2,700 m2, in addition to office space with modern equipment, also provides professional services: business consulting, business trainings, business networking, transfer of knowledge and technology, the possibility of applying for initial SEED capital, financial, marketing, accounting and legal services . 21 companies from the IT sector currently operate within this center. Another is the Virgin Pulse company, with its headquarters in Tuzla, as one of the leading IT industry companies in BH, with over 500 employees.

On the other hand, if tourism is strategically well-designed, it can, in effect, trigger major development of the entire economy. The city of Tuzla has made a big step in this regard since 2003, when the first Pannonian lake was built, which was a turning point in the development of Tuzla. The city won second place in the UN World Tourism Organization, Odyssey in 2012 for the valorization of natural inheritance. More than 5 million guests have visited this destination so far. The city of Tuzla is only 15 kilometers from Tuzla International Airport, and some 70 km from the EU, which makes it a very attractive tourist destination. In addition to the Pannonian lakes, of which we have 3, Tuzla boasts attractive and unique salt waterfalls, the Archaeological Park "Neolithic-Sojenički naselje", the Geological Exhibition "Pannonica", a children's amusement park, and many other catering, cultural and entertainment facilities. The historical core of the city was also reconstructed, in which the central place is occupied by Salt Square, with a museum display, a fountain and a protected old well from the Ottoman period, then Freedom Square - the largest and most beautiful square in BH, the City Park dedicated to the continuity of the statehood of BH, a monument to the first Bosnian king Tvrtko Kotromanić I, Dom književnosti, Memorial Center Kapija, House of the Bosnian Language, etc. The fact that the City of Tuzla is the initiator and owner of the most relevant regional award for a novel since 2001 (within the framework of the "Cum Grano Salis" international literary meetings), named after another famous citizen, Meša Selimović, is also favorable to the development of tourism. There are numerous manifestations that enrich the tourist offer of the city of Tuzla, namely: "Summer in Tuzla", "Winter in Tuzla", Youth Festival "Kaleidoscope", "Interbifep" and many others.

4.1.2. Guidelines, effects and organisation

The key guidelines in the field of smart economy, i.e. smart solutions for companies and entrepreneurs lie in the development of digital entrepreneurship skills and digital transformation for the beginning of utility companies, and then for all others. With the aforementioned goal, they create the prerequisites and foundation for the transition of utility companies to a newer, more innovative and competitive business model. On the other hand, when we talk about tourism, the key goal should be to increase the arrival of tourists to the city of Tuzla with the help of digital technologies, extend their stay and increase consumption. One of the preconditions for achieving this is to create a positive experience for tourists during their stay in Tuzla with the help of digital technologies, and thus create a basis for attracting new tourists.

The parties affecting the development of the smart economy area should be the City of Tuzla Services, which are responsible for the areas of economic development, entrepreneurship, tourism, strategic planning and budget, as well as all others that need to create prerequisites for economic development, and tourism.

Entities participating in the field of smart economy are: City of Tuzla and city public enterprises and institutions. Groups of service users (G2C, G2B, G2G...) are: City of Tuzla, citizens, the unemployed, Tuzla Employment Bureau, employers interested in implementing the mentioned digital skills development programs, as well as competent ministries of higher levels of government.

4.1.3. Measures of priority in the field of smart economy

The following are the measures of priority that will enable the achievement of the stated goals, i.e. the realization of the planned effects in the field of smart economy:

- Incubator for high technologies;
- Support for start-ups;
- Automated system of internal controls in city public enterprises and institutions;
- Using digital technologies to position the city of Tuzla as the most desirable tourist destination that must be visited;
- Development of a platform for different types of services (temporary work, rental of various devices, borrowing...);
- Improving rural development through the use of modern technology.

Incubator for high technologies - The aim of this measure to improve the economic development of a Smart City is to equip the Incubator for high technologies and high-tech development centers so as to strengthen the entrepreneurial and innovative potential of the city of Tuzla. The main purpose of the “Incubator for high technologies” project, i.e. the provision of new spatial capacities of the BIT center, is to create a favorable entrepreneurial environment and fulfill the prerequisites to significantly increase the competitiveness, innovation potential and efficiency of the business sector in the city of Tuzla and the wider surroundings of the city, with equipped technology centers that will serve for the development and testing of products and services.

Support for start-ups - The aim of this measure is to strengthen the ecosystem that encourages the development of start-up entrepreneurship and the construction of sustainable and inclusive Smart City development. This measure should be designed in such a way as to enable support in the work of development teams that contribute to the development of the start-up ecosystem of the city of Tuzla. Especially, this is to be done by developing solutions in the broadest technological sense, i.e. taking into account the stimulation and development of priority areas of smart specialization: health and quality of life, energy and sustainable environment, traffic and mobility, security, food and bio-

economy, education, robotics, fintech, tourism and Data/AI. The focus on specific priority areas will enable the provision of individualized comprehensive support to start-ups through the use of space adapted to the pre-acceleration program, financial support in the form of grants and comprehensive mentoring, consulting support as well as marketing support in the promotion of projects.

Automated system of internal controls in city public enterprises and institutions - The goal of this measure is the system of internal controls (Financial Management and Control), which represents a set of principles, methods and procedures of internal controls, established by the responsible person of the institution for the purpose of successful management and achievement of general goals. These are: performing business in a proper, ethical, economical and efficient manner, compliance with laws and other regulations, protection of funds from losses, misuse and damage, strengthening responsibility for the achievement of business goals, and reliability and comprehensiveness of financial and other reports. The system of internal controls should be based on five related components of internal controls based on the International Framework for Internal Control:

- control environment,
- risk management,
- controlled activities,
- information and communication,
- monitoring and evaluation.

Public companies that introduce a system of internal controls will be able to: monitor the execution of all business processes in one place through checklists, better manage risks, have the possibility of reconstructing all individual activities and their approval via digital audit trails. In addition, an important fact regarding this system is that the companies that have introduced it have reported to have become more efficient, their business is more stable, and thus their service is of better quality.

Indicative activities and projects of this priority measure are as follows:

- creating a map of business processes;
- preparation of the risk register and evaluation of recognized risks;
- list of preventive and corrective actions;
- create a list of signatories and authorized persons;
- creation of checklists.

The challenges facing public companies in terms of the implementation of this system are:
o Implementation of the Internal Control System in a public company - business processes are implemented according to implementation guidelines;

- Risks are “refreshed”;
- Preventive and corrective actions are implemented.

Possible sources of funding for the implementation of this system are: budget of public companies, budget of the City of Tuzla, EU Funds, EBRD, etc.

Using digital technologies to position the city of Tuzla as the most desirable tourist destination that must be visited. Considering the influence that social media have today, it is definitely thought out to create content (visual promotion) that can attract tourists to visit the city of Tuzla. It would potentially be a good idea to involve content creators who have a large number of followers to share their positive experiences of their visit to Tuzla. In addition, systematic and targeted work should also be done on the creation of all those accompanying elements from the set of digital technologies (Wi-fi, information desks, interactive maps, applications that facilitate movement around the city, provide current information on gastronomic, touristic, cultural, recreational, entertainment offers, but also information about free parking spaces, accommodation, other tourist experiences, recommendations, etc., which can make it possible for tourists to feel comfortable when they visit the city of Tuzla and create a positive tourist experience that can be a lure and incentive for new tourists to visit.

Indicative activities and projects of this priority measure are as follows:
- As part of the development of tourism in the city of Tuzla, foresee the use of digital technologies to promote the tourist offer and increase its quality;
- Create different content on social networks about the attractions and beauty of the city of Tuzla;
- Advertise tourist attractions of the city of Tuzla on different portals;
- Set up information points with interactive maps at frequent locations in the city (possibility of charging mobile phones and smart devices)
- Create different interactive applications that make it easier to move around the city, but also offer different information about events, cultural, historical and religious sights, sports and recreational facilities, places to visit, free parking spaces, accommodation, gastro-enological offer. All these applications have the possibility for visitors to enter and rate individual contents themselves.

Challenges that may be encountered when implementing this measure may be related to:
- Coordination of a large number of participants who are carriers of the tourist offer;
- Ensuring the up-to-date information that will be on the application;
- By developing a common communication platform or standard for information exchange;
- Securing financial resources;
- Education and awareness raising of citizens.

Participants who should benefit from the implementation of this measure can be the following: City of Tuzla, various participants from the fields of tourism, culture, entertainment and sports, then various public companies and public institutions, and companies that would develop the mentioned application.

Development of a platform for different types of services (casual work, renting various devices, borrowing...) The goal of this activity is to enable the citizens of Tuzla to communicate in one place what they need in terms of different devices or services and what they can offer, so that both supply and demand come together in one place. In this way, interaction between citizens can be encouraged, and on the other hand, certain needs of citizens can be solved in a relatively simple way.

Indicative activities and projects of this priority measure are as follows:
- Development and implementation of a digital platform;
- Digital marketing – promotion of the digital platform;
- Inclusion of social media.

The key challenge in the implementation of this measure may be related to the willingness of the citizens of Tuzla to participate, and the lack of finances. The City of Tuzla as an administrative unit and the citizens of the city of Tuzla would benefit the most from the realization of this activity.

Improvement of rural development through the use of modern technology - The rural area around the city of Tuzla used to rely exclusively on traditional agricultural production, while today the possibilities of developing this area are much wider, and should include new ways of agricultural production, development of crafts, and small and medium-sized businesses. On the other hand, in the rural area today there are factors limiting development, such as weak and insufficient human resources, emigration due to unemployment and lack of social infrastructure, which results in an older population with poor education, not so inclined to use modern technologies. Modern agricultural production requires large areas and employs fewer people.

The potential for agriculturally valuable production on small areas is the extensive cultivation of vegetables and fruits, and short supply chains. The essential problems of the rural areas of the city of Tuzla are:
- Emigration of the younger and educated population;
- Lack of jobs in rural areas;
- Lack of networking of producers and service providers;
- Lack of supply chains and distribution chains for products from rural areas;

- Lack of recognition of rural areas, their values and diversity.
- Inadequate education regarding the use of modern technologies in agriculture.

The most important guidelines and effects that can be achieved in the field of rural development are as follows:

- Development of environmentally and economically sustainable agricultural production (cooperatives). The development of the rural area is not possible without the development of the urban area, on which it relies. It is necessary to work on the synergy of the urban population of the city of Tuzla and the local community in rural areas with the aim of strengthening the procurement and distribution of local agricultural products, and to encourage networking and connection of local agricultural producers with the urban area of the city of Tuzla.Strengthening rural communities and increasing the quality of life of local residents. The availability of social infrastructure is of primary importance for the development of rural communities, where rural communities are largely dependent on nearby urban areas, and traffic connectivity is one of the most important factors of development. After enabling the availability of social infrastructure for the quality of life in rural areas, it is important to limit the development of entrepreneurship by preserving the environment and natural values.
- Education of farmers for the use of new information and communication technologies such as:
  - the use of sensors for monitoring humidity, soil temperature, soil nutrition. Such technology is used to with planting and supplementing the soil,
  - the use of unmanned aerial vehicles - drones in order to obtain a detailed picture of the condition of crops in terms of the presence of plant diseases, pests or lack of water in a few minutes.

Responsible for the development of the smart economy in the field of rural development are the Administration Services whose areas of responsibility include: spatial planning and development, environmental protection, communal and housing construction, and finance and economy. Subjects that should participate in this area are: City of Tuzla, local communities, commercial companies, catering companies and secondary schools. Users who can benefit from this area of smart economy are: (G2C, G2B, G2G...) - citizens, owners of OPGs.

Analyzing the area of rural development in the area of the city of Tuzla led to the definition of basic priority measures for this area, namely:
a) Development and implementation of the “Digital Market” concept
b) Encouraging the use of “Smart technologies” in agriculture - the use of sensors and drones.

a) Development and implementation of the “Digital Market” concept: the development of environmentally and economically sustainable agricultural production in the rural areas of the City of Tuzla is achieved by strengthening the synergy between the urban and rural population of the City of Tuzla, with the aim of strengthening the procurement and distribution of local agricultural products, and encouraging networking and connecting local agricultural producers with the urban area of the city of Tuzla. The development of the digital platform “Digital Market of the City of Tuzla” will enable producers and processors in rural areas to come together and further expand and strengthen on the local market, as well as increase the placement of their own products on the regional market. The growing demand for domestic and ecological products also represents a very high motivational need for the realization of this project.
Indicative activities and projects of this priority measure are as follows:

- Development and implementation of a digital platform;
- Development of virtual communities in rural areas;
- Digital marketing – promotion of the digital platform;
- Inclusion of social media;
- Promotions at events.

Challenges that we may encounter during the implementation of this measure are the lack of financial resources and the insufficient involvement of citizens and communities from rural areas. The implementation of this measure can bring great benefits to the City of Tuzla, as well as to

the rural population, businesses and trades in the field of agricultural production, caterers, hotels, kindergartens and hospitals.

b) Encouraging the use of "Smart technologies" in agriculture - the use of sensors and drones: as has been said several times, in the area of the city of Tuzla, there are potentials for active and high-quality farming, however, due to the abandonment of agricultural land, the systematic departure of the younger population, but also due to lack of education and willingness of existing farmers to learn new skills, there is continuous lack of use of existing capacities, which results in further reduction of interest in agriculture as an important development resource.
One of the ways to increase yields from agricultural land is the safe and greater use of modern information and communication technologies, often used in agriculture today and easily accessible to everyone. At this point, it is important to note the use of sensors and drones. Sensors can be installed with the aim of collecting data on soil moisture and soil temperature in order to know when is the optimal time for planting or irrigation, as well as collecting information on soil quality, which again can be a good basis for defining the timing and composition of supplementary nutrition. On the other hand, by using unmanned aerial vehicles - drones, the farmer can get a detailed picture of the condition of the crops. From pictures or videos, you can clearly see which parts of the field have been attacked by plant diseases, pests or suffer from lack of water. Much more information can be gathered in just a few minutes than after hours of walking through the fields.
In order for these technologies to become accepted and used, educational seminars on how such technologies are used, what is needed to implement them and how much initial investment would be required must be organized. This could certainly be of help to those who have only just started farming, but it would also be of help to farming veterans, because new knowledge and the use of the mentioned technologies, could significantly improve their efforts. After that, it would be necessary to connect the producers of the mentioned technology with potential farmers and try to help with advice on implementation.
Indicative activities and projects of this priority measure are: organization of presentations, seminars and/or education on the use of sensors and drones, mentoring, creation of brochures and establishment of a portal with experiences and examples of good practice, knowledge bases, frequently asked questions and advice. Challenges that may arise in the implementation of this measure can be reflected in the willingness of citizens to participate in this form of education, finding companies and experts who would maintain this education, lack of financial resources for the mentioned technologies, insufficient and/or small involvement of communities from rural areas, fear of "the unknown"

4.2. Smart mobility

4.2.1. City lighting and traffic signaling

4.2.1.1. Contemporary approaches to improve energy-efficient (EE) city lighting and traffic signaling

Nowadays, the human need for mobility has produced high-quality public lighting, both during the day, through natural sources, and at night, through artificial light sources. High-quality public lighting enables the safe flow of traffic and the smooth performance of a wide variety of activities, gatherings, playing sports, socializing, etc. Outdoor lighting can be divided into street lighting (road lighting), urban lighting (square and pedestrian zone lighting) and reflector lighting (lighting facades and buildings).

Basic recommendations for efficient public lighting and dynamic savings are:
- use of energy-efficient light sources (advanced technology),
- use of efficient lamps (light pollution),
- designing public lighting in accordance with norms,
- efficient management of public lighting,

- monitoring the costs and consumption of public lighting (cadaster of lamps, choosing a tariff model),
- regular maintenance.

A historical overview of improvements with respect to energy efficiency of light sources, lifetime and basic photo-technical characteristics is illustrated in table 4.1.

White light sources, similar to natural sunlight, such as LED (Light Emitting Diode) are used increasingly for high-quality and energy-efficient room lighting. There are numerous advantages of this technology, which until now has been used in various industrial applications, mobile phones, computers, interior lighting, and recently its great benefit to public lighting has been recognized. LED is a light semiconductor diode that emits directed light due to the electroluminescence effect. It represents a special type of semiconductor diode and consists of an LED chip made of semiconductor material, a cathode and an anode, a reflector, a lens and a housing. LED public lighting lamps consist of a matrix of smaller diodes that gradually weaken in intensity, not all at once.

Street lighting is a public service whose expenses are not negligible. About 4% of the city budget is spent on the consumption of electricity to light the streets in the area of the city of Tuzla. Replacing the existing street lighting with LED bulbs would reduce energy and maintenance costs by up to 50%. In order to take full advantage of LED lighting, these bulbs should be networked. This enables remote control and improved operation with the possibility of dimming the street lights and controlling their operation time depending on the conditions (e.g,. shorter/longer days). This principle of controlled action based on networking brings an additional 10-20% savings in energy, in addition to those savings achieved by the use of LED lighting itself. Networking enables simpler detection of outages, and thus reduced maintenance and repair costs with more precise management. Networked LED lamps bring slightly higher investment costs, but they have more advantages and a more significant benefit than just installing LED lamps.

4.2.1.2. The potential of energy-efficient public lighting in the city of Tuzla

Public lighting participated in the energy balance of the city of Tuzla in 2020 with 7,019.90 MWh, i.e. with 1.05%. The EE (energy efficacy) potential of this sector in relation to the total EE potential of the city of Tuzla is low, but taking into account the constant growth of energy prices and market instability, it is becoming more and more significant. In the case of switching to networked LED technology, the savings that could be achieved amount to 70-80% of the current consumption. The effects of this replacement would significantly relieve the city budget and at the same time raise the quality and functionality of public lighting.

According to available data in 2020, there were 20,150 lighting fixtures in the public lighting system. As for the lighting fixtures in use, sodium (Na) high-pressure bulbs are mostly represented, while mercury (Hg) bulbs are represented by 2% and LED by about 1%.

The structure of lighting fixtures according to power is:

- high pressure bulbs - 400 W 5 %;
- high pressure bulbs - 250 W 40 %;
- high pressure bulbs - 100 W 40 %;
- Metal-halide bulbs 12 %;
- Hg bulbs 2 %;
- LED 1 %.

Table 4.1. Characteristics of light sources for public lighting

Type of bulb	Application	Efficiency (lm/W)	Lifespan (h)	Color rendering
fluorescent light tubes	energy savings of up to 80% compared to a standard light bulb, one of the most popular light sources, application in public and business buildings	60-100	20,000	good
low pressure sodium bulb	extremely high efficiency and relatively poor color reproduction, they are produced in powers of 10 to 180 W, they are not used in new systems	200	18,000	poor
mercury bulb	it is used in street and industrial lighting, they are produced in 50-1000 W power, they are about to be banned in the EU due to their high mercury content	40-60	16,000	sufficient
metal-halide bulb	it is used in a very wide area, from automotive to indoor and outdoor lighting, and they are produced in powers of 20-2000 W, it is possible to obtain different color temperatures	do 120	20,000	very good
sodium bulb	the highest efficiency, but with weaker color reproduction (emphasized warm yellow color), the best solution for street lighting	do 150	32,000	poor

There are no dimmable lamps, nor ones with illumination control.

The public lighting system also includes traffic lights that regulate traffic at a total of 25 intersections in the city. Since 2016, the complete traffic light system has been based on LED technology, so their consumption is very low. Also, the complete system is time-programmed. The power of traffic light bulbs is around 7-8 W, so the total power per intersection does not exceed 150-200 W, which is a satisfactory level in terms of energy requirements.

It should be noted that the public lighting system also includes holiday lighting that is used during the months of December and January. Modern decorations with low energy requirements (LED technology) are mainly used, which are powered from the distribution network of public lighting.

According to the planning documents and strategies, the proactive policy of the city administration towards switching the complete public lighting system to LED technology in the coming period is evident. By implementing this project, the city of Tuzla will save over 80% of its current consumption.

4.2.2. Transport in the city of Tuzla

Determining the potential of EE in the transport sector in cities is a very complex procedure with many factors influencing it. It is not enough, as often happens in our country, to present the legislative framework, determine energy consumption by type of energy source, types and number of registered vehicles and show sketches of traffic infrastructure. First of all, it is necessary to take into account the global trends in improving the operational- and- energy efficiency of traffic in cities, the new more

efficient generation of vehicles and fuels with lower GHG emissions and, finally, the socioeconomic conditions of the observed city. The following is a brief overview of the factors that decisively influence the EE of traffic in cities.

Decision makers in developing cities face the challenge of establishing sustainable urban transport systems. Searching for EE represents a real opportunity to achieve this goal. Not only do EE measures reduce fuel consumption, but they also help solve other traffic-related problems. Organized and modernly managed city traffic greatly reduces costs for energy, congestion, noise, local air pollution, risks of traffic accidents and global GHG emissions, and at the same time ensures economic growth.

4.2.2.1. Transport and economy

Transport is often referred to as the "engine" that drives the economy. Favorable ways of transporting cargo enable other economic sectors to optimize the various steps in the chain from raw materials to finished products. Personal mobility provides freedom to people and enables them to organize work, life and recreation optimally. As such, traffic is inextricably linked to the structure of modern society. Therefore, traffic policies aim to improve the mobility of people and goods as a prerequisite for further economic growth. The transport sector represents numerous economic activities that include the activities of transport companies, vehicle manufacturers, oil companies, construction companies for the construction and maintenance of infrastructure, as well as a number of supply and service companies. In some large European countries, 10% of the population works directly or indirectly for the automotive industry.

Developing countries and emerging economies are facing a rapid increase in energy demand for transportation. High rates of population growth and urbanization cause the expansion of traffic, and the emerging middle class tends to use private motor vehicles, which results in an escalation of fuel consumption. Therefore, it is no longer a luxury but a necessity to establish an efficient traffic system that meets demand, but consumes as little energy as possible. This is important because fast and safe transportation of people and goods is a prerequisite for economic growth. Given the challenges of climate change, limited resources, rising energy prices, environmental pollution and health risks, it is necessary to choose the right path in order to cope with the rapidly growing needs for modern transport.

4.2.2.2. The role of transport in global energy consumption

Currently, global mobility of people and goods accounts for 20% of total primary energy consumption and 25% of CO2 emissions caused by energy consumption. On the other hand, 98% of the world's energy consumption in the transport sector is based on oil. For this reason, the transport sector is highly dependent on the price and availability of oil.

In recent years, it has been shown that the price of oil can increase to an unexpected level due to, for example, geopolitical instability, natural disasters and technical mishaps. Furthermore, the world demand for oil is increasing due to the increased demand of Western countries and the rapid economic development of some Asian countries. Although the world's oil resources are still significant, they are much more limited than coal and gas resources. In any case, it is expected that the costs of oil exploitation will increase. At the same time, some analysts expect that in the next 30 years or so, world oil production will reach its peak ('peak oil'), and will no longer be able to meet the growing demand. This is expected to lead to large changes in the price of oil, with possible negative economic consequences.

The World Energy Outlook (WEO), published annually by the IEA, provides insight into possible future trends in energy supply and demand. For example, the IEA reference scenario (WEO 2009) describes

how global energy markets will develop if governments do not change their existing policies and if trends in energy demand and supply continue. The reference scenario should not be considered a reliable forecast because it does not include possible or likely future policy initiatives. It is expected that the average annual increase in the demand for primary energy in the world will amount to 1.5% until 2030. This would lead to an overall increase in energy consumption of 40% in the period from 2007 to 2030. Fossil fuels will remain the primary source of energy worldwide, and the share of renewable energy sources (RES) will slowly increase.

Growth in energy demand varies regionally. More than 90% of the expected increase comes from non-OECD countries. They will have an annual increase in primary energy consumption of 2.4%, while an annual growth of 0.2% is expected in OECD countries. The highest growth rates are predicted for China, India and the Middle East. Despite higher annual growth in energy demand in non-OECD countries, their per capita consumption will remain significantly lower than in the rest of the world. Different sectors of final consumption (transport, industry, households, services, agriculture and non-energy uses) will stimulate demand growth in different ways, but transport will remain the largest sector of final energy consumption.

Road transport accounts for about 70% of energy in the global consumption of the transport sector. Road passenger traffic alone accounts for 50% of this energy consumption. There is a close correlation between income levels and the share of private vehicles, although average per capita income does not always result in the same ownership rate. For example, the average number of private vehicles in the USA is around 700 per 1,000 inhabitants, while in the highly industrialized countries of Europe this average is around 500 vehicles per 1,000 inhabitants. In contrast, in developing countries such as China and India, private ownership is well below 100 vehicles per 1,000 inhabitants. In 2020, there were 317 vehicles per 1,000 inhabitants in the city of Tuzla.

4.2.2.3. Increase of EE in the transport sector - in general

Energy-efficient transport offers a huge potential for reducing demand, both for oil and for energy in general. The IEA estimates that advanced technologies and alternative fuels (for example, hybrid vehicles, electric vehicles and fuel cell vehicles) can reduce the energy intensity of traffic by 20 to 40% by 2050, compared to the Reference Scenario. Such an outcome could also halve the demand for fossil fuels. However, even if energy intensity is reduced, total energy demand is still likely to rise above current levels due to increased demand for transport and motorization. In order to reduce future demand from current levels, it is necessary not only to reorient to more efficient means of transport, but also to reduce the total demand for travel per inhabitant.

Currently, it is difficult to quantify the value of improvements in EE and alternative fuels in relation to the issue of energy security. It can be assumed that the economic value will certainly be greater than the avoided fuel consumption. In order to better harmonize different goals when formulating new policies and measures, it would be desirable to develop a methodology for quantifying aspects of energy security in such a way that they can be compared with environmental indicators such as the costs of reducing GHG emissions. Improving EE means using less energy to provide the same service or activity level, or getting more service for the same energy input. A relative reduction in energy consumption can be related to technological changes, but it can also be achieved through better organization and management, as well as through behavioral changes. Energy efficient traffic should be supported on three different levels. There is a possibility of achieving higher EE for individual vehicles (vehicle efficiency) and trips (trip efficiency), as well as the entire traffic system (system efficiency).

Based on these three levels of EE in traffic, there are also three basic strategies for improving EE:
- Avoiding increased traffic activity and reducing the current demand for transportation,
- Shifting demand to a more efficient mode of transport,
- Improving the use of vehicles and fuel.

These principles are summarized in the well-known approach “Avoid-Shift-Improve” (ASI), which provides a holistic framework for strategic action to foster a sustainable transport system (Figure 4.1). Each strategy addresses a different level of EE: avoiding/reducing transport demand improves system efficiency, changing transport mode demand increases travel efficiency, and vehicle and fuel improvement increases vehicle efficiency.

As shown in the figure, total EE of the city transport system is the result of performance on all three levels: EE of the city transport = vehicle efficiency × transport efficiency × system efficiency.

System efficiency – strategy: avoidance/reduction - System efficiency refers to the way in which the need for traffic and different modes of traffic is generated. Research has shown that infrastructure and urban concentration affect traffic needs. Energy consumption per inhabitant increases proportionally when the density of the city decreases. Reducing the volume of traffic is a key aspect of energy efficient traffic. Therefore, land use planning should optimize the positioning of settlements and production structures in order to avoid traffic or reduce travel distances. A dense mixed urban structure is essential for the high efficiency of the system. This includes shorter travel distances and a change of model from road transport (which takes up a lot of space) to more efficient modes of transport such as walking, cycling and public transport. The prerequisites for the efficiency of the system include not only a dense urban structure, but also proper management of traffic needs and an adequate public transport network.

Freight traffic also benefits from a dense urban structure with short distances. In mixed residential and commercial areas, the transport of private goods is reduced. The challenge is how to ensure sufficient space and high-quality infrastructure for modern business. In general, in order to measure the success of EE strategies and quantify the achieved energy savings, it is necessary to use several indicators that together describe the performance of the traffic system at all three levels of efficiency. Most indicators are based on local statistics or require surveys of travelers and households. Limited availability of data often prevents proper planning or adequate assessment of EE potential and corresponding measures.

As already pointed out, the generated traffic volume and the efficiency of the city system are closely related. Passenger activity is influenced not only by the city structure, but also by economic, cultural or behavioral factors. In any case, planning decisions have a significant impact on the scope and efficiency of the system.

Since energy consumption is directly related to the density of traffic, the key indicator for evaluating the efficiency of the system is the annual passenger kilometer (pkm) per inhabitant. It is calculated by dividing the total distance traveled in a given period by the number of people who traveled. For example, in 2006 in Germany this indicator amounted to about 15,000 pkm per inhabitant in urban, inter-urban and rural areas, while in China it amounted to only 2,400 pkm per inhabitant.

Another indicator of system efficiency is population density (persons/km²), which can reveal structural reasons for different traffic volumes. A possible third indicator is energy consumption for passenger transport per person (MJ/person).

Travel efficiency - shift strategy: Travel efficiency refers to the energy consumption of different modes of transport. The main parameters of travel efficiency are the relative advantage of different modes of transport (modal split) and the vehicle load factor. The specific energy consumption per passenger kilometer or kilometer per ton varies between different modes of transport. An alternative way to increase energy efficiency is to encourage passengers or drivers to use more efficient forms of transportation, such as public transportation and non-motorized vehicles.

Generally speaking, private motorized modes of transport are significantly less energy efficient than

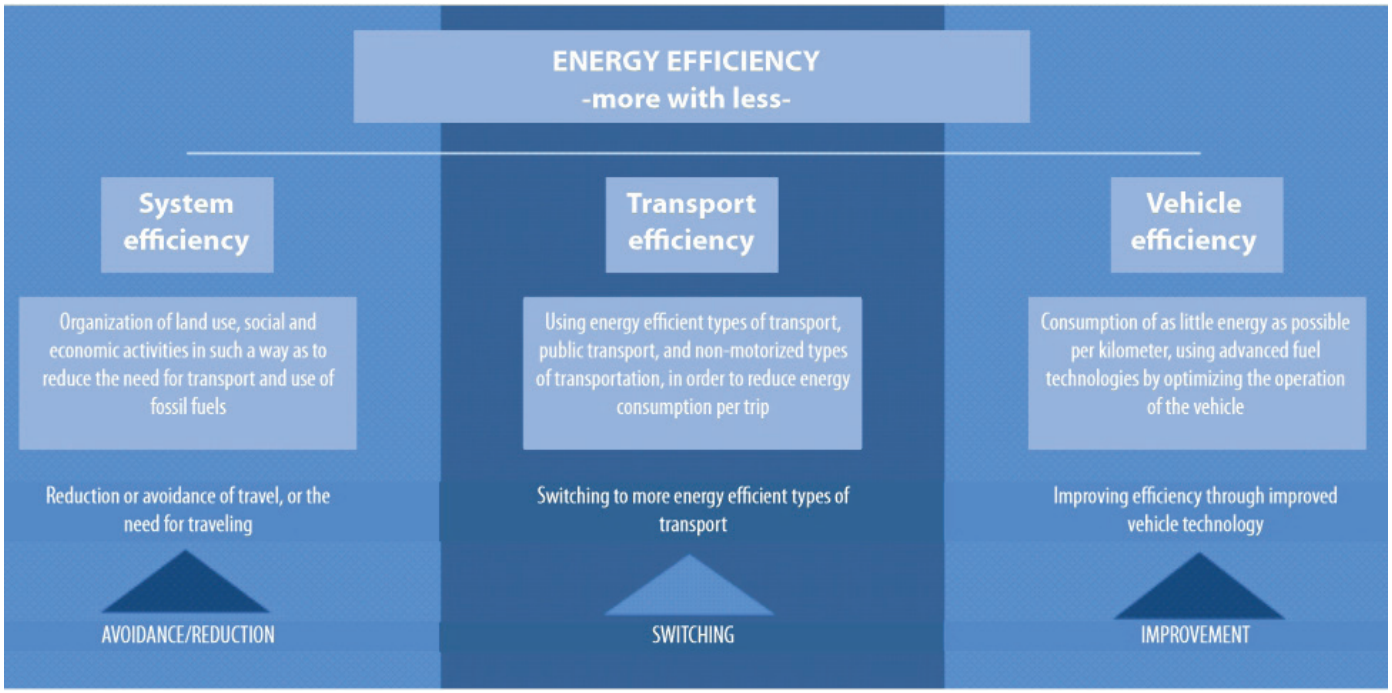


Figure 4.1. ACI concept of EE traffic

public transport. Other important alternatives include non-motorized forms of transportation that require no fuel at all. Energy consumption per inhabitant depends to a large extent on the number of vehicles used. It is necessary to reduce driving by motorized transport, and the share of non-motorized and public transport must be increased. Especially in urban areas, most trips involve distances of less than five kilometers. Various measures can be implemented to encourage citizens to travel such distances by bicycle or on foot, thereby avoiding unnecessary fuel consumption. For longer journeys, the alternative to a car is to use public transport. Increasing the participation of public transport will lead to a higher rate of use of buses and other means of public transport, which will further increase their EE.

In addition to passenger transport, EE should also be increased in freight traffic. Freight transport by rail is particularly energy efficient due to the high load factor, while its flexibility is, of course, limited. A sophisticated logistics network, including multimodal logistics centers (rail/road or port/road), can help redirect cargo to more efficient modes of transportation. That is why the efficiency of travel depends mainly on the participation of more energy efficient means of transport. In addition, the energy intensity of each mode of transport is also important, which depends on the efficiency of the vehicle and the occupancy rate.

The participation of each form of transport in the total number of trips, as well as the corresponding passenger-km (pkm) or ton-km (tkm) can be used as an indicator of travel efficiency. It is also necessary to take into account the energy consumption per passenger kilometer (MJ/pkm) or ton kilometer (MJ/tkm) of each mode of transport. Finally, the vehicle occupancy rate is a key aspect of travel efficiency. This is already considered under energy consumption per pkm/tkm, but a separate analysis is often useful.

Vehicle efficiency - improvement strategy: Reducing fuel consumption per vehicle kilometer increases their efficiency. This can be achieved with technological and design improvements, but also through more efficient driving techniques. Measures can be grouped into three categories:

- improvement of existing vehicles,
- new fuel concepts,
- development of new vehicles.

The improvement strategy does not only apply to personal vehicles, but also to freight and public transport. Specific measures for personal vehicles include the use of lightweight materials, the reduction of engine displacement and car size and/or the use of hybrid engines. The combination of such measures significantly reduces energy consumption compared to the average private car. Comparing different cars of the same size, where consumption can vary by as much as 20%, highlights the potential benefits of vehicle technology. Such technological improvements are mainly a business for vehicle manufacturers and research institutes. However, legislation and fiscal measures can be important drivers of technological progress. Local and national authorities can support the spread of efficient technologies in the market by setting standards, raising awareness and initiatives among private and commercial owners to buy more energy efficient vehicles.

Fuel efficiency can be measured by specific consumption (liters per 100 km), or fuel economy (km traveled per liter). Different measures must be taken in different countries, such as meeting standards for fuel consumption and CO_2 emissions. Unlike travel efficiency, which is measured by passenger (pkm) or ton kilometer (tkm), vehicle efficiency is important for both private motor vehicles and public transport vehicles. Measuring fuel or energy consumption per vehicle kilometer (MJ/km) is a simple way of monitoring vehicle efficiency. Since fuel consumption and CO_2 emissions are mutually dependent, another way to assess vehicle efficiency is to measure CO_2 emissions per vehicle kilometer (gCO_2/km), but it is important to take into account that not all fuels provide the same energy. The overall efficiency of the vehicle, also depends on the average age of the vehicle. Cities differ in their topographical, historical, economic and political circumstances. It is best to compare your own traffic system with those of other similar cities, as this will enable the transferability of the results.

4.2.2.4. Accompanying benefits

In the transport sector, cities and municipalities often have to bear additional costs in order to ensure energy-efficient transport systems that will be important for the population and the local economy. However, some investments pay off in the long run. EE improvements can have multiple benefits and thus provide additional incentives to local and national governments to implement expensive measures, depending on local circumstances, and additional benefits of EE policies can be the original reason for their adoption and can justify investments. General (co)benefits can be divided into the following four categories (Figure 4.2).

Stronger economic development - As a rule, import dependence on oil and cars does not encourage local jobs or sustainable economic development of cities. As in BH, in many countries vehicles and fuel are the largest category of imported goods, and such costs can be significantly reduced. In contrast, increasing the participation of public transport and non-commercial means of transport can bring certain economic advantages to cities. For example, reducing city traffic congestion leads to time savings. More efficient use of energy resources is accompanied by greater efficiency in the use of other scarce and valuable resources, such as land. The urban transport system is based on the needs of public transport, which requires far less space than a traffic system based on cars. Cities with smart urban transport systems and low levels of congestion often attract more foreign direct investment than other cities, as large companies recognize that their employees are healthier, can travel more easily and arrive on time, and like the place they work. The functionality of such cities as business locations is also safe, because deliveries and business trips can be planned and carried out efficiently using a smart urban transport system. Impressive examples of this in Asia are Singapore and Hong Kong.

Increased quality of life - Lower energy consumption reduces emissions of harmful substances and improves air quality in cities. Urban space is limited and a car-based transport system usually takes

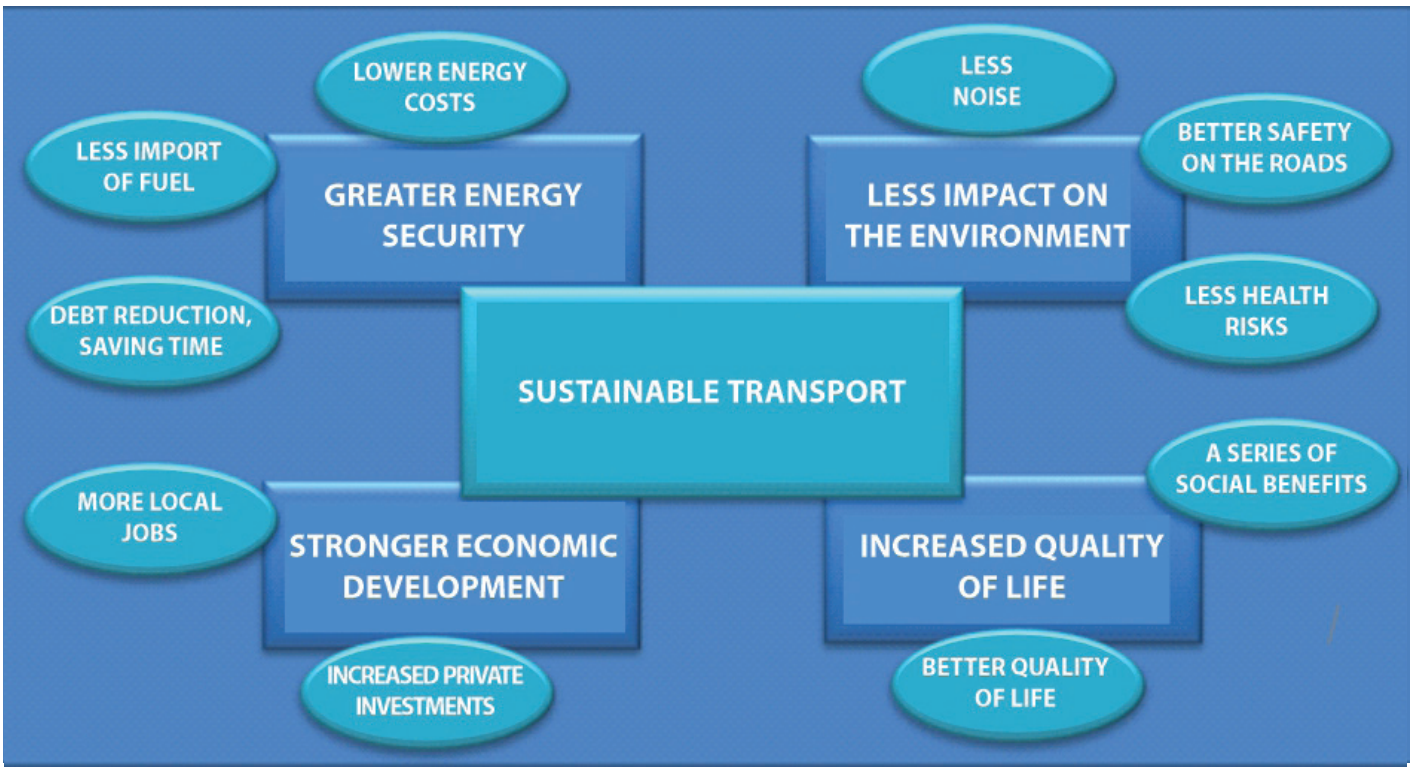


Figure 4.2. Possible additional benefits of EE measures in the transport sector

up a lot of road and parking space. This is to the detriment of urban parks, footpaths or recreational areas. In contrast, public transportation requires far less space to meet similar requirements, meaning city planners can provide greenways, parks, and other recreational areas. Road traffic noise impairs the quality of life of many residents and reduces the value of land and buildings. Sustainable transport also reduces health risks in terms of road safety as well as air pollution.

Better energy security - Fuel subsidies and other forms of support for the automotive industry put pressure on the state budget, and also worsen energy security and increase dependence on imports and oil prices. As "peak oil" is possible, world oil production is likely to decline over the next decade. Oil prices will continue to rise, reaching the level of €170/barrel or more. However, lower fuel consumption due to EE measures reduces oil import dependence of the country or individual regions.

Other - By promoting the role of public transport, traffic congestion and risks of accidents can be significantly reduced. A large part of the city budget is spent on mitigating the negative consequences of road transport. Such costs are not borne directly by road users, but are imposed on society. For example, cities must invest in noise prevention measures, or in health care to cover the costs of treating diseases caused by air pollution or traffic accidents.

4.2.2.5. Geo-traffic position and traffic infrastructure of the city of Tuzla

It was emphasized before that the potential of EE in the transport sector depends to a large extent on the level of construction and functionality of the transport system. Today, the transport infrastructure in European cities is developing primarily in the direction of shifting transit traffic to city bypasses, adapting to public passenger and non-motorized traffic. The main stimulating generators of traffic development are traffic position in relation to regional communications, demography, economic activity and employment, educational and cultural profile of the population in a certain territory. The wider area of the city of Tuzla, especially the hilly and mountainous part, does not have a developed road infrastructure that would improve existing conditions and enable integral development based on evident potentials (agriculture, energy, tourism, forestry...).

A characteristic that essentially affects the quality of the road network of the city of Tuzla is its age. Namely, most of the regional and main roads were built more than 40 years ago, and the investments in their construction and maintenance in the last 20 years have been very low. Vehicles are often inadequately loaded (transit freight traffic), which contributes to accelerated deterioration and damage to the road infrastructure. Transit traffic takes place through the urban area of the city, that is, it is intertwined with the city's road system, which reduces the quality of traffic.

In the last 10 years, the city of Tuzla has developed rapidly. Considering the current state of construction development and planned construction projects, it is highly probable that this area will continue to grow. In particular, the city's urban area expanded with thousands of new residents in previously sparsely populated areas, e.g. Irac and Slavinovići. The construction of a complex of artificial salt lakes and the improvement of Tuzla's tourist sites have caused an increase in incoming traffic. Bearing in mind the expected development and its spatial limitations imposed by the topography and structure of the land, efficient and optimal use of space is of crucial importance. This development is sure to change regional mobility needs. The existing system of public passenger transport and traffic road infrastructure do not even meet the current needs of citizens for mobility. Therefore, efficient and optimal traffic management is very important.

The development of Tuzla was strongly shaped by the industrial development of the region. Although the construction land in the urban part of the city is mostly full, the existing land creates a great potential for denser development of that area. In the last 15 years, an intense growth in the number of motor vehicles is evident, and estimates show the continuation of this trend in the future. The current method of traffic-spatial planning strongly favors motorized individual traffic, while other modes of traffic (public transport, bicycle traffic, walking) are neglected. There is enough "space" for changes in the structure of citizens' mobility, so that the City of Tuzla can significantly influence the choice of means of transport in the coming period by adopting regulatory documents, implementing infrastructure projects and stimulating measures.

A large share of internal traffic in the total number of movements of individual motorized vehicles is evident, as is the uneven load on roads in the urban area. The traffic flow is not extreme, but it is most active during the 12-hour period from 7 am to 7 pm. Due to non-optimized traffic flows, despite the relatively low volume of traffic, there is frequent overloading of certain traffic junctions.

Although the offer of parking spaces is at a quantitatively satisfactory level, the distribution of existing capacities is not optimal. There is a good traffic-spatial potential for reducing the number of internal movements of motorized individual vehicles. Despite strong spatial limitations, there is good potential for organizing an efficient public transport system. Pedestrian and bicycle movements currently encounter many and frequent obstacles that can be removed by more efficient and comprehensive spatial and traffic planning.

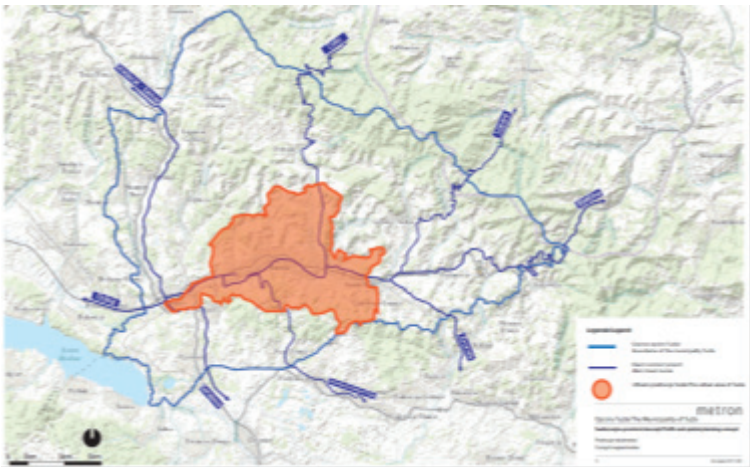


Figure 4.3 – Tuzla city area with road corridors

On the basis of the analyses presented in this document, it is obvious that radical changes must occur in Tuzla in terms of traffic function, so that perspectives are opened to a technically efficient system of organized public transport which, in combination with pedestrian movement and bicycle transport, can meet all the mobility needs of citizens .

Tuzla is located in the north-eastern part of Bosnia and Herzegovina with the most urban area, located at 44˚ 33' north latitude and 18˚ 42' east longitude. The topography of Tuzla is characterized by: the Majevica mountain range in the northeast, and the Ilinčica hill in the south, while the rivers Solina and Jala, as well as some smaller watercourses, form natural valleys through which spatial communications are realized. The main communication axis consists of the east-west direction (Jala river), and transverse valleys and local communication corridors are vertically connected to it. Tuzla, as the most important center of industry in Bosnia and Herzegovina (mines, power plants, chemical industry, etc.) developed intensively in the past period, which left significant consequences for the entire city area, and especially for the inner city core.

The traffic connection between Tuzla and the neighboring cities and regions is achieved through two basic corridors:

- east-west (main road M4: Doboj-Tuzla-Bijeljina- Republic of Serbia),
- north-south (main road M.18: Republic of Croatia-Orašje-Tuzla-Sarajevo) and
- railway lines: Doboj-Tuzla and Tuzla-Zvornik.

Large migration movements of the population in the 90s, transition processes, the city "destroyed" by industry, poor development of the road and railway network, are some of the factors that significantly affected the complete traffic system of the city of Tuzla.

The problems that are currently considered the most significant are:

- the absence of higher-ranking roads (expressways, highways),
- the rapid and intensive development of individual settlements is not adequately accompanied by the construction of road infrastructure (low-grade roads),
- certain sections of roads and intersections are overloaded due to the lack of alternative roads,
- a large number of roads and even individual settlements were destroyed by land subsidence,
- a large number of landslides and mine surfaces spatially limit the development of the road network,
- "illegal" construction slows down the implementation of infrastructure facilities,
- railway traffic and the railway network have not been developing for the last 30 years,
- transit (passenger and cargo) traffic passes through the inner city core,

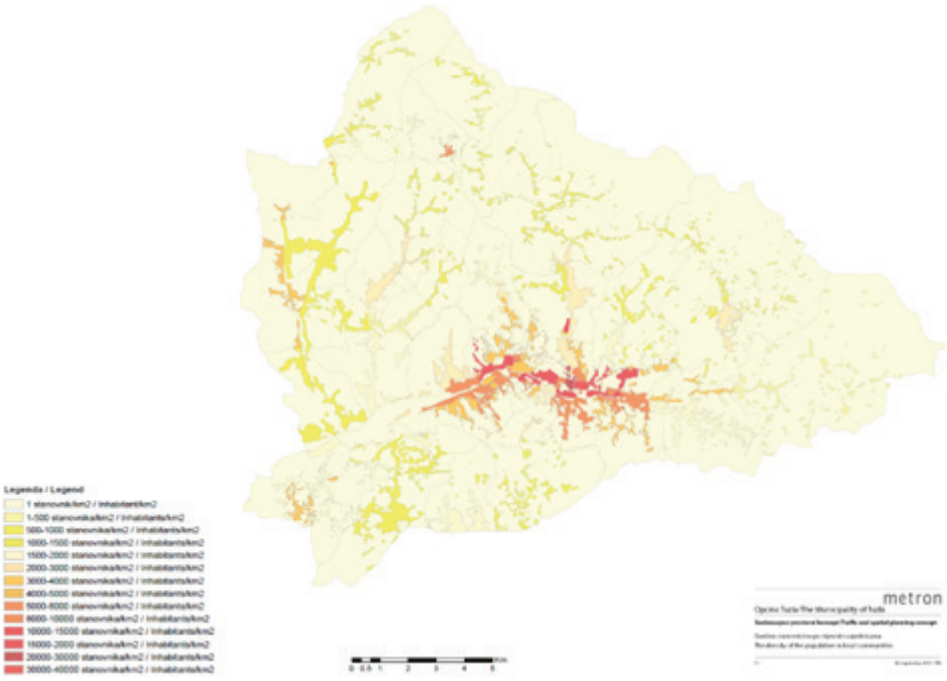


Figure 4.4. Population density in the area of the city of Tuzla

- the passenger transport company does not provide quality service
- o bicycle traffic and infrastructure are not developed.

A large number of traffic projects are planned or underway in the area of the city of Tuzla, but it should be noted that they are mainly road infrastructure construction projects. The plan includes the construction of the highway Orašje-Tuzla-Zepče, the reconstruction and modernization of the main road Tuzla-Sarajevo, and the construction of the southern and northern bypass around Tuzla. The time period for the realization of the mentioned projects is very difficult to predict.

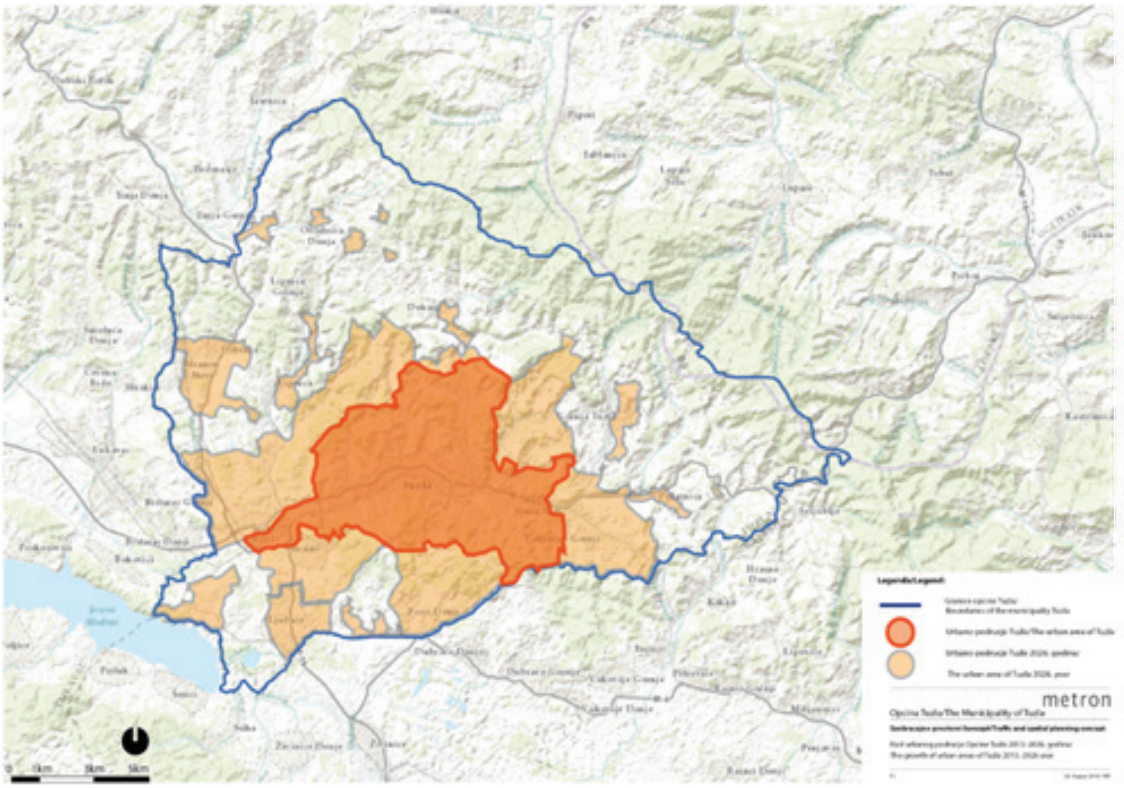


Figure 4.5. Expansion of the urban area according to the Spatial Plan of the City of Tuzla for the period 2010-2030.

4.2.2.6. Energy balance in the transport sector of the city of Tuzla (vehicle fleet, public transport and private and commercial vehicles)

As in most countries and regions, the city's road transport sector is a large consumer of imported petroleum products. From an energy and ecological point of view, this circumstance requires special measures for savings and rationalization. The consumption analysis for the year 2020 is based on the data of departmental services of the city of Tuzla and other institutions, published by SECAP of the City of Tuzla. However, it should be noted that the presented data must be accepted with a grain of salt. It is not possible to provide exact data on the amount of fuel used in the city of Tuzla as a whole because it is impossible to keep accurate records of particular energy sources. This is also supported by the fact that Tuzla is a transit center with high traffic dynamics, so even data on the amount of fuel sold at gas stations cannot represent sufficiently relevant indicators. The total amount of fuel sold would certainly differ significantly from the amount sold exclusively for the needs of vehicles moving within the city limits. In the same way, due to the absence of relevant records, it is not possible to determine even the mileage traveled on the territory of the city, and especially not the indicators passenger (pkm) and ton kilometer (tkm) which, in accordance with the methodology from chapter 4.2.2.3, are a condition for quantifying the EE potential in this sector.

According to SECAP data, the transport sector participated in 2020 (Figure 4.6) with 46.2%, i.e. with 307,764.78 MWh. From table 4.2. it can be seen that in the transport sector the dominant share is diesel (79.5%), followed by gasoline (15.7%), while natural gas (LPG) participates with 4.8%. When it comes to means of transport, about 91.9% is accounted for by passenger cars, so the specific consumption and use of these vehicles has the greatest EE potential.
For the purposes of the analyzes carried out in SECAP, traffic energy consumption was classified into three sub-sectors: vehicle fleet owned and used by the city, public transport (city bus traffic and taxi traffic) and private and commercial vehicles.

The overview of the situation in this sector is based on the following characteristics: the number of vehicles by individual sub-sectors, the types of energy sources in use and the consumed energy of individual energy sources in kWh.

Vehicle fleet owned and used by the city of Tuzla - The vehicle fleet of the city consists of vehicles that are used for the purpose of performing tasks for city services and companies. In 2020, the total number of vehicles was 249. Based on their purpose, city companies use cargo, combined, special and work vehicles. The participation of the vehicle fleet of this sub-sector in the total consumption of the city is almost negligible (0.7%), so it does not represent a significant domain for improving EE in traffic. Otherwise, a large number of old vehicles have been replaced by new, more energy-efficient models, which have better performance, so the negative impact on the environment is accordingly milder compared to the previous period.

Public transport (city bus traffic and taxi traffic) - in 2008, the "Pinga" bus station was moved from the city center, so the bus terminals are located at the eastern and western entrance to the city. At that time, certain changes were made to most of the bus lines at that time. In 2008, "GIPS" d.d. Tuzla acquired 10 low-floor buses with EURO 3 engines, and in 2010 it acquired 30 buses with EURO 3 engines that have additional particle filters installed. Buses that are now used to transport passengers are mostly low-floor, which is why they are accessible to a larger number of people. In 2015, there are ownership changes, the management is taken over by a private company that immediately invested significant funds in the modernization of equipment and staff education, which directly affects the increase in the quality of the service provided. Currently, the fleet of the "GIPS" company includes 59 buses that use natural gas as a fuel and that in the control year 2020 consumed a total of 22,600.24 MWh by burning fuel, of which 17,176.18 MWh (76.00%) came from diesel, and 5,424.06 MWh (24.00%) from gas.

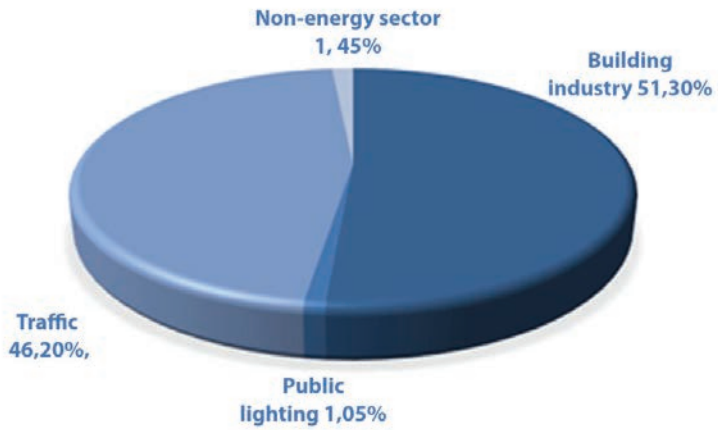


Figure 4.6. Individual sectors' energy consumption in the City of Tuzla in 2020 according to SECAP

Private and commercial vehicles - A total of 34,995 vehicles were registered in the city of Tuzla in 2020, of which 34,784 were personal and commercial vehicles. It is noticeable that the largest number of vehicles (over 60% of the total number) belong to the ecological categories EURO 3 and EURO 4, in contrast to 2002, when the majority of vehicles that make up the transport sector were vehicles manufactured before the establishment of the EURO categories. Now, these low-quality vehicles account for slightly more than 13% of the total number of vehicles. The structure of vehicles from this subsector in the control year 2020 according to eco categories is shown in the following diagram. In the sub-

sector of passenger and commercial vehicles, a total of 282,965.41 MWh was consumed in 2020, of which 225,439.06 MWh or 79.67% came from diesel fuel, 48,143.16 MWh or 17.01% from gasoline, and 9,386.19 MWh or 3.32% from liquefied petroleum gas. By burning these fuels, 72,179.07 tCO2 was released into the atmosphere, of which 60,191.43 t or 81.00% by burning diesel, 11.987.65 t or 16.13% by burning gasoline, and 2.130.66 t or 2.87% by burning liquefied petroleum gas. oil gas.

Table 4.2. Individual transport sectors' energy consumption by energy source

CONTROL INVENTORY - ENERGY [MWh] IN THE TRANSPORT SECTOR				
	Vehicles under City jurisdiction	Public city transport	Personal and commercial vehicles	TOTAL BY ENERGY SOURCE
Diesel	1,881.18	17,176.18	225,436.06	244,493.42
Motor gasoline	317.95		48,143.16	48,461.11
Liquefied petroleum gas		5,424.06	9,386.19	14,810.25
TOTAL	2,199.13	22,600.24	282,965.41	307,764.78

4.2.2.7. The use of more energy-efficient vehicles

New generations of vehicles have improved energy and environmental performance. For example, the EU is reducing the specific fuel consumption per vehicle by 25% (from 0.56 kWh/vehicle in 2002 to 0.42 kWh/vehicle in 2014), while this indicator in the EU in 2002 was then significantly lower in BH. For the usual car consumption in BH of 7 l/100 km, the specific consumption is estimated at 0.73 kWh/vehicle according to the same methodology. By taking measures to improve the traffic infrastructure and excluding vehicles older than 2009, the specific consumption would be reduced to 0.47 kWh/vehicle, the EE potential in the automobile traffic of the city of Tuzla would amount to about 182,183.21 MWH or 65% in relation to the consumption from 2020. There is a great potential for EE by replacing trucks of older production, at least at the level of 10%, which would result in additional savings, as well as the replacement of public transport vehicles.

The main problem for realizing this potential is that its predominant part refers to the sub-sector of private and commercial traffic. Due to the large number of subjects in this subsector and the right to freely dispose of vehicles in their possession, insufficient awareness of good and bad personal and collective effects, this subsector is more difficult to influence than the other two. The modern development of the city must provide adequate conditions for the life and functioning of the citizens, but the citizens must also have a more responsible attitude towards the values of the city, as well as the specific collective environment. To this end, public campaigns are necessary to raise awareness of the benefits of purchasing and optimally using more energy-efficient vehicles, as well as various incentive measures to increase the use of public transport.

Specific fuel consumption increases with frequent stops and driving in busy traffic. It is possible to reduce these phenomena with appropriate traffic signals in urban areas, based on monitoring the number and speed of vehicles, i.e. the intensity of traffic and adjusting the light signals accordingly. Economic measures, with time-defined tolls in urban areas, are also recommended, which would affect the lower use of vehicles during peak traffic jams and at the same time direct the transition to public city traffic. In intercity traffic, it is possible to reduce traffic jams with appropriate informational support that informs drivers about congestion, traffic jams, collisions, etc., so that drivers can choose an alternative route in a timely manner.

In addition, a very effective measure aimed at renewing the vehicle fleet with energy-efficient vehicles with lower specific consumption, and therefore lower specific CO_2 emissions, is the introduction of a tax proportional to the prescribed fuel consumption. This measure involves paying a higher tax when buying a new vehicle with higher fuel consumption, which motivates the purchase of more energy efficient vehicles.

4.2.2.8. Other possiblilities of increasing EE in traffic

It was not possible to base this study on indicators for all three levels of EE traffic in cities (system efficiency, travel efficiency and vehicle efficiency), primarily due to the lack of relevant data necessary for a more comprehensive strategic approach that includes technological, infrastructural, financial, as well as behavioral measures (driving style and technique) and spatial planning measures. For example, studies within the framework of the European Climate Program have shown that with appropriate driving methods and techniques (without sudden braking and acceleration, etc.) it is possible to increase EE by 10 to 12% and reduce GHG emissions by 5 to 25%.

Furthermore, measures to avoid traffic include encouraging cycling and walking. In urban areas, there are often shorter distances that, instead of using a motorized vehicle, can be covered on foot or by bicycle. In order to increase the participation of this mode of transport, adequate traffic infrastructure is needed, which would, above all, enable cyclists to have an increased radius of movement as well as safer transport. Riding a bicycle reduces traffic density and traffic jams, which directly enables the vehicle to travel a greater distance in the same period of time.

The mentioned EU policies and specific measures are very instructive and somewhat binding for BH as a future member state. According to these policies and measures, there is significant additional potential on various grounds, which can be of the order of the already estimated EE efficiency potential of transport means. This potential is difficult to quantify for certain urban environments. Its activation depends on national and local legislation, the quality of spatial plans, administrative and financial predispositions, and especially on the general awareness and culture of citizens to accept and use modern policies of sustainable development.

4.2.2.9. General recommendations

In order to achieve the full potential of EE policies and measures, it is important to appreciate the complexity of the transport sector. Individual, uncoordinated measures may have limited success. The correct policy for increasing EE in the urban transport system must refer to all three levels of energy-efficient transport: system efficiency, travel efficiency and vehicle efficiency. Adequate strategies and packages of policies and measures enable such a mixed approach. Ideally, push measures must be followed by pull measures. A well-developed and adequate public transport infrastructure can attract more passengers, but this alone is often not enough to trigger a large shift from private car use to public transport. The fundamental factors that support car use, such as comfort and status, continue to prevent people who can afford a car from using public transport. Therefore, steps must be taken to overcome these factors, such as pricing measures that increase the cost of using a car, or parking restrictions that reduce the convenience of using private cars. In general, these and similar steps in the package of measures will encourage a faster shift towards more energy efficient modes of transport.

4.2.3. New „smart“ technologies in the transport sector

4.2.3.1. Traffic development trends in the world

The development of the traffic system so far in the developed industrial world has enabled an extremely high level of people's mobility. The development of mobility was primarily based on measures that encourage the use of individual vehicles. This enabled comfort, independence, accessibility to work, health services, education and social interactions. The technological improvements that followed on means of transport and on the accompanying traffic infrastructure contributed even more to the development of mobility, which affected the affordability of means of transport and all other attributes of attractiveness, which are linked to it. Such a development of people's mobility, on the other hand, has had an impact on unpredictable growing external environmental and economic costs. Environmental costs include costs incurred due to excessive noise, air pollution and greenhouse gas emissions. Degradation of urban space, time delays in traffic congestion, traffic incidents fall within the framework of socio-economic factors.

Aware of these consequences, the developed countries of the world are turning to the approach of sustainable mobility, which in the framework of the sustainable development of cities to a greater extent connects the use of space as a system of activities with the overall traffic system. When promoting sustainable mobility, it is necessary to emphasize turning towards the values that are traditionally favored by the majority of the population and by means of which the promotion itself is easier to achieve: a healthier lifestyle with reduced exhaust gases and increased activity of residents with the use of non-motorized modes of transport, reduced negative impacts on the environment and on health of residents. Part of this approach is also implemented by the EU with the strategy of limiting CO_2 emissions in traffic. It is necessary to develop bicycle and pedestrian traffic, encourage and improve mass public transport, coordinate the use of land, improve the management of urban freight traffic and stationary traffic, carry out efficient transport billing (parking fees, compensation in the center...), carry out measures to reduce traffic, develop more acceptable forms of transportation to protect the environment, limit access to vehicles that pollute the space in which we live and encourage the use of cleaner and quieter road vehicles.

The goal of sustainable mobility planning is to meet the mobility needs of residents without endangering the health of people and the ecosystem. In this sense, the harmonization of traffic planning and spatial planning is important. The key factor in this is the limitation of individual car traffic and the development of alternative forms of traffic.

Traffic infrastructure in European cities today is developing primarily in the direction of shifting transit traffic to city bypasses, as well as adapting to public passenger and non-motorized traffic. The construction of city bypasses reduces the density of traffic flow on the busiest roads that carry transit traffic through the city on the one hand and reduces negative environmental emissions for residents on the other.
Active traffic policy is also important for reducing negative emissions that occur as a result of traffic flows in European cities. It is directed towards encouraging the use of public transport means with an appropriate offer of public transport. Daily migrations of the population should be redirected as much as possible to means of public transport, which must be competitive from the point of view of price, travel time and comfort. By restricting individual road traffic in the city center, as a result, more infrastructural areas appear for the development of other sustainable forms of traffic (e.g. bicycle paths). A high-quality system of public passenger transport and the development of non-motorized forms of transport are areas that should be focused on in the coming period.

The change of mode together with the introduction of new technologies is achieved by appropriate traffic policy measures, namely by reducing the speed of traffic in the settlements, greater restrictions on the access of individual vehicles to the city center, various fees and increasing public transport.

This encourages the development of non-motorized forms of travel and the use of public forms of transportation at the expense of the use of individual vehicles. One of the recognizable solutions for the establishment of sustainable mobility is the construction of a "P+R" (English park and ride) system on the outskirts of the city, so that commuters from the region on their way to the settlements can transfer to more organized public passenger transport. Passengers park their vehicles at "P+R" locations on the outskirts of the city and continue their journey towards the city by public transport vehicles, because these locations or points are efficiently connected to the city.

4.2.3.2. An outline of the traffic in Tuzla

The main traffic problems in the city of Tuzla, currently considered the most significant, are:
- the absence of higher-ranking roads (expressways, highways),
- the rapid and intensive development of individual settlements is not adequately accompanied by the construction of road infrastructure (low-grade roads),
- certain sections of roads and intersections are overloaded due to the lack of alternative roads,
- a large number of roads and even individual settlements were destroyed by land subsidence,
- a large number of landslides and mine surfaces spatially limit the development of the road network,
- "illegal" construction slows down the implementation of infrastructure facilities,
- railway traffic and the railway network have not been developing for the last 30 years,
- transit (passenger and cargo) traffic passes through the inner city core,
- the passenger transport company does not provide quality service,
- bicycle traffic and infrastructure are not developed.

4.2.3.3. Possibilities for the improvement of traffic in Tuzla

The purpose of sustainable mobility in Tuzla is the development of a traffic system based on meeting the criteria of sustainable development. As part of sustainable development, it is necessary to enable coordinated development of sustainable mobility with spatial development. Sustainable traffic is defined as the possibility of meeting the needs of society in such a way as to create conditions for free movement, with free access, communication and establishing connections without sacrificing other important human or ecological values both today and in the future.

This concept refers in essence to:
- Displacement of transit traffic from the city with the construction of city bypasses and connection to the highway network,
- Changes in the modality of source-destination traffic with measures to improve the public transport system,
- Increasing areas for pedestrians and cyclists at the expense of areas for individual vehicles.

Displacement of transit traffic from the city center - Transit traffic is represented by passenger and freight traffic flows. Such flows represent a great traffic burden for the city and its inhabitants. City bypasses generally ensure the displacement of transit from the area of the urban agglomeration. Transit traffic through the city center increases traffic jams. As a result, in addition to the lost time of road users, there are also emissions that pollute the environment of city residents. This results in high economic costs, both at the level of society and at the level of households. Therefore, transit traffic represents a threatening factor for the environment, if we take into account the volume of traffic, the possibility of negative phenomena that accompany traffic functioning (noise, air pollution, dust, etc.). Displacing this type of transport, i.e. relieving the city center of heavy vehicles, as well

as reducing the risk of possible accidents during transport, should be one of the priorities in the organization of traffic.

Changes in traffic modes - The major traffic problem in Tuzla is that cars are used for the majority of movement, with very poorly organized public transport, and inadequate infrastructure for other types of traffic. The key to solving the mentioned problem is to change the mode of movement, that is, the mode of traffic, that is, to increase the number of users of public passenger transport (PPT) and alternative modes of transport (cycling and walking). In order to achieve this, it is possible to carry out the following activities:

- improvement of the PPT system with: integration of city and suburban bus transport and increase in the accessibility of PPP citizens, introduction of new lines and stops, increase in the frequency of rides on the lines,
- introduction of auxiliary lanes and priorities for PPT vehicles,
- construction of main corridors of bicycle and pedestrian paths, and areas with limited traffic.

The introduction of auxiliary lanes and priorities for buses depends on the number of passengers transported by PPT on a working day. These auxiliary lanes can also be used in incident situations for vehicles with the right of way.

The construction of the main bicycle corridors ensures access and connection to places of interest by other, alternative modes of transport. Following the example of European cities and with the purpose of protecting and preserving the city core (buildings, promenades, parks), some areas in cities and city centers would have to be accessible only to PPTs and non-motorized forms of transport. In order for solutions of this type to be successfully introduced, it is necessary to prepare appropriate measures in advance and make a joint effort to find new solutions.

Measures to limit or completely close the city center for traffic have numerous positive and also negative consequences. The positives include: positive impact on air quality in the city, regeneration of the city center and service activities, development of non-motorized traffic, greater safety for pedestrians, etc. The negative consequence of closing the city center is a decrease in traffic and visitors, if adequate accessibility is not ensured with PPP. It is necessary to ensure the availability of vehicles that supply the closed part of the city with passes for the needs of bars, restaurants, shops and the availabiliy of residents of that area for emergencies.

Increasing the area for pedestrians and cyclists - in the coming period, the City of Tuzla should pay special attention to changing the mode of movement of citizens, with the aim of increasing the movement of citizens by bicycle and on foot. In accordance with the above, the city should pay attention to the development and improvement of the infrastructure for these types of traffic, that is, in further development the city should have the following guiding ideas:

- Establishing a main bicycle corridor (east-west) that would represent an axis that leads bicycle traffic past the city center and the area with the largest number of points of interest,
- Maximizing the use of existing roads for the implementation of the main corridor,
- Establishing new traffic regimes that put bicycle traffic on an equal footing with motorized traffic,
- Mixing bicycle and motorized traffic on lower-ranking roads,
- The bicycle path network is upgrading the public transport system,
- Increase safety and improve the flow of the main bicycle corridor by solving critical points - conflicts with motorized traffic (southern road),
- Develop bicycle infrastructure - bicycle parking in the immediate vicinity of the main public transport stations and main points of interest.

The central city area of Tuzla has a fairly good pedestrian infrastructure. The network of footpaths is punctuated by localized “weak” points and the lack of a network. Conflict or “weak” points are

found mostly in streets dominated by motorized traffic, either because of the way the space is used or because of the amount of traffic. Additional pedestrian traffic potential can be created by removing "weak" network points and implementing traffic calming measures. Although pedestrian traffic already plays a significant role in the mobility of citizens, it is to be expected that its importance will increase due to the future dense development of the urban environment of Tuzla. The largest increase in the amount of pedestrian traffic is expected in the city center and smaller neighborhood centers, as well as at the transfer points of the public transport system. Therefore, it is important to take into account the freedom of pedestrian mobility and safety when planning these locations.

4.3. Smart environment

4.3.1. Water supply in the city of Tuzla

4.3.1.1. Structure and functionality of the water supply system

The Tuzla Water Company owns a 700 km distribution network and draws water from 3 different municipalities: Tuzla, Živinice and Kladanj. For the reason of easier monitoring and monitoring of the water supply system, since 2016, the company has carried out controlled zoning of the complete water supply system, dividing it into DMA (District Metered Area) zones. DMA zones are areas where measurements and analyses of pressure and flow can be carried out independently for the purpose of regulating water supply and locating losses. They are hydraulically isolated by permanently closing the valve and installing meters, which are equipped with a telemetry data recorder (logger). The key principle of managing DMA zones is the control of hydraulic parameters (maintaining pressure at the minimum required levels) and flow analysis, which determines the presence of excessive and new leaks. In Tuzla, the entire system is divided into 29 DMA zones.

In 2023, the city of Tuzla is supplied with drinking water from four main sources:

- Stupari, where the waters of the springs Zatoča, Tarevčica and Sedam vrela (the so-called Stupar springs) are affected,
- Toplica - underground water intake,
- Sprečko Polje - underground and
- Modrac Reservoir (since 2007).

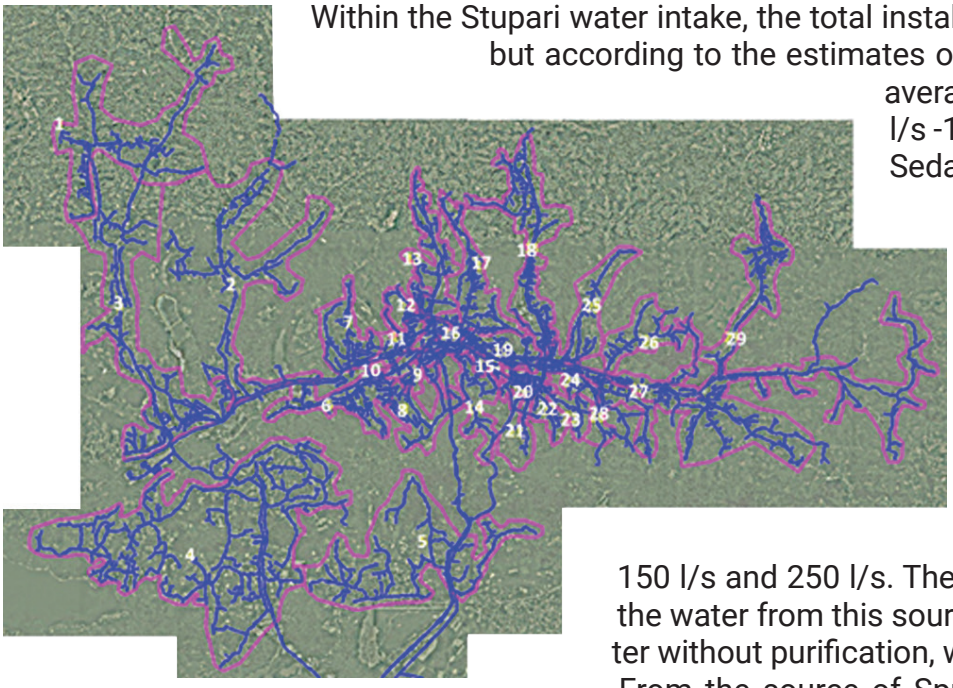


Figure 4.7. Schematic representation of the Tuzla Water network, divided into 29 DMA zones

Within the Stupari water intake, the total installed capacity of the intake varies, but according to the estimates of the competent city service, the average capacity is 190 l/s (Zatoča: 50 l/s -140 l/s; Tarevčica: 23 l/s - 160 l/s; Sedam vrela : approx. 100 l/s without evident oscillations in yield). Water treatment of Stupari springs includes filtration and disinfection.

The Toplica water intake in the municipality of Živinice, built in 1980, has an installed capacity of 200 l/s, while the actual capacity of the spring is between 150 l/s and 250 l/s. The quality of the water is such that the water from this source is used to supply drinking water without purification, with water disinfection

From the source of Sprečko Polje, the groundwater of the alluvial deposit of the Spreča River is captured by a

system that includes four deep drilled wells. The average capacity of the Sprečko Polje catchment is 65 l/s (minimum capacity 25 l/s, and maximum 100 l/s), and the wells tap the first and second aquifers. Analyzes of the affected water revealed that it contains increased amounts of iron and manganese, and its purification, which includes pre-chlorination, coagulation, flocculation, sedimentation, filtration and disinfection, is carried out at the plant near the Živinice pumping station.

By the end of 2006 and the beginning of 2007, the water intake and purification project from the Modrac reservoir was completed - Phase I, which provided the city with an additional 300 l/s of drinking water. Water from the reservoir Modrac (330 l/s) is purified at the site of the city reservoir Cerik, using membrane technology.

Table 4.3. Main water springs and capacity

Spring	Capacity (l/s)
Zatoča	80
Tarevčica	120
7 Vrela / 7 Springs	100
Toplica	200
Sprečko polje	140
Dobrnja	20
Emergency water supply plant for the City of Tuzla - Cerik	300
TOTAL	**960**

The volume of water is measured with electromagnetic flow meters at all water spring sites. Transport and distribution of water is carried out by combined gravity and pumping. In addition to the mentioned springs and water purification plants, the system also includes 700 km of water supply network, 40 pumping stations, and 22 water reservoirs.

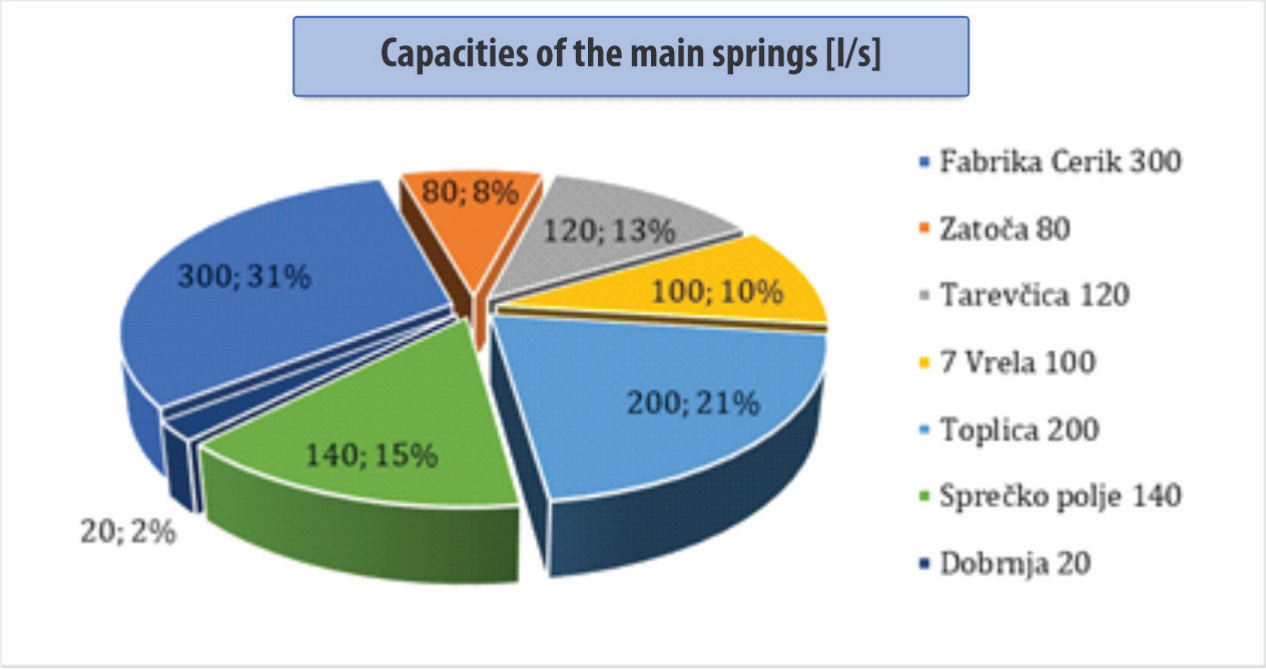


Figure 4.8. Ratio of individual

In 2021, the average monthly amount of produced water in the system is 1,272,485 m3, while the average monthly amount of invoiced water is 725,301 m3. The total number of connections is 49,228

(households 45,762, business entities 3,466). The actual losses in the network are 35.13%, and the coverage of the city territory with the service is 98.47%.

The biggest losses are on pipelines made of asbestos and cement, and built in the period 1960-1980. The total electrical power of all pumps is 3,464.3 kW (of which regulated work management for pumps with a total power of 886.70 kW), and the total amount of measured and calculated electrical energy used to operate those pumps is 9,650.10 MWh.

4.3.1.2. The potential of EE systems for water supply

Pumping stations are significant consumers of electricity, so it is necessary to regularly monitor the mode of operation of pumping aggregates and the level of their utilization, as this can influence the reduction of electricity consumption.

The characteristic of the water supply system of the city of Tuzla is the relatively large specific consumption of water. In relation to the produced quantities, the average specific consumption is about 152.56 l/per capita per day. Due to losses in the network, the invoiced amount is about 57%, it follows that the average is about 86.96 l/inhabitant per day.
Reducing losses is important due to the preservation of natural resources, as well as due to the proportionally reduced cost of electricity.

A significant potential for reducing the consumption and electricity costs for the operation of the mentioned pumps lies in the fact that the system contains a significant number of low-efficiency pumps of an older generation, and the monitoring of consumption needs, i.e. flow regulation, is mainly performed by throttle valves, which means that the pumps work with a constant number turnover with a high number of working hours per year. The most energetically and environmentally efficient way to regulate the flow, and thus to avoid unnecessary consumption of electricity, is the introduction of frequency regulation of pump operation, which enables a reduction in the number of rotations of the electric motors of the pumps in periods of reduced demands for water quantities (reduction of the required flow), which is proportional to the reduction of the required electricity. The energy savings made possible by the frequency regulators would very quickly compensate for the investments in the installation of the system, and in addition, the efficiency of the system would increase, protect the electric motor of the pump and extend its life.

This includes the acquisition of equipment and the introduction of frequency regulation for pumps with a total power of 750 kW, which would reduce electricity consumption by 2,192.40 MWh. At the same time, by reducing the losses that would be achieved by reconstructing and rehabilitating the part of the network that feeds these pumps, from the current 36.7% to 30.0%, an additional reduction in electricity consumption of 464.30 MWh would be achieved, which gives a total reduction in electricity consumption energy of 2,656.76 MWh.

The budget was made taking into account the number of connections in 2020 (47,283), and the projection of growth in the number of connections of an average of 1% per year (approx. 500 connections/year). The continuation of the current trend of reduction of the annual captured and pumped water by approx. 2.0% was also taken into account. With the implementation of the mentioned measure in 2030, the consumption of electricity at the system level would be 5,619.40 MWh.

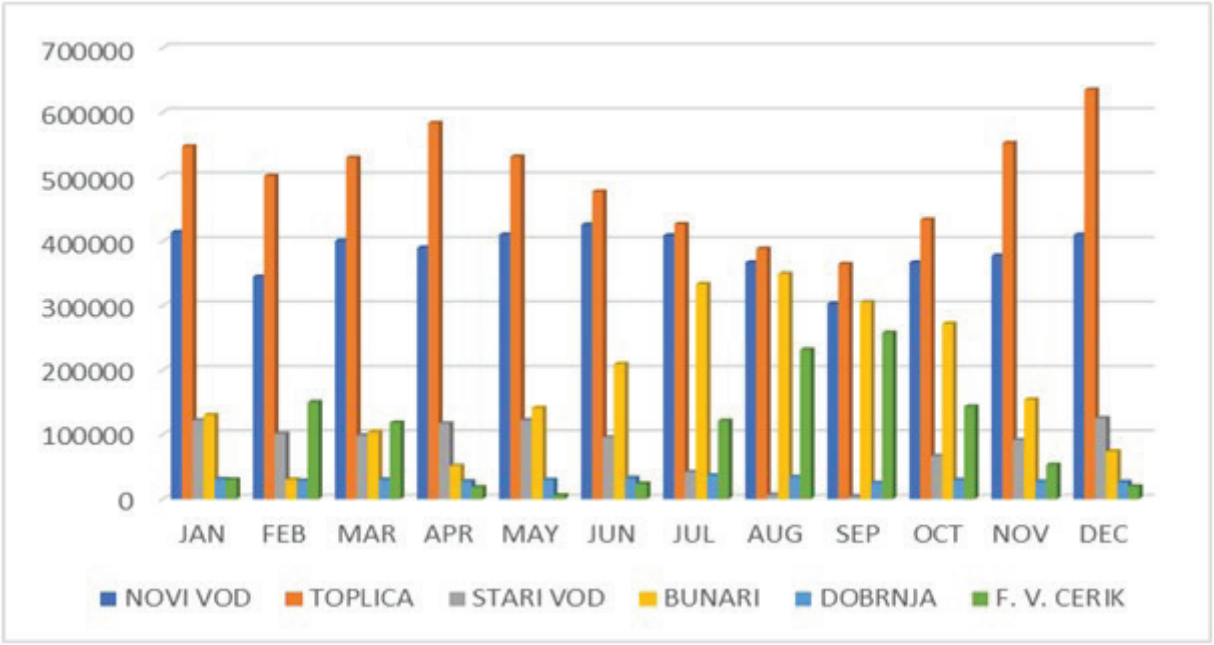
4.3.1.3. Waste water

The beginnings of the construction of the sewage system in Tuzla date back to Austria-Hungary, since the first parts of the sewage system were built in 2012. The capacity of the first part of the

Table 4.4. Produced and invoiced quantities of water in 2021

Month	Produced water [m³]	Invoiced quantity of water [m³]
January	1,274,532.00	706,354.54
February	1,156,537.00	668,778.83
March	1,281,290.00	688,527.26
April	1,187,986.00	712,706.99
May	1,240,398.00	722,138.02
June	1,264,356.00	703,774.20
July	1,369,042.00	761,223.38
August	1,377,480.00	863,240.85
September	1,260,237.00	778,446.50
October	1,312,333.00	730,428.45
November	1,255,446.00	679,350.65
December	1,290,185.00	688,643.49
	15,269,822.00	8,703,613.16

sewerage system was planned for 14,000 inhabitants and the same was on the stretch of elementary school “Pazar” - hospital “Kreka”.



Figurea 4.9. Amount of water produced per month 2021

The first capacity expansion was realized in the period 1965-1967 when the construction of the left and right collectors along the Jala river was realized. The last significant investment in the expansion of the sewage network in Tuzla took place at the beginning of 1985, when the construction of a common collector began on the stretch from the Kreka Hospital to the Tuzla Thermal Power Plant.

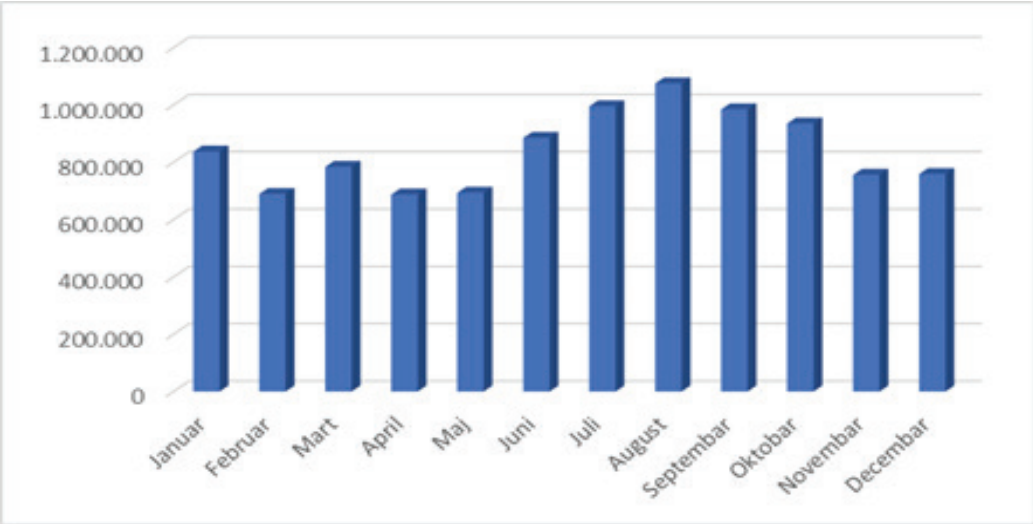


Figure 4.10. Electricity consumption of pumping stations in kWh for 2021

The length of the common collector is 3,862 meters, while the length of the left and right collectors is about 19,000 meters. Collectors are represented with diameters from DN 500 mm to DN 1200 mm.

The sewage system in the city of Tuzla is of a mixed type in the central part, while a separate sewage system has been built for collective housing settlements built from 1980 to the present day: Stupine, Zlokovac, Sjenjak, Slavinovići, Solina, etc. The urban part of the city of Tuzla is 100% covered by the sewage network, while the possibility of pumping/emptying septic tanks has been introduced for the outskirts of the city since 2016 based on the annex to the contract with JKP (Public utility company) "VIK" d.o.o. Tuzla. On this basis, more than 1,700 annexes to the water supply contract were concluded, which extends the service to the pumping/emptying of septic tanks.

According to the Report on the Operations of PUC "Vodovod i Kanalizacija" for the year 2021, the total number of connections to the public sewage system of the city of Tuzla, at the time the report was prepared, was 26,681, of which 23,735 were connections for the household category, and 2,946 were for the category of legal entities.

4.3.1.4. Improvement of utility activities using smart technologies and modernization of equipment

The control and management of the water supply system is carried out from the dispatch center through a telemetry system - a remote monitoring and management system.

The application of smart technologies in the field of water supply and wastewater treatment includes:
- smart meters,
- water loss sensors,
- pressure sensors,
- flow meters and
- water quality sensors.

All the data obtained from the sensors are forwarded to the control center for analysis in and out of real time, and for taking control actions (SCADA system). The benefits that can be expected from the application of smart technologies in the water supply sector are:

- Condition monitoring for preventive maintenance. By analyzing the obtained data, the condition of the water pipes can be assessed and, based on this, needs can be defined and strategies for repairing or replacing existing pipes can be adopted.

- Measuring water pressure in pipes enables the implementation of corrective actions in order to reduce stress on pipes, avoid breakdowns and extend the service life of pipes and accompanying equipment.

- Water flow measurement enables monitoring of consumption in normal operating conditions, as well as determination of water leakage due to malfunctions in pipes and accompanying equipment. Sensors and meters enable the detection of water leaks from water pipes due to malfunctions before their escalation and the appearance of water on the surface. In addition, it is possible to determine the location of the fault with a certain degree of precision in order to send repair teams. Also, by automatically starting the valve, water losses, floods and additional damages can be minimized.

- Water quality monitoring enables early warnings and automatic control actions by closing valves to prevent the spread of infected water,

- Water consumption meters enable end users to monitor consumption in real time for the purpose of water conservation and its more efficient use. Also, by analyzing this data paired with hydro and meteorological measurements, water supply companies can get better predictions of water consumption requirements for planning the dispatching of pumps, reserves in pools, water network loads, etc

- Analyses of measured data can play a significant role in the future planning of the development of the water supply network.

Similar solutions can be implemented in the waste water system, regardless of whether it is a separate or combined sewage system and a system for the removal of atmospheric precipitation, as well as with waste water treatment plants.

PUC “Vodovod i kanalizacija” d.o.o. Tuzla applies GIS, Geographic Information System for the collection, processing, archiving, analysis and display of spatial information. With the development of water and sewer system management, GIS has become an invaluable tool due to the ability to provide information such as location, pipe diameters, types of materials the pipes are made of, dates of construction, and the like. GIS models enable utility companies to better monitor and adapt to laws and regulations with simple and quick reviews and analyzes of all potential problem areas, as well as making correct decisions related to the development and reconstruction of water and sewage systems.

The Tuzla water company is currently working on digital mapping of the primary and secondary water supply network. This includes photographing all reservoirs, pumping stations, shafts and recording geodetic data on their locations with the aim of easier finding of the infrastructure during regular maintenance and due to breakdowns. Considering the deformations of the terrain, which are very common in the Tuzla basin, it is necessary that the GIS database contains the categorization of the terrain for unstable terrain, conditionally stable terrain and stable terrain. Knowledge of the geological structure of the terrain as basic data for evaluating the stability of the terrain will enable the planning of the extension of the water supply network to these areas, as well as more frequent control of already installed facilities in these areas in order to reduce losses. The unique GIS database enables

the review and analysis of all potential problem areas, as well as the making of correct decisions related to the development and reconstruction of water supply and sewage systems in these areas.

Figure 4.11. Digital spatial representation of the water supply network in GIS

All this is in the initial phase of monitoring the complete water supply network.

The water company must have the appropriate equipment and professional staff to detect pipeline damage. Without equipment, it is not possible to get good results, because many defects are invisible and there can be water leaks in those places for years without being noticed.

In 2018, the Tuzla water company acquired the best and most modern equipment for fault detection, which was on the market at that time:
• Severin A200 water leak detector
• Portable ultrasonic flow meter Micronis PF 330

Figure 4.12. Severin A200 water leak detector and Micronis PF 330 portable ultrasonic flow meter

- Digital pressure gauge DM01
- Pipe positioning device CG 50
- Device for determining the position of pipes and cables Tili Trac R 130
- Geodetic GPS

Figure 4.13. Digital pressure gauge DM01, pipe positioning device CG 50 and pipe and cable positioning device Tili Trac R 130

Detecting defects and their quick repair is the most important activity that contributes to the reduction of water losses. After the visibly poor state of the zone and large water losses in the zone, the process of reducing losses began. From June 2018, when the detection teams were equipped and trained, they started working according to the new organization of work on the investigation of failures on the primary and secondary network in the water supply system. Zone monitoring and a continuous process of detection and repair of malfunctions have been established.

4.3.2. Waste management in Tuzla

The collection, transport, disposal and processing of municipal waste represents a public interest and is of special importance for all citizens. Waste management is one of the most important conditions for the orderly development of life and work of citizens. The city of Tuzla has 40 local communities and all of them are covered by municipal waste collection. About 42,500 households and 2,100 business entities, institutions and business persons are covered by the municipal waste collection service.

Figure 4.14. Infrastructure of PUC "Komunalac" Tuzla

Waste removal is carried out using 20 special vehicles for loading waste from containers and bins from households living in individual residential buildings. Currently, around 1,700 containers with a volume capacity of 1.1m^3 are placed in the area of the city of Tuzla. The transport of waste from commercial entities is mainly carried out with 5 lifters for the transport of containers with a volume of 5m^3 and 7m^3. A grab for handling and loading bulky waste is mounted on one forklift.

Municipal waste is disposed of at the "Desetine" city landfill. The landfill is equipped with a bulldozer, a compactor, a backhoe and a mobile shredder for shredding waste, in order to reduce the volume of waste for disposal at the landfill, as well as shred previously separated secondary raw materials for their further placement and recycling.

On average, around 4,500-5,000 tons of municipal waste are collected from the city area per month in the spring-summer period, while in the autumn-winter season, around 5,500-6,000 tons are collected per month. This difference is a consequence of the large amount of ash and slag in municipal waste during the burning season, as well as the consequence of the content of a greater amount of moisture in the winter period. An overview of annual amounts of waste for the previous three years is given in the table. There is an evident increase in the total amount of waste.

Table 4.5. Annual amount of mixed waste [15]

Year	Annual amount of waste per ton
2020	41,730.32
2021	47,810.14
2022	63,832.08

The frequency of municipal waste removal for individual streets or parts of the city is once a week to once a day, and is determined based on the amount and type of waste generated in those streets or neighborhoods, the type of housing, the number of shops, the number of receptacles for municipal waste disposal, the development of roads for a specific settlement.

Bulky waste is collected four times a year, in the last week of January, April, July and October.
In addition, citizens can bring their own bulky waste to the recycling yard, which is located at the landfill, every workday from 8 a.m. to 2 p.m. If citizens do not have the possibility to provide personal transport to take their bulky waste to the landfill, they can use the service of the PUC Komunalac, for a fee. Legal entities pay for disposal and treatment of bulky waste according to the established deposit price list.

Figure 4.15. Collection of bulky waste

In the area of the city of Tuzla, a large number of butcher shops are use the service of separate waste collection of meat product waste, previously separated in specially designed containers, which the

client keeps in their facilities until the moment of collection. The goal of these activities is to prevent the disposal of this type of waste in city containers for municipal waste for hygienic and sanitary reasons.

In October 2010, at the city landfill "Desetine", a facility for the selection of municipal waste was set up, to pre-treat municipal waste before depositing it on the landfill site by separating useful fractions from it (paper, cardboard, PET, all types of plastic, transparent and colored foil, all types of metal, etc.), both due to the effect of an economic nature and to reduce the load on the depositing area. However, manual separation of mixed municipal waste in this plant did not prove to be the right solution.

In 2017, the city of Tuzla created a five-year plan for waste management 2017-2022, which was the basis for changing the approach to waste management in Tuzla [16].

Figure 4.16. Containers for separating packaging waste and glass

From 2018 to 2022, 59 specialized areas for disposing of packaging waste have been installed in the urban part of the city, not far from the collective residential buildings. Each specialized area unit contains two containers (1.1m3) for packaging waste, and containers for separate collection of waste glass are placed next to them. In addition, yellow containers for packaging waste have been placed in the Brčanska Malta Municipal Health Centre.

In the narrow core of the city, 7 waste canopies have been installed, under which a certain number of containers for packaging waste are placed. Containers are emptied by a special vehicle for packaging waste as needed.

Primary waste selection has been introduced for about 5,000 households, which also live in individual residential buildings. Service users were given two bins for separate disposal of packaging, a 240-liter yellow bin and a 120-liter gray bin for mixed waste. The trend of introducing primary selection in individual housing will continue. The goal is to empty the bins for packaging waste once every 15 days, and the bin with mixed waste once a week.

In all educational institutions (primary and secondary schools, colleges, kindergartens) in the area of the city of Tuzla, primary selection of waste is carried out at the point of origin, and recycling yards are set up. Recycling yards include units containing bins, specially marked for the disposal of secondary raw materials (plastic packaging, paper and aluminum cans, as well as bins for mixed waste). In addition to educational institutions, primary waste selection was introduced in the same way in a number of public institutions.

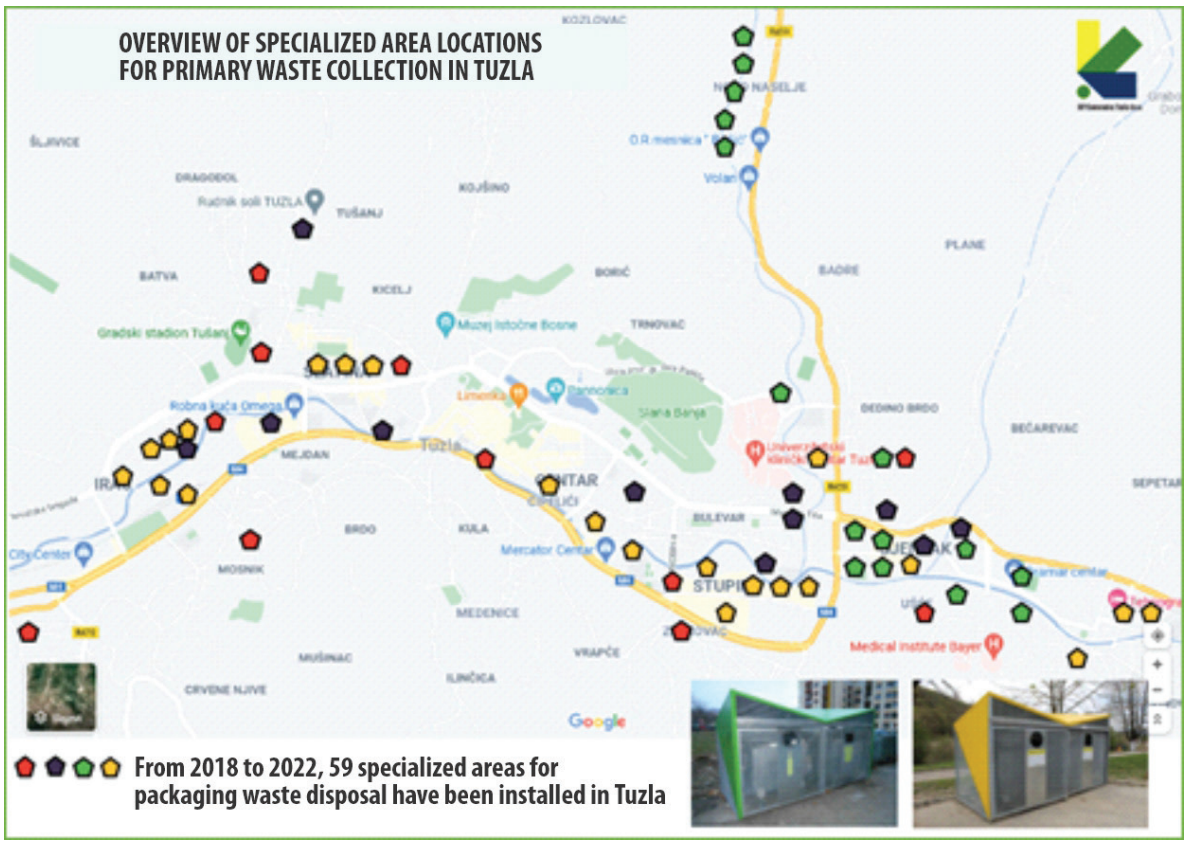


Figure 4.17. Map of 59 locations of specialized areas for packaging waste disposal

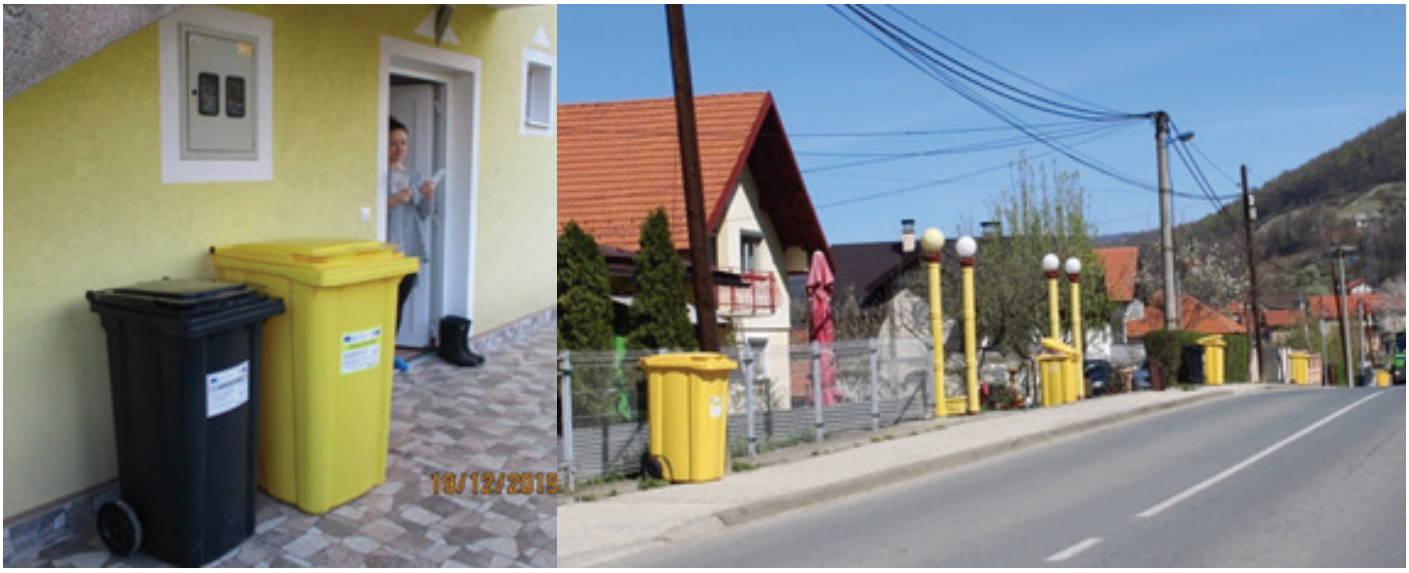


Figure 4.18. Primary selection of waste in individual residential buildings

For all other citizens, who are not covered by the infrastructure for primary waste selection, there is a center for selective waste disposal in the city center, i.e. a smaller recycling yard, where the following can be disposed of: PET, different types of plastic, paper, cardboard, metal and glass.

Figure 4.19. Recycling yard in the city cener

The amount of collected packaging waste is growing year by year. An overview of the amount of packaging waste in 2020, 2021 and 2022 can be found in the table below.

Table 4.6. Amount of packaging waste

Year	Amount of packaging waste in tons
2020	219.35
2021	407.85
2022	510.33

After transportation, packaging waste goes to the Center for secondary waste selection, where it is manually sorted into different secondary raw materials.

Figure 4.20. Separation of waste into secondary raw materials in the Center for secondary waste selection

Smaller electrical and electronic waste (EE) is deposited in dedicated containers at 21 locations in the city. The location map is shown in Figure 4.21.

ZEOS, operator of electrical and electronic waste, is responsible for taking over and disposing of this type of waste. Larger EE waste is taken free of charge by citizens to the recycling yard at the “Desetine” municipal landfill, or a utility company is invited to collect it for a fee.

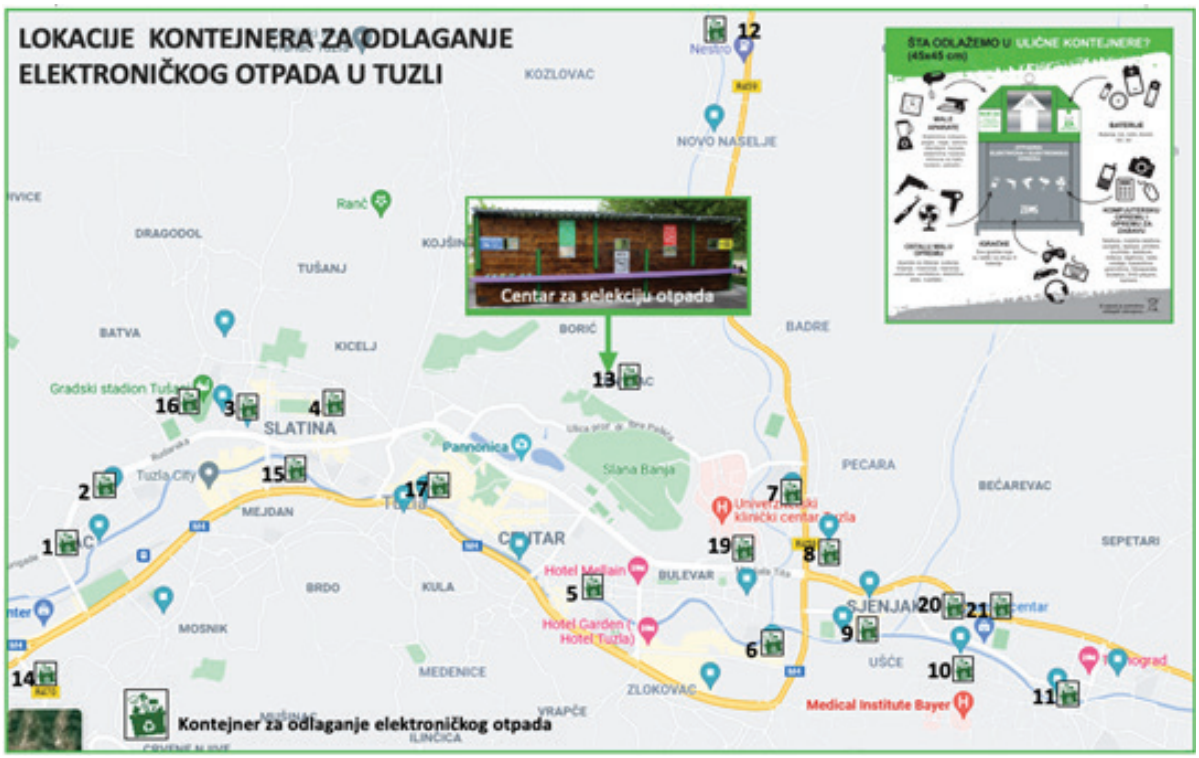


Figure 4.21. Locations of electonic waste containers

4.3.2.1. Application of smart techologies in waste management

Smart technology in waste management can be applied in waste collection, waste recycling, waste to energy transformation and waste disposal.

Waste collection and transport relatively expensive and, due to exhaust gases, also has a harmful effect on the environment. Smart waste collection solutions can eliminate unnecessary truck trips to locations where there is not enough waste, which directly reduces costs for workers, fuel and emissions, while reducing related operational and vehicle maintenance costs.

The technologies of waste recycling, transformation of waste into energy and disposal of waste are technological operations in which the influence of smart technology is reflected to the greatest extent in the application of sensor technology that enables process optimization.

The installation of sensors in waste containers is a smart solution because the previous, fixed, schedule of emptying waste containers by a certain hourly schedule and route means wasting time and fuel, because it happens that trucks arrive at individual containers that are empty or half-empty. In order to better determine when the waste containers really need to be emptied, utility companies can install micro sensors in the containers that determine the status of their occupancy and forward this information to the data center.

Waste quantity sensors can also be installed in combination with containers and/or waste bins with content compaction. This increases container capacity and further reduces the number of truck trips required for waste collection.

Waste containers with content compression have the ability to compress mixed or specific content (plastic, paper, etc.) using built-in mechanical compressors, thus achieving an increase in capacity and reducing the need for frequent emptying. This could be particularly interesting in Tuzla for the

specialized areas for larger packaging waste collection. As a result, the costs of the employed workforce are reduced and the operation of the utility service is optimized. These containers use electricity, which can be obtained from their own source through solar cells and small batteries.

Systems for labeling containers with the help of radio frequency identification – RFID. In some cities, systems with radio frequency identification (RFID) tags are being developed. The tags are linked to a specific resident or address and, similar to a bar code, can be read by equipment on collection vehicles. Collected RFID information is sent to a database that is analyzed (filling of the container, amount of collected waste or secondary raw materials, emptying, etc.) Analysis of this data enables utility companies to optimize the routes and schedule for emptying the containers. The expected results are a reduction in the number of trucks operating, the number of kilometers, the emission of exhaust gases and air pollution. The technical study of the European Commission on the use of RFID in the recycling industry shows that the use of the RFID system can reduce waste collection costs by up to 40% due to the reduction of fuel consumption and air pollution [17].
Another possible use of RFID tags is to monitor residents who put their waste in bins for waste selection. Based on the analysis, cities could direct educational programs towards those who do not participate in primary waste selection, provide incentives for people who do, etc. This technology can also be used to develop the "pay as you throw" (PAYT) system. , by which each user of the utility company's service is charged as much as the amount of waste they produce and dispose of.

The use of the Global Positioning System (GPS) of waste collection trucks has proven to be very useful for optimizing routes for the collection of mixed waste and secondary raw materials. Its application has a positive effect on the responsible behavior of drivers and the reduction of operating costs.

Geographic Information System (GIS) is used to create routes for vehicle movement, capture, analyze, manipulate and display geographic information. GIS technology is increasingly important in modern ways of solid waste management. It can help determine the optimal routes for collecting mixed waste or secondary raw materials, which will have a positive impact on sustainable business. An additional possibility of applying GIS is when determining locations for setting up typical facilities or containers for collecting packaging waste and glass[12].

4.3.3. The potential of renewable energy source use (RES)

Reduction of greenhouse gas emissions (especially CO2), programs of energy efficiency and rational use of energy (the European plan "20-20-20" from 2008, which includes a reduction of greenhouse gases by 20%, a reduction of energy consumption by 20% and an increase in the share of renewable sources in the production of electricity from 8.5% to 20%), deregulation and liberalization of the electricity system, opening of the electricity market, diversification of energy sources, and requirements related to the self-sustainability of national energy systems - represent levers of synergy, which at the end of the 90s of the last century caused an increase in interest in distributed energy production, as an indispensable element in the creation and planning of modern energy [17].

At the COP26 conference in Glasgow, 13.12.2021. the Glasgow Climate Agreement was signed, which harmonized climate policies [18]. It was concluded that climate change is the biggest long-term threat to humanity in the 21st century and that coordinated global action by humanity is urgently needed to save the way of life we currently know [19]. The causes of the energy crisis in Europe are the high prices of electricity from October 2021, which are primarily the result of a multiple increase in the price of natural gas. For example gas price on March 2, 2022. is 194 €/MWh (consequently the share of gas in the price of electricity is 388 €/MWh), more than 100% more than 7 days before that date.

The consequences and response of the European Commission and key EU members is the intensification of the implementation of the Green Plan (A European Green Deal) [18], especially in the areas of energy efficiency in buildings and renewable sources of electricity, including small distributed generators and electrification of transport. The EU Green Plan is therefore not abandoned but intensified. This entails an increasing implementation of renewable sources in the electric power system, so there are significant changes in the very organization of the system hierarchy, starting from the role of the transmission network to transfer the electricity produced in power plants (electricity generators) to high-voltage (400 kV, 220 kV, 110 kV) lines and cables to consumers, i.e. first to the distribution network, which further transforms the received energy to lower voltage levels (35 kV, 10 (20) kV and 0.4 kV), and transmits and distributes it to end consumers [18].

Distributed generation of electricity is a term used in the power industry for the production of electricity at the consumer's location [19]. Therefore, distributed sources of electricity (DI) are sources of electricity located near consumers, that is, on the territory or in the immediate vicinity of consumer consumption. DIs are most often connected to the distribution network, which in principle helps to reduce losses in the transmission system. DI represent the decentralized production of electric (and thermal) energy and as such increase the reliability of supplying consumers with electric energy and, in principle, reduce losses in the transmission network. Also, their application reduces the emission of harmful substances into the environment.

The main advantages of production from DI are:
- Energy is produced nearby, i.e. at the very place of consumption,
- Security of supply increases,
- Preservation of the environment and climate (less emissions of harmful substances into the environment). Better utilization of the network with a change in regime parameters that are basically positive in nature (improvement of voltage conditions and reduction of losses), but can also have negative effects in relation to voltage conditions and losses of electricity.

The Electric Power Research Institute [19] (EPRI) defines distributed production as the production of installed power from several kW to 50 MW, while the Gas Research Institute defines distributed production in the range of 25 MW to 50 MW, [20]. CIGRE [20] defines distributed production as production with an installed capacity of 50 to 100 MW.

Distributed sources are, according to the type of primary energy source, divided into:
- Renewables (wind power plants, solar power plants, small hydropower plants, biomass and biogas power plants, geothermal power plants and power plants that use sea energy (tides, ebbs and waves),
- Non-renewable (fossil fuel power plants: coal, oil and natural gas and fuel cells).

According to the installed power, distributed sources are divided into: micro, small, medium and large sources, as illustrated in Figure 4.22.

Distributed sources are divided according to their functional role into:
- Distributed sources for backup power (standby): diesel-electric aggregates, fuel cells and accumulator batteries,
- Autonomous sources (stand-alone): diesel-electric aggregates, photovoltaic (photovoltaic PV) systems, wind turbines and hybrid systems,
- Distributed sources for powering remote and rural consumer centers (rural and remote applications): small hydropower plants, biomass power plants, wind and diesel generators,
- Sources for co-generative production of electricity and hot water (combined production of heat and power - CHP): thermal power plants, diesel aggregates, fuel cells, geothermal power plants, small domestic cogeneration,

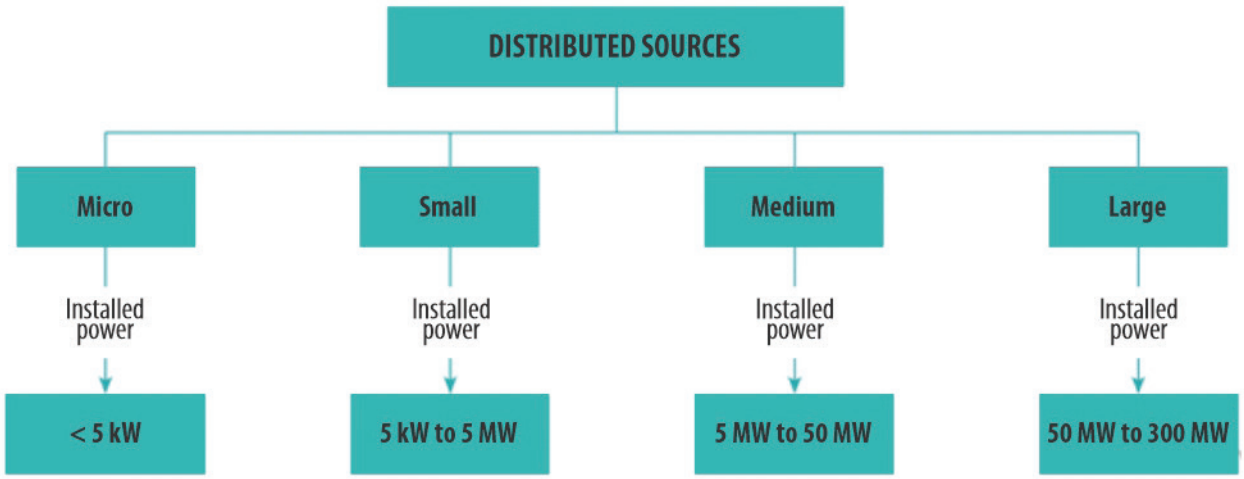


Figure 4.22. Classification of distributed sources according to installed power

- Sources for covering peak load (peak load shaving): fast microturbine power plants, storage small hydropower plants,
- Sources for covering base production (base load): flow-through small HPPs, wind power plants, solar power plants, etc.

4.3.3.1. Hydropower potential as an available RES potential

Previous research and various energy programs at the national and local level have shown that the city of Tuzla has a very generous resource of solar energy from RES, and some research has also been conducted on the use of wind by erecting wind generators. It was established that both biomass and municipal waste represent an important resource.

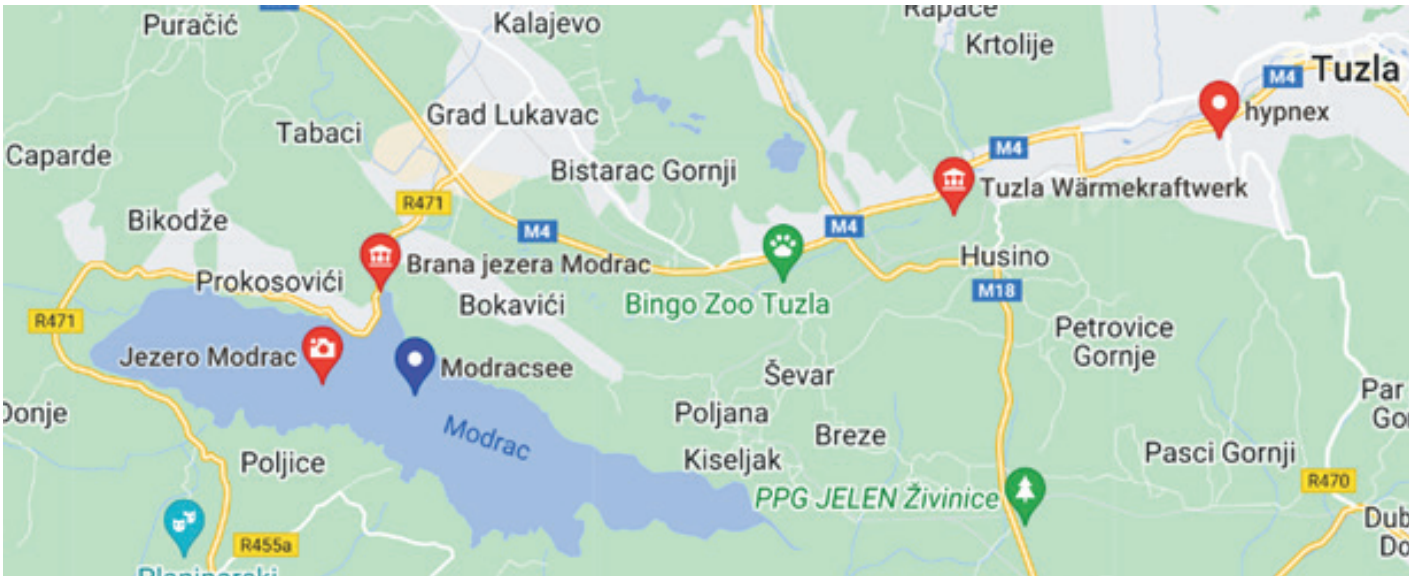
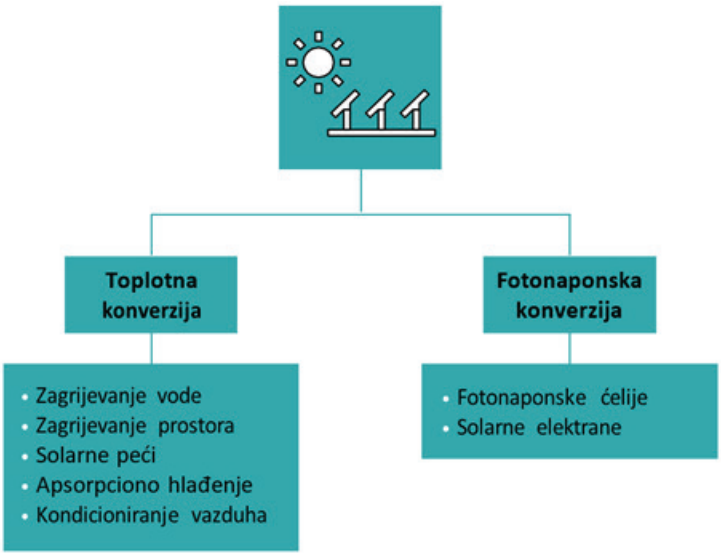


Figure 4.23. Position of the mini-hydroelectric plant of Lake Modrac

Unfortunately, hydropower, which represents the most rational, management-flexible and ecologically clean RES, can only be planned by increasing the capacity of the 1.9 MW mini-hydroelectric plant of Lake Modrac.

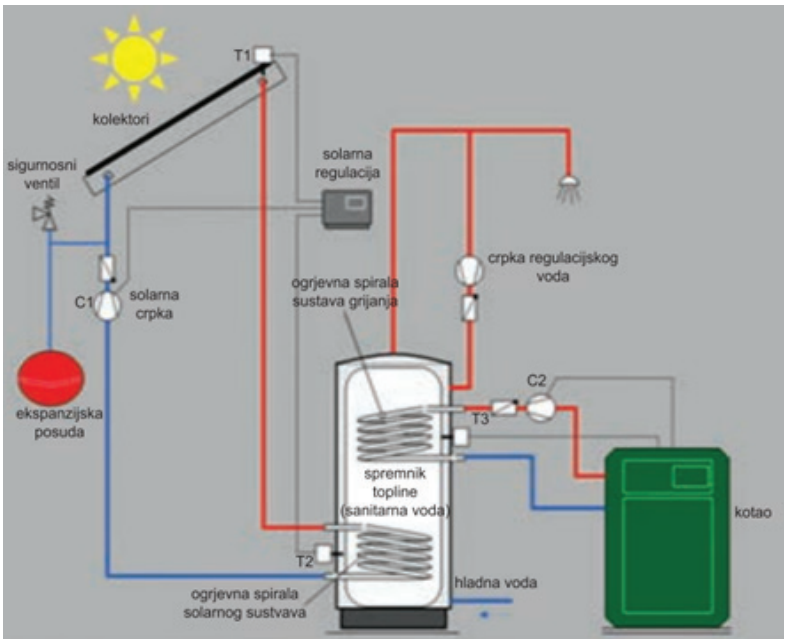
4.3.3.2. Solar energy as an available RES potential

There are two basic ways of using solar energy: through thermal and photovoltaic (PV) conversion. Thermal (thermal) conversion implies the conversion of solar energy into heat (in solar collectors) which is later used to heat water, rooms, greenhouses, etc. PV conversion implies the direct transformation of solar energy into electrical energy through the photoelectric effect, as shown in Figure 4.24.



Slika 4.24. Načini korištenja solarne energije

Heat energy, obtained by conversion from solar in solar collector systems of various types and designs, is used for:
o Heating sanitary water in apartments, houses, restaurants, sports facilities, etc.
o Water heating in swimming pools (private pools and pools in sports and recreation centers),
o Heating water or other fluids in industrial processes,
o Heating of greenhouses and greenhouses in agricultural production,
o Drying of agricultural products,



Slika 4.25. Solarni sistem za dobijanje tople vode sa automatskom regulacijom [26]

o Distillation of water for industrial needs,
o Space heating as a supplementary means in periods when there are plenty of sunny days,
o Production of electricity based on heat conversion of solar radiation (steam turbines),
o In space cooling processes.

Solar collectors for the preparation of hot water - Thermal conversion of solar energy takes place on the entire sunlit surface. In order to direct the energy of the Sun and use it for specific needs, it is necessary to have a suitable receiver or collector, as the most important part of the system for thermal conversion of solar energy.

Today, thermal conversion of solar energy is mostly used for heating sanitary water in residential buildings (dominantly houses), as well as for space heating. The principle of using solar energy for these purposes is shown in Figure 4.26. For further clarification, part A refers to domestic water heating and part B to space heating.

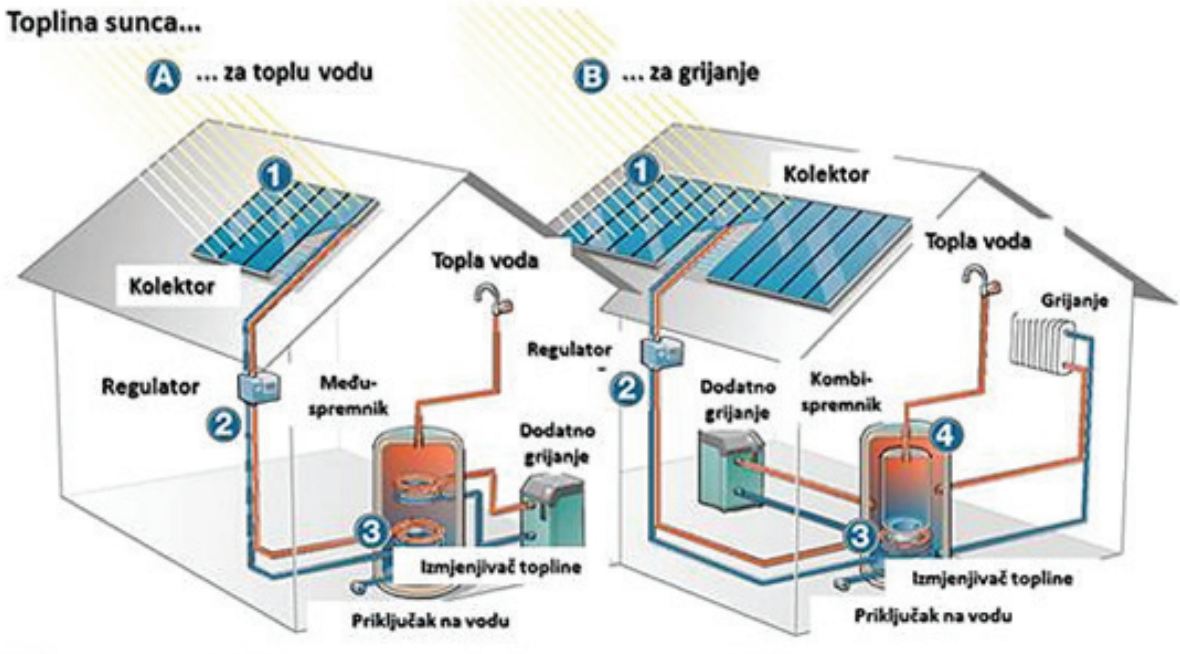


Figure 4.26. The principle of using solar energy for heating sanitary water and rooms

Namely, the principle is as follows: The sun's rays heat the liquid medium in the collector (1). The medium heated to 90°C circulates between the collector and storage tank(2). In the heat exchanger, the medium heated by solar heat heats the water (3). Heat is accumulated in the storage tank, which is available at night as well as on cold days. Solar collectors for hot water are used in domestic hot water systems, as well as for swimming pool heating. The use of pool covers is also used for heat retention whenever possible, for example, for preheating hot water for hotels, restaurants, water in swimming pools, agricultural greenhouses, etc.

By considering the possibilities in the use of RES, the activity of installing solar collectors on residential blocks owned by the City of Tuzla was proposed. Solar systems of the collector type (plate or tubular) are suggested and would serve primarily for heating sanitary water. In the city of Tuzla, there are several positive examples of using solar energy for water heating. They can also be used as an additional segment in the heating system, for example in combination with a heat pump. According to the achieved results, the given activity would include, in subsequent phases, a larger number of residential buildings owned by the City.

Photovoltaic solar systems (PV) - PV conversion means the direct transformation of solar energy into electricity through the photoelectric effect. PV systems mean systems that supply consumers with direct and alternating current. PV systems can be divided into two basic groups: PV systems that are not connected to the grid (off-grid), or standalone systems (standalone systems) and PV systems connected to the public power grid (on-grid). A more detailed breakdown of the PV system is shown in Figure 4.27.

A stand-alone PV system is an excellent source of energy for remote houses, weekend homes, caravans, telecommunications facilities, boats and sailboats.

Two basic processes are characteristic of such a PV system: the transformation of solar radiation, that is, light energy into electricity, necessary for the operation of consumers, and the transformation

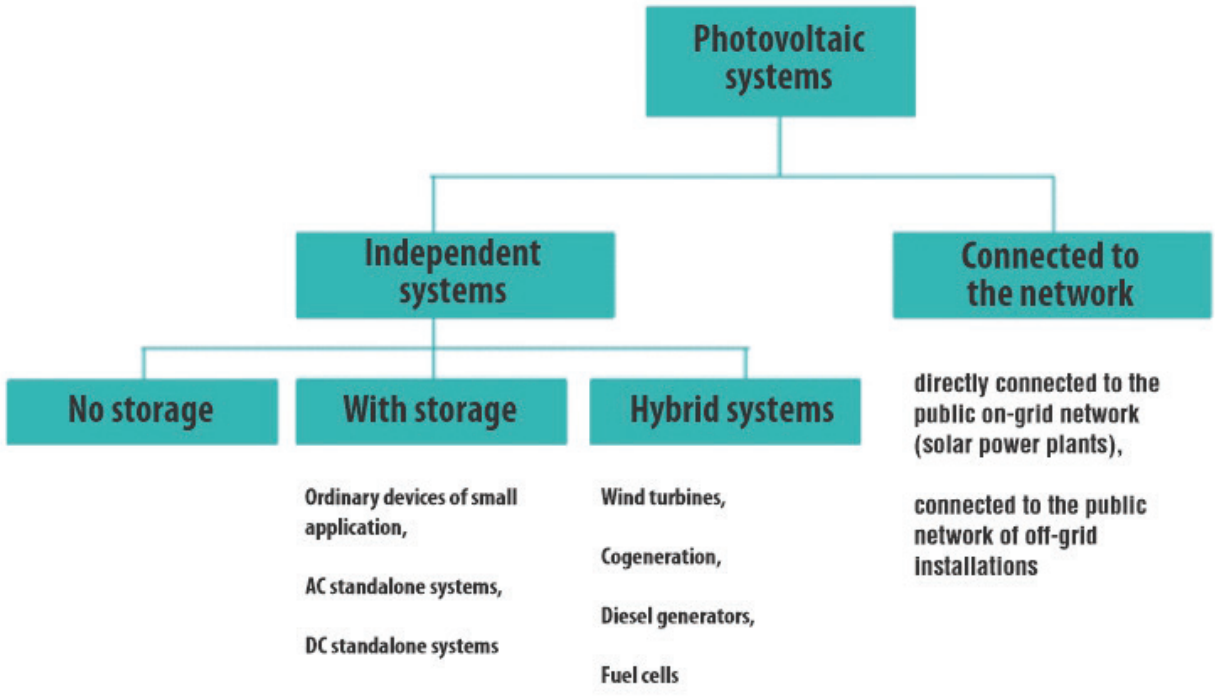


Figure 4.27. Division of PV systems

of electricity into chemical energy and, conversely, chemical energy into electricity, due to the need to store energy in the battery.

There are also so-called hybrid PV systems that use a combination of PV and other energy sources (diesel fuel, gas or gasoline generators, wind turbines or small hydrogen generators). With these systems, consumers are supplied with electricity produced by solar modules or wind turbines, and excess energy is stored in the so-called solar batteries. In the event that there are no conditions for the production of electricity by solar modules or wind turbines, the source for powering DC or AC consumers will be the battery. If the battery no longer has energy to supply the consumer, the diesel or biodiesel generator is switched on.

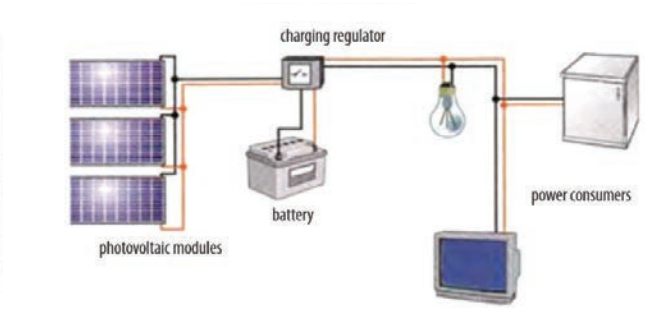


Figure 4.28. Independent PV system with direct current consumers [20]

PV systems connected to the public grid (Figure 4.29) through the home installation belong to the distributed production of electricity. They are mainly connected to the low-voltage distribution network.

A PV system connected in this way to the public grid via a DC/AC inverter (5) delivers excess electricity to the grid, and in case of insufficient solar energy, it supplements the consumer's needs with energy from the grid. Measurement of delivered or received electricity is done using meters (6 and 7).

PV systems are installed not only on buildings or in their immediate vicinity, but also on free, unused areas, next to roads, and with the eventual construction of a part of the connection network (substation of appropriate power), they are connected directly to the power system. The described type of PV

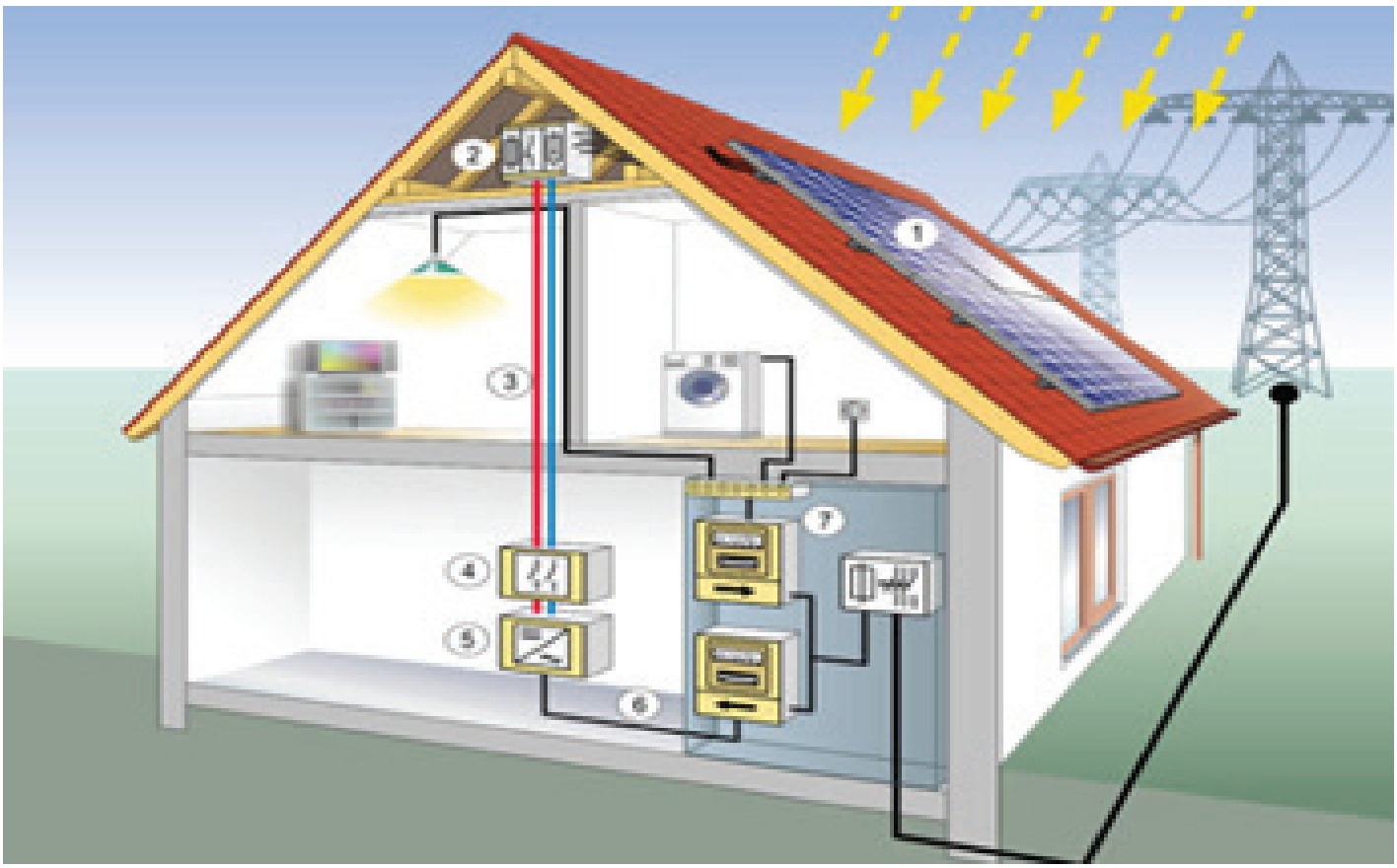


Figure 4.29. Components of a PV system connected to the distribution network: 1- PV panels, 2- charging regulator, 3 – direct current lines, 4 – fuses, 5 – DC/AC inverter, 6 – meter of energy supplied to the network, 7 – meter of energy taken from the network [20]

system is called a solar or PV power plant. The production of electricity through solar power plants takes place in the following order: energy from the Sun > concentration of thermal energy on the working medium > generation of steam > mechanical energy in the steam turbine > electrical energy. Solar power plants deliver all produced electricity to the power system. They have higher power and are mostly installed on larger areas, often in deserts. They are characterized by efficiency in the range of 20-40%. Because of the need for high temperatures, almost all types of solar power plants must use some form of concentrating the Sun's rays from a large area to a small area. Considering the diversity among the mirrors (heliostats) and the overall performance of the system, solar power plants are divided into:

- o power plants with parabolic (distributed) collectors,
- o power plants with a central receiver (solar towers),
- o solar panels.

Figure 4.30. Red Stone Solar Power Plant South Africa [22]

Which of the mentioned solutions is the most suitable for the possible zones on the territory of the city of Tuzla should be analyzed in detail with feasibility studies. The first two types require significant space, while the second can be realized even on hilly terrain, while the third is more demanding in terms of constant supervision and maintenance.

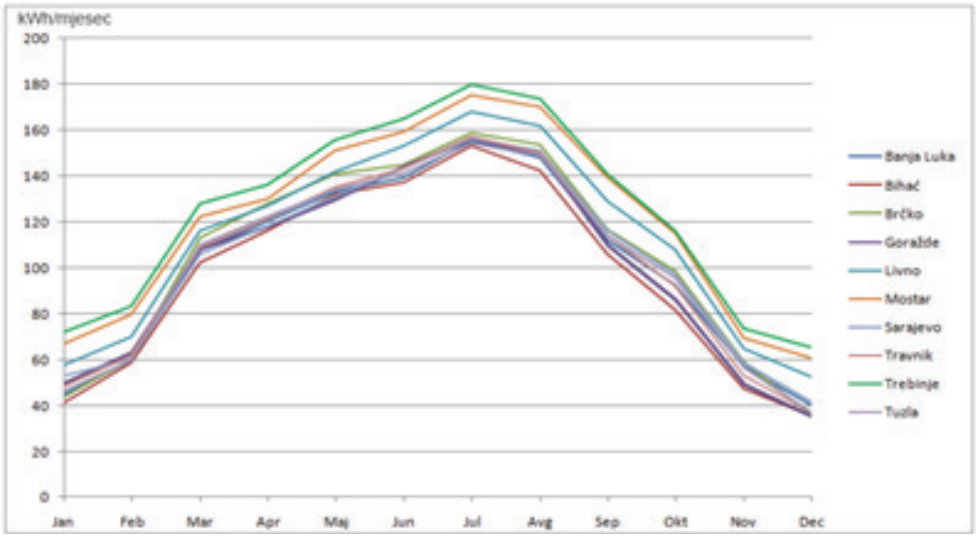


Figure 4.31. Possibilities of production of electric PV panels of 1kW for different cities in Bosnia and Herzegovina [23]

Due to the relief configuration of rural zones for solar power plants in the city area, variants with solar fields on the surface of the earth could be the optimal choice. The city of Tuzla has great potential for the development of a system for the use of solar energy, since the total insolation time is 1797.3 kWh/m2 per year, the sunniest month is July with 250.4 hours, and the least sunny is December with 53.5 hours. On average, there are 69 foggy days per year [24]. The total insolation time of Tuzla is greater than or equal to other cities in Southeast Europe, e.g. Rome (1,602 kWh/m²).

The city of Tuzla, as a city with a large number of sunny days, should provide:

- financial incentives for the construction of individual off-grid and on-grid systems, such as the already built solar power plant on the Pannonian Lakes,
- register of roofs, as a potential for the use of solar energy,
- work on testing the possibility of manufacturing and installing solar collectors and other equipment and parts in hot water systems,
- enable measures to promote low-energy buildings and use RES in public buildings under the administration of the City and other buildings,
- it is necessary to carry out research and evaluation of spatial planning documentation for the development of PV systems in the rural and urban parts of Tuzla,
- when issuing urban planning and technical conditions for construction facilities, it is mandatory to provide guidelines for energy efficiency and the use of solar and other forms of RES.
- use the resources and experience of the non-governmental sector for the promotion and installation of all forms of RES.

The total installed capacity of solar power plants in BH in 2021 was 56.51 MW.

4.3.3.3. Wind energy as an available RES potential

The price of energy from wind farms is slowly falling, while the price of energy from classic non-renewable energy sources is rising. All this has contributed to the increase in the amount of electricity produced from wind power plants in Europe. The good sides of using wind energy are the high reliability of the plant's operation, no fuel costs and no pollution of the environment. For households, small windmills with a power of up to several tens of kW can be quite intriguing. They can be used as

an additional source of energy or as a primary source of energy in remote areas. When they are used as a primary source, it is necessary to add batteries (accumulators) to them[ ].

According to earlier data, there are three large wind power plants operating in BH with a total installed power of 134.60 megawatts (MW) and 0.4 MW of small hydropower plants - only 2.9 percent of the total installed power in BH. In 2021, wind power plants produced 381.81 gigawatt-hours GWh - 2.2 percent of the total electricity produced in BH (17,055.44 GWh). When talking about the wind potential of BH, it is above the thermal power plant that has the largest installed power, TE Tuzla, which is 715 megawatts (MW) [25].

Figure 4.32. Solar power plant 25kW on the Pannonian lakes [24]

The higher frequency of wind in the high-altitude parts of the city of Tuzla (Ilinčica hill) makes it possible to plan and erect wind generators. The association Front slobode supported the project "Exploration of wind potential in the city of Tuzla" with its "Green Transformations" program. This project will initially explore the potential of wind in the city, and in due course work on the development of vertical wind turbines for energy production. Devices for measuring wind speed, so-called anemometers, are installed at 6 urban locations. The preparation of the Study is in progress [27].

4.3.3.4. Biomass as an available RES potential

Biomass is the first and oldest source of energy used by humans, which is widely used today to obtain both thermal and electrical energy, thus contributing to the preservation and protection of the environment. The term biomass refers to a wide range of remains of plant cultures and materials created by biological means. Solid biomass is a biodegradable material obtained from forest waste (branches, bark), wood industry waste (sawdust, shavings, shavings), the rest of agricultural crops (fruit residues, straw, chaff, sedges), dedicated energy plantations [27].

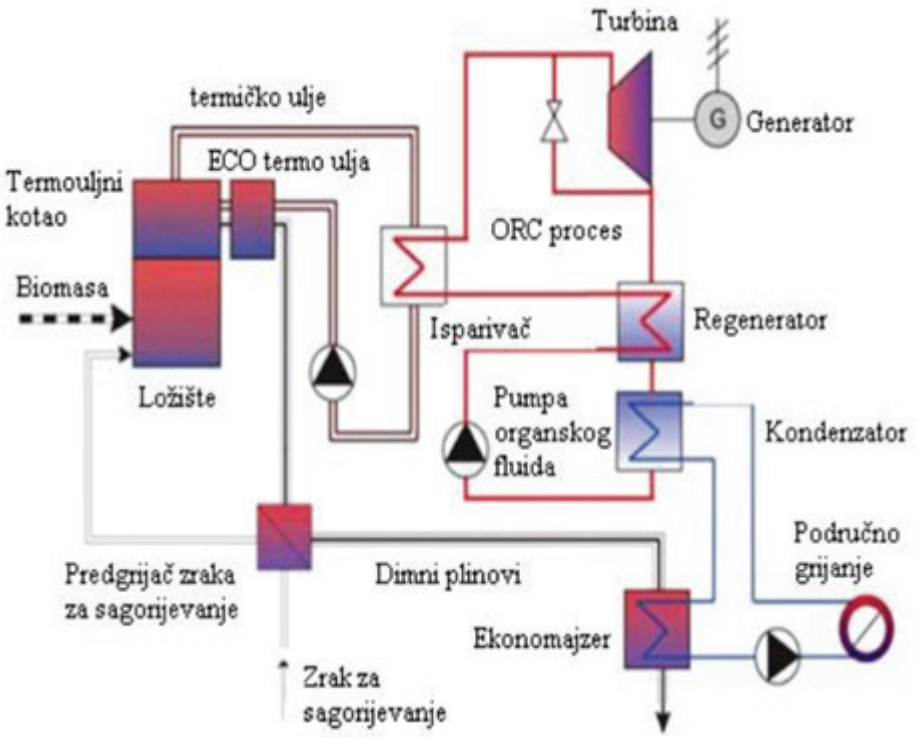


Figure 4.33. ORC biomass cogeneration plant [27]

Depending on the type, humidity and size of the pieces of biomass, there are different technologies for its preparation and combustion - that is, the types (construction) of the combustion chamber of the boilers in which the com-

bustion takes place. For combustion, classical combustion technologies are mainly used on grates (fixed, movable, inclined and stepped).

Recently, biomass has been used for cogeneration, i.e. for the simultaneous production of thermal and electrical energy (Figure 4.33), which is achieved by applying the Organic Rankine Cycle (ORC), which is already widely used in Europe, in a wide range of obtained powers of 0.2 up to 5 MW and more. The implementation of such a system is most profitable in areas that are rich in forest or in places where the necessary biomass can be provided. ORC uses an intermediate circuit for the transfer medium of thermal oil, which serves as an intermediary for the transfer of heat from the flue gases to the working fluid, which, in this case, is not water but an organic fluid. The advantages of the ORC system are a high degree of cycle efficiency (especially in the case of cogeneration), flexibility and high inertia of the system, automatic and safe control, lower pressure in the boiler, high degree of turbine efficiency (up to 85%), low turbine mechanical stress, no blade erosion turbines, very long service life of the machine (no erosion and corrosion of pipelines, valves, turbine blades), no water purification system is required, simple START-STOP procedure and quiet operation.
Considering the flexibility, this cogeneration system is used in various applications such as central heating (heating plants), pellet production, sawmills (and similar industries that have biomass as a by-product) and the like.

The Canton of Tuzla and the City of Tuzla have significant resources in biomass for the implementation of such systems, but it is necessary to educate farmers and agricultural complexes, to present them with advantages and benefits, and with appropriate support and incentives. Through the co-financing program, the City of Tuzla co-financed the purchase of 455 pellet stoves from 2019 to October 2022.

4.3.3.5. Heat pumps

Toplotne pumpe danas spadaju u najefikasnije sisteme grijanja i hlađenja. Od 100% energije koju generiše toplotna pumpa 75-80% je besplatno jer dolazi iz okolnog okruženja, a samo 20-25% energije dolazi iz električne mreže ili kako je već raširenо u Evropi iz fotonaponskih izvora (slika 4.34).

Nowadays, heat pumps are among the most efficient heating and cooling systems. Out of 100% of the energy generated by the heat pump, 75-80% is free because it comes from the surrounding environment, and only 20-25% of the energy comes from the electrical network or, as is already widespread in Europe, from photovoltaic sources (Figure 4.34).

Heat pumps are heat machines that operate according to the thermodynamic cycle, removing heat (cooling effect) from a source of lower temperature and transferring heat (heating effect) to a sink of higher temperature with minimal work. Heat pump capacities range from 5kW to several tens of MW. Cooling devices (refrigerators, air conditioners) work on the same principle. The main difference between them and heat pumps is in the effect that is to be achieved. With cooling devices, the goal is cooling, that is, taking heat from a space or medium (heat source), and with heat pumps, the goal is heating, that is, transferring heat to a space or medium (heat sink).

The heat source for heat pumps can be the soil, underground water, geothermal water, surface water (larger rivers, natural or artificial lakes), water and sewage networks, as well as waste heat from various industrial processes (use of air from rooms or industrial waste water). The type and characteristics of heat sources and sinks significantly influence the conception, construction and way of fitting the machine into the energy flows of the given object.

Heat pumps are widely used in buildings (heating, cooling and preparation of hot sanitary water) and in industry for various technological processes (cooling and heating of products, achieving higher temperatures in the technological process). The advantage of heat pumps is the ratio of invested and obtained energy, which ranges from 1:3 to 1:5. This means that for 1 kWh of electricity invested, 3-5 kWh of heat energy can be obtained, depending on the type of heat pump, type of heating system and heat source from nature. In order to install a heat pump, it is necessary to fulfill some of the conditions, such as: a sufficiently high and constant temperature of the heat source for a long time, a short distance between the heat source and the sink, a heat sink of moderate temperature, as well as a large number of hours of use during the year, when greater profitability is achieved.

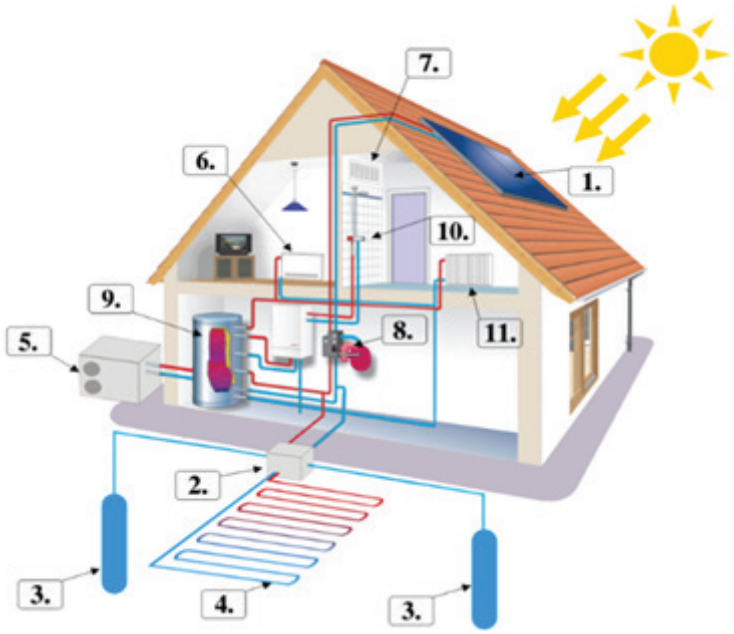


Figure 4.34. Heating and cooling with heat pumps and solar collectors [28]

(1 - Solar collector, 2 - Heat pump, 3 - Well 2, 4 - Horizontal geothermal collectors,
5 - Air-water heat pump, 6 - Wall fan, 7 - Ceiling fan, 8 - Pump, 9 - Boiler,
10 - Sanitary water, 11 - Radiator)

The City of Tuzla is allocating significant funds for co-financing energy efficiency and heating system changes in individual residential buildings, among other things, by installing heat pumps. At a time of enormous energy price increases, this approach acquires a significant social and environmental dimension. From 2019 to October 2022, the installation of 165 heat pumps in individual residential buildings in the city of Tuzla was co-financed.

4.3.3.6. Biogas as an available RES potential

Unlike fossil fuels, biogas is a permanently renewable fuel, as it is produced from biomass, which, through photosynthesis, is a living storage of solar energy. The use of biogas helps to improve the country's energy balance and contributes to the preservation of natural resources and environmental protection. Although CO_2 is also produced during the combustion of biogas, the main difference compared to fossil fuels is that the carbon in biogas is absorbed from the atmosphere in the process of photosynthesis. The carbon cycle closes in a very short period of time - from one to several years. The production of biogas reduces greenhouse gas (GHG) emissions from untreated animal manure. These are methane (CH_2) and nitrogen suboxide (N_2O), which have 23 and 296 times stronger greenhouse effect than CO_2.

Biogas is a fuel that consists mostly of methane (CH_2) and carbon dioxide (CO_2). It is produced in a biochemical process called anaerobic digestion, during which complex organic substances (organic substrates) are decomposed in the absence of oxygen. Biogas is used for the production of heat energy, combined production of electricity and heat energy (in a cogeneration plant), or combined production of electricity, heat and cooling energy (trigeneration).

Different types of organic substrate can be used for biogas production, and the most common are:
o liquid and solid manure,

o degradable organic waste from the food and agricultural industry (of animal or plant origin),
o organic fractions from municipal waste and catering,
o dedicated cultivation of energy crops (corn silage, sorghum, etc.).

The rest of the anaerobic digestion can be used as a high-quality fermented biofertilizer, or as biomass fuel (after previous drying and/or palletizing). The configuration of the biogas production plant mostly depends on the type and characteristics of the substrates used, although for a given combination of substrates, numerous variants of equipment combinations are possible, as shown in Figure 4.35. for one smaller plant. The configuration of the equipment affects the quantity and quality (percentage of methane) of biogas.

Substrates can be divided into liquid (which can be pumped) and solid substrates:
o Liquid substrates, after temporary storage in reservoirs, undergo a pasteurization process and are sent to a digester.
o Solid substrates are stored in “trench” silos (silage) or underground concrete tanks (biological waste from the food industry) and, after previous manipulation and preparation, they are transported to a digester [ ].

The development and application of biogas production systems, based on national and regional biomass resources, increases the security of energy supply and reduces dependence on imported energy sources. At a time when we are increasingly faced with problems related to excessive production of waste and its disposal, biogas production in anaerobic digesters is an excellent way to reduce the amount of waste material and activate valuable resources.

Since the production of biogas requires labor for the production, collection and transport of the substrate, for the production of technical equipment and, finally, for the installation, management and

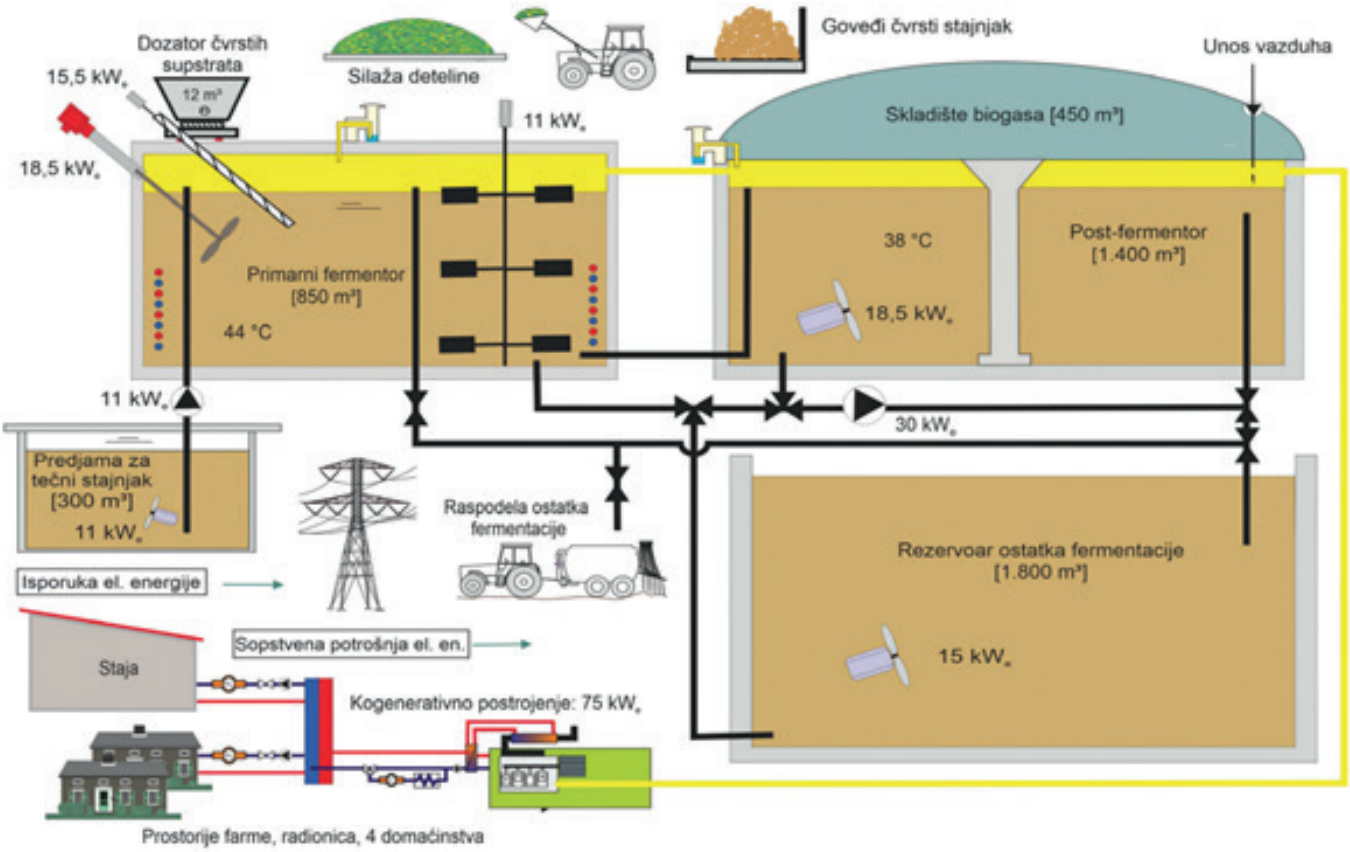


Figure 4.35. Scheme of one small biogas plant for up to 4 households [29]

maintenance of biogas plants, this means that the development and application of this technology contributes to the creation of new enterprises, increasing income in rural areas and the creation of new jobs.

Since biogas is a very flexible fuel, it can be efficiently used for the combined production of electrical heat and/or cooling energy, pumped into the natural gas network or used as a fuel to drive motor vehicles. Biogas technology should show how agricultural individual farms, large agricultural producers and local communities can be less energy dependent and at the same time ecologically clean. On this basis, they can increase the competitiveness of their products and provide higher revenues.

Micro biogas plants in households - Micro cogeneration or micro CHP is the name for a distributed energy source used in households, or small production units. In the case of micro CHP systems, heat and electricity of less than 5 kW are produced at the same time. Most importantly, micro CHP, instead of a conventional boiler in a central heating system, uses a small gas engine that drives an electric generator. Possible engines for cogeneration can be combustion engine, Stirling engine, steam engine and fuel cells. The waste heat of the engine is used in the primary circuit of the heating system, while the produced electricity is used in the household, or the surplus is fed into the electricity grid (Figure 4.36 a). It has the same efficiency of converting gas into heat as a conventional gas boiler and is about 80%. In contrast to large CHP plants, with micro CHP the primary production is thermal energy.

Figure 4.36 b shows a schematic view of a micro CHP system (ecoPOWER), manufactured in Germany, which is present on the regional market. It is the first micro cogeneration on the market that is certified according to the strict European directive for gas appliances (90/396/EEC). The system has a gas engine with a variable number of revolutions (1,200 - 3,600 rpm), and generates electric power 1.3 - 4.7 kW and heating power 4.0 - 12.5 kW. A connection to the public electricity distribution network is necessary.
The overall level of efficiency of these systems is constant and is above 90%. It is characterized by low GHG emissions and a sound level of 56 dB(A), at a distance of 2 m. For the specified type, the dimensions (height/width/depth in mm) are 1,080/740/1,370, it has a mass of 395 kg, and the external the appearance is aesthetically adapted to most household appliances.

4.3.3.7. Feasibility of expanding distributed RES

In addition to other factors, the feasibility of expanding distributed RES is conditioned by certain technical problems of integrating these sources into the electrical energy system:

- criterion of the permitted power of a small power plant, defined by the power of the short circuit at the point of connection to the grid and the type of generator,

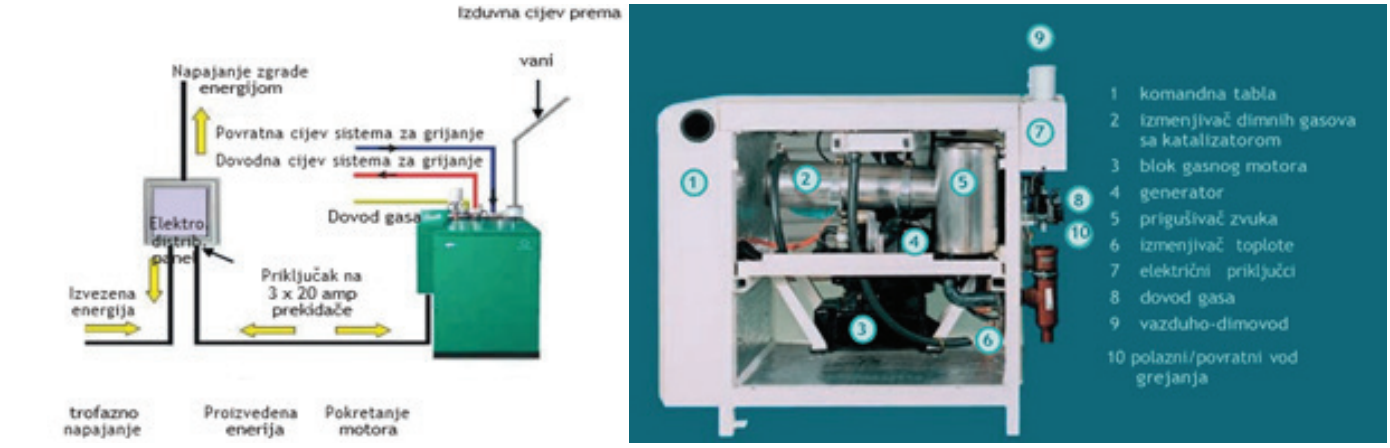


Figure 4.36. a) Micro CHP home system; b) Schematic representation of the ecoPOWER unit

- the criterion of flicker (short interruptions), which is assessed using the disturbance factor of a small power plant, caused by flicker of a long duration (over two hours),
- the criterion of permitted higher harmonic currents, which is assessed based on the value of the higher harmonic current reduced to the short-circuit power at the connection point,
- the three-phase short-circuit current criterion (if the condition is not met, the three-phase short-circuit current is limited, the switchgear and other equipment are replaced, the connection point is changed, etc.).

There are additional positive and negative aspects, some of which are listed in Figure 4.37, and which must be taken into account in the variant of RES integration into a concrete power system. Also, there are sometimes negative reactions of the local population to the construction of RES, and depending on the type of facility (solar, wind generators, biomass, etc.) because they believe that there are more or less pronounced accompanying negative impacts on the environment. The aforementioned factors should be analyzed and documented for each individual case before construction.

Please note that for the improvement of energy efficiency there is a whole series of legal acts of the EU (Directive 2012/27/EU of the European Parliament and of the Council of October 25, 2012 on energy efficiency [30]) contains many elements related to the encouragement of energy efficiency and greater application OiE.

Energetically and ecologically sustainable building and construction strives towards:
- Reduction of heat losses from the building by improving the thermal protection of external elements and a favorable relationship between the base and the volume of the building,
- Increase of heat gains in the building by favorable orientation of the building and use of solar energy, about the use of OiE in buildings (biomass, sun, wind, etc.),
- Increasing the energy efficiency of thermal energy systems.

As stated in the SECAP and other planning documents of the City of Tuzla, geothermal energy from the abundance of underground water and a system of heat pumps should be used for air conditioning. During the architectural design of buildings (roofs, facades), it is necessary to integrate installations for the use of solar energy. The best way to integrate these installations is to place the collector in the plane of the sloping roof if the roof is oriented to the south, with deviations of ± 30°. The most suitable typologies of buildings for this kind of integration are residential buildings, either for

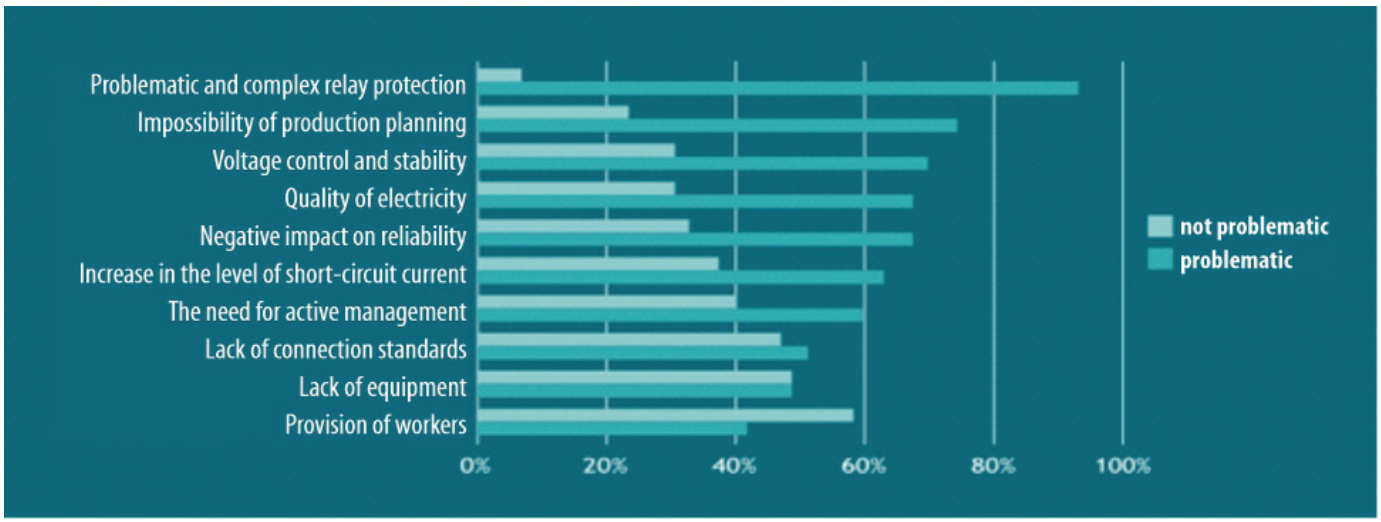


Figure 4.37. Participation (%) of negative and positive aspects of RES integration into the electrical energy system

collective or individual housing. In the case of buildings with a flat roof, the optimal solution is to place the solar installation on supports that guarantee the optimal slope of the collector.

4.3.3.8. Citizen co-financing programs

Based on the Decision on the conditions, criteria and procedure for the allocation of funds for the co-financing of measures to reduce air pollution in the area of the city of Tuzla, every year since 2019 a public call for the allocation of funds for the co-financing of measures to reduce air pollution in the area of the city of Tuzla has been published. The subject of this public call is the allocation of funds from the Budget of the City of Tuzla for the co-financing of air pollution reduction measures in individual residential and individual residential and business facilities in the area of the city of Tuzla. Air pollution reduction measures that are subject to co-financing include:
a) procurement and installation of heat pumps,
b) "warming" of buildings in which the installation of a heat pump is planned, in the form of procurement and installation of materials for the insulation of external walls and ceilings of buildings and procurement and installation of external carpentry,
c) procurement and installation of compact thermal substations - KTP,
d) procurement and installation of boilers with exclusive drive on wood biomass - pellet stoves.

Measures to reduce air pollution, which are not subject to co-financing, include the procurement and installation of heating devices powered by electricity. As part of this program, 778 beneficiaries of this program were registered until the end of October 2022, in which 2,355,763.77 KM were invested. This program will continue.

At the same time, the Ministry of Spatial Planning and Environmental Protection of the Tuzla Canton, on the basis of the Decision on determining the conditions, criteria and procedures for the distribution of dedicated funds from environmental fees, announced a public call for co-financing measures to reduce air pollution in the area of the Tuzla Canton for the year 2022. The subject of the public call is the allocation of dedicated funds from environmental fees to natural persons, for the co-financing of measures to reduce air pollution. The following energy efficiency measures are co-financed with the support of the Ministry in the procurement and installation of systems up to 50%:

- thermal insulation of the walls,
- thermal insulation of roofs and covers,
- replacement of exterior doors and windows,
- installation of a heat pump and
- solar photovoltaic systems, exclusively intended for own use of electricity.

Therefore, both at the cantonal and city level, air pollution is recognized as the most current environmental problem, and in the framework of the incentive measures, RES are foreseen as a significant element of mitigating the consequences. In future strategic planning documents, it is necessary to determine space in urban and rural zones for installations and energy production from solar sources and photovoltaic power plants. As presented, the pilot projects (Pannonian lakes) have already been implemented, but support for these activities should be continued.

In the strategic planning document, the conditions for setting up the PV system should be determined, which should enable a balance with the protection of significant natural, cultural and other values, and in accordance with other development projects and infrastructure. It is necessary to define the physical, relief and climatic parameters of potential locations for the implementation of solar projects and to identify those where this is prohibited (protected natural assets). It is essential to consider the impact on the environment, economic benefits, etc. All future buildings must be built in such a way that they combine energy-efficient design and RES production technologies for buildings with zero net energy consumption.

Since the adoption of the new Law on RES and efficient cogeneration in FBH is expected in the coming period, which will provide for "prosumers" and make it easier for citizens to install photovoltaic

systems on their roofs and become producers and consumers of electricity, the citizens of Tuzla are expected to show great interest. Because of all this, some of the basic advantages and disadvantages of three typical designs of PV power plants should be singled out.
Advantages of solar power plants:
- produce clean energy, practically without any pollution,
- have high reliability,
- have negligible operating costs.

Limitations to be reckoned with when implementing solar power plant projects:
- have high investment costs,
- require a specific area for installation,
- their production depends on the amount of sunlight.

4.3.4. Application of smart technologies in the energy sector
4.3.4.1. Energy management

Energy management is the process of continuous management of the costs of energy use, and monitoring the efficiency of energy consumption within a unit (buildings, factories, hospitals, cultural or sports facilities, etc.) with the aim of reducing consumption costs with the same level of comfort for users of the same unit [30]. Energy is the basis of a technically highly developed world. The extent of today's energy use and the importance of energy is illustrated by the fact that more energy has been used in the last thirty years than during the entire historical period before that. Energy consumption is by no means stagnant, but is constantly increasing, and this trend will continue in the future. From the plow to the computer, from the horse-drawn carriage to the satellite, from the open flame to the microwave oven, it took us less than 100 years. In such a world, on the path of radical and extremely rapid changes, the energy balance represents the gap between progress and poverty, further development and regression.

Energy consumption dictates its production, and energy production, especially from fossil fuels, has a significant negative effect on the environment. Today, climate change is one of the most recognizable global problems, the cause of which lies in the excessive emission of greenhouse gases, especially carbon dioxide. Every time we drive to the store, turn on the washing machine, computer, stove or do something else that requires energy produced from fossil fuels, we create greenhouse gases that contribute to climate change and pollute the air.

By using energy efficiently and making wise consumer choices, you can reduce greenhouse gas emissions by around 20% or one ton per year, just on a personal example, without losing comfort. For the sake of illustration, one ton of greenhouse gases can be represented as the volume of a two-story house with an area of about 150 m2. Let's take the example of lighting using an ordinary light bulb. Its energy efficiency is about 5 to 10% (because 90-95% is spent on heat). Energy saving bulbs, however, are 3 to 4 times more efficient in converting energy and convert about 20-25% of electrical energy into light. In addition, the power of energy-saving light bulbs is up to 5 times lower, and modern LED bulbs are up to 9 times less than ordinary ones, with the same light effect.

Let us compare the losses on the way from the power plant to the light bulb that illuminates our office, as shown in Figure 4.38. That is why it is important to use the supplied energy in the most efficient way possible. Thus, we reduce the need to burn an increasing amount of fuel at the beginning of the electricity production process, protecting the environment, while simultaneously saving money for the electricity consumed.

4.3.4.2. Current state of the system

The Law on Transmission, Regulator and Operator of the Electricity System in BH [30] regulates the establishment and work of the State Regulatory Commission for Electricity (SERK), the Independent System Operator (ISO) and the Electricity Transmission Company and defines the functions and powers of each of these bodies. One of the mandated responsibilities of the SERC is the collection

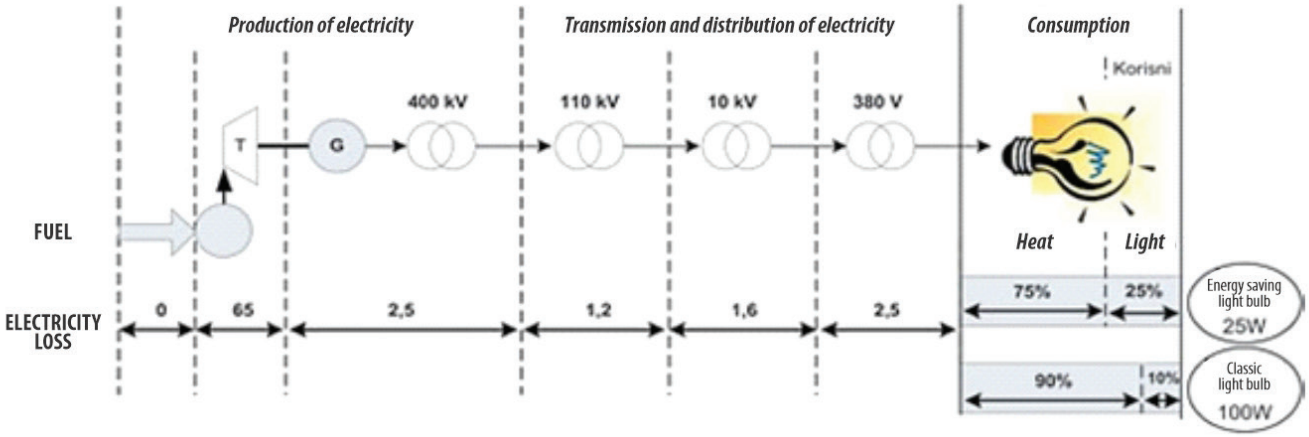


Figure 4.38. Electricity losses on the way to consumption and comparison of two types of light bulbs.

of regulatory fees paid by license holders for electricity transmission, coordination of activities of the independent system operator, international trade, supply of customers, and distribution of electricity in the Brčko District of BH.

We highlight some competences and powers of SERC of interest [31]:
- Issuing, changing, suspending, canceling and monitoring, and enforcing compliance with electricity transmission licenses,
- approving, monitoring and enforcing tariffs and tariff methodologies for the transmission and regulation of ancillary services,
- establishment, monitoring and implementation of quality standards for electricity transmission services and auxiliary services,
- consumer protection, which ensures:
  - fair and equal treatment,
  - high quality services,

The modalities of mutual monitoring and coordination of actions applied so far will also be used in 2022 in relations with the Regulatory Commission for Energy in the FBH and the Regulatory Commission for Energy of the RS, as well as with other regulatory bodies established at the state level, primarily with the BH Council of Competition.
In order to meet the needs of different decision-making levels for quality and reliable statistical data in the field of energy, SERK remains a reference source and an active generator of this data. To this end, SERC should follow the development of EU rules and respect the agenda of the Energy Community, while continuing to cooperate with the BH Statistics Agency.

4.3.4.3. Electricity system of Bosnia and Herzegovina

The total installed capacity of production facilities in BH is 4,608.26 MW, with the following distribution:
o larger hydropower plants 2,076.6 MW,
o thermal power plants 2,065 MW,
o larger wind power plants 134.6 MW,
o small hydropower plants 180.18 MW,
o solar power plants 56.51 MW,

o biogas and biomass power plants 2.11 MW,
o small wind power plants 0.40 MW,
o industrial power plants 92.85 MW.
The map of the BH electric power system [30] is shown in Figure 4.39.

4.3.4.4. Realization of the balance in the Federation of Bosnia and Herzegovina

- The achieved total production of electricity in FBH in 2021 was 9,289.39 GWh, of which it was produced in:
- on thermal power plants 4,840.81 GWh,
- on large hydroelectric power plants 3,748.25 GWh,
- on small HPP owned by EP BH 63.59 GWh,

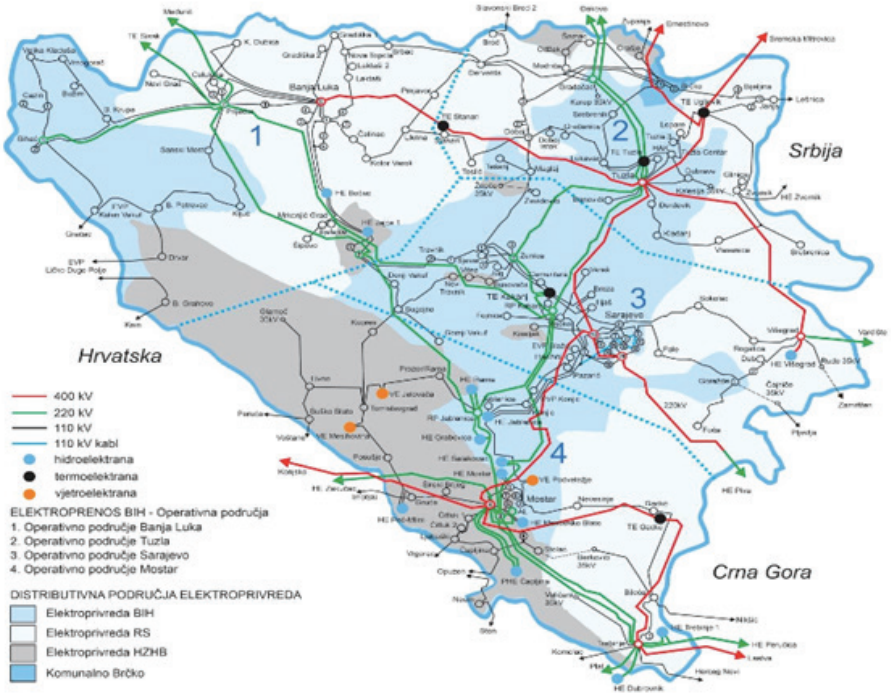


Figure 4.39. Map of the electric power system of BH with operational areas of Elektroprijenos BiH and distribution areas of electric companies (December 31, 2021)

- on wind power plants 382.88 GWh,
- o from independent producers - industrial power plants 19.98 GWh,
- on solar power plants and small hydropower plants 233.38 GWh [30].

The incentive for electricity production from renewable energy sources in FBH is based on guaranteed tariffs. Calculation of guaranteed purchase prices is performed by FERC on the basis of the Rulebook on methodology on the method of determining guaranteed prices of electricity from plants for the use of renewable energy sources and efficient cogeneration ("Official Gazette of the Federation of Bosnia and Herzegovina" number 50/14). This budget is made every 18 months, while the final approval of these prices prepared by FERK, on the proposal of the Federal Ministry of Energy, Mining and Industry, is given by the Government of the Federation. During the calculation, the investment costs, capital price, operation and maintenance costs, fuel costs, and investment return period are considered, based on which guaranteed purchase prices are obtained for all plants depending on the installed power and the primary energy source used. The law on the use of renewable energy sources and efficient cogeneration stipulates that all qualified producers, who acquire the status of a privileged producer, have the right to sell the produced electricity at guaranteed prices during a

Table 4.7. Balance of the size of the electric power sector of Bosnia and Herzegovina

Year 2021	EP BH	ERS	EP HZHB	Utility company Brčko	Other subjects	BH
Production of hydroelectric power plants	1.665,49	2487,46	2.082,77		78,27	6.313,99
Production of thermal power plants	4.840,82	3107,68			1.872,48	9.820,98
Production of larger wind farms	107,17		162,99		111,65	381,81
Production of small and industrial power plants	63,59	58,89			416,17	538,66
Production	6.677,06	5.654,04	2.245,76		2.478,58	17.055,44
Distributive consumption	4.861,66	3.896,14	1.424,27	285,65		10.467,72
Transmission losses	369,20					
Big customers	549,67	422,94	12,95		184,32	1.169,88
Own consumption of power plants and pumping		12,43	143,86		6,69	162,98
Consumption	5.411,33	4.331,51	1.581,08	285,65	191,01	12.169,78
2020	EP BH	ERS	EP HZHB	Utility company Brčko	Other subjects	BH
Production of hydroelectric power plants	1.024,07	1.677,83	1.533,93		40,65	4.276,48
Production of thermal power plants	5.155,80	3.285,61			2.001,57	10.442,98
Production of larger wind farms			147,50		114,31	261,81
Production of small and industrial electricity.	58,05	36,07			315,28	409,40
Production	6.237,92	4.999,51	1.681,43		2.471,81	15.390,67
Distributive consumption	4.677,57	3.690,32	1.352,59	272,74		9.993,22
Transmission losses	317,16					
Big customers	560,62	216,72	17,20		95,50	890,04
Own consumption of power plants and pumping		12,57	112,59		3,92	129,08
Consumption	5.238,19	3.919,61	1.482,38	272,74	99,42	11.329,50
2019	EP BH	ERS	EP HZHB	Utility company Brčko	Other subjects	BH
Production of hydroelectric power plants	1.443,95	1.604,74	2.537,38		63,53	5.649,60
Production of thermal power plants	4.527,31	3.017,35			2.068,32	9.612,98
Production of larger wind farms			165,98		87,69	253,67
Production of small and industrial electricity.	62,52	47,24			448,00	557,76
Production	6.033,78	4.669,33	2.703,36		2.667,54	16.074,01
Distributive consumption	4.737,34	3.726,24	1.407,10	271,87		10.142,55
Transmission losses	323,95					
Big customers	493,33	374,32	571,41		311,52	1.750,58
Own consumption of power plants and pumping		13,83	96,28		2,94	113,05
Consumption	5.230,67	4.114,39	2.074,79	271,87	314,46	12.330,13
2018	EP BH	ERS	EP HZHB	Utility company Brčko	Other subjects	BH
Production of hydroelectric power plants	1.533,61	2.729,05	1.984,86		52,56	6.300,08
Production of thermal power plants	5.648,34	3.249,42			2.056,00	10.953,76
Production of larger wind farms			103,50			103,50
Production of small and industrial electricity.	63,46	50,58			401,61	515,65
Production	7.245,41	6.029,05	2.088,35		2.510,18	17.872,99
Distributive consumption	4.705,96	3.770,48	1.392,22	270,02		10.138,68
Transmission losses	398,77					
Big customers	464,34	361,65	131,09		1.646,73	2.603,81
Own consumption of power plants and pumping		11,77	137,43		3,49	152,69
Consumption	5.089,64	4.143,91	1.650,44	270,02	1.650,22	13.293,95
2017	EP BH	ERS	EP HZHB	Utility company Brčko	Other subjects	BH
Production of hydroelectric power plants	941,41	1.575,30	1.287,41		27,27	3.831,39
Production of thermal power plants	6.007,23	2.870,62			2.040,59	10.918,44
Production of small and industrial electricity.	60,38	42,21			298,98	401,57
Production	7.009,02	4.488,13	1.287,41	0	2.366,84	15.151,40
Distributive consumption	4.730,02	3.772,64	1.399,58	276,86		10.179,10
Transmission losses	341,52					
Big customers	1.225,42	339,99	3,40		993,01	2.561,82
Own consumption of power plants and pumping		14,03	266,11		3,82	283,96
Consumption	5.955,44	4.126,66	1.669,09	276,86	996,82	13.366,40

period of 12 years.

4.3.4.5. Energy balance of the City of Tuzla

In 2011, the City of Tuzla created the Sustainable Development Action Plan of the City of Tuzla (SEAP). At the end of 2018, the City Administration applied for the "Public call for the preparation of an action plan for energy sustainable development and climate change (SECAP[2]) in the area of local self-government units". The next important step in confirming the commitment to the principles and practices of sustainable energy development and adaptation to climate change of the City of Tuzla

Table 4.8. Balance of individual sources in total electricity production

Production facility	2021. (GWh)	The share of individual sources in the total production of electricity in 2021 (%)
Thermal power plants	4.840,81	52,11
Hydroelectric power plants	3.748,25	40,35
Wind power plants	382,88	4,12
Solar power plants and small hydropower plants	297,47	3,20
Industrial power plants from independent producers	19,98	0,22
TOTAL	9.289,39	100,00

was made on October 31, 2019, when the City Council adopted the decision to create an Action Plan for sustainable energy management and adaptation to climate change [30]. The action plan for sustainable energy management and adaptation to climate change is a document that shows how the obligations and measures of the local community to mitigate climate change, which will be achieved by 2030, will be realized. For each local community, joining this initiative represents joining an active community of cities and municipalities that have committed themselves to continuous improvement of the living conditions of their citizens and dedicated work to achieve the vision of decarbonizing their territory, adapting to climate change and providing sustainable and safe energy available to all their residents.

Input data for the analysis of past energy consumption in the considered sectors - In this phase of SECAP, the calculation of CO2 emissions in the base year 2002 from all considered sectors and subsectors was performed. At the same time, the appropriate final energy consumption calculation was first performed, while the CO2 emissions were obtained by multiplying the obtained energy with the appropriate emission factors for individual energy sources. After that, emissions from all the mentioned sectors were calculated for the control year 2002, taking into account all the changes that occurred in the period 2002-2020. The comparison of final energy consumption in shows that the final energy consumption in the area of the city of Tuzla in the control year 2020 is 21.68% lower compared to the consumption in the base year 2002. Table 4.9 and Figure 4.40 show changes in total energy consumption and consumption in the considered sectors, as well as the share of individual sectors in total final energy, in the period from the base year to the control year.

In the period 2002-2020. the largest reduction in energy consumption was achieved in the building sector, where energy consumption by the control year 2020 decreased by 35.55% compared to the base year 2002. The main reason for this progress is the willingness of citizens to implement energy efficiency measures and use more efficient heating systems, which was recorded by surveying households in the phase of collecting input data. In table 4.7. direct emissions are shown, which

2 Sustainable Energy and Climate Action Plan - SECAP

are the result of energy consumption that physically takes place on the territory of the city of Tuzla. On the other hand, indirect emissions, which refer to the consumption of electricity from the grid, where facilities for its production can be located outside the territory of the city of Tuzla, but its consumption takes place in the territory of the city of Tuzla, are also an important sector that, with the introduction of savings, energy efficient devices and technologies of renewable energy sources have a positive impact on this kind of analysis.

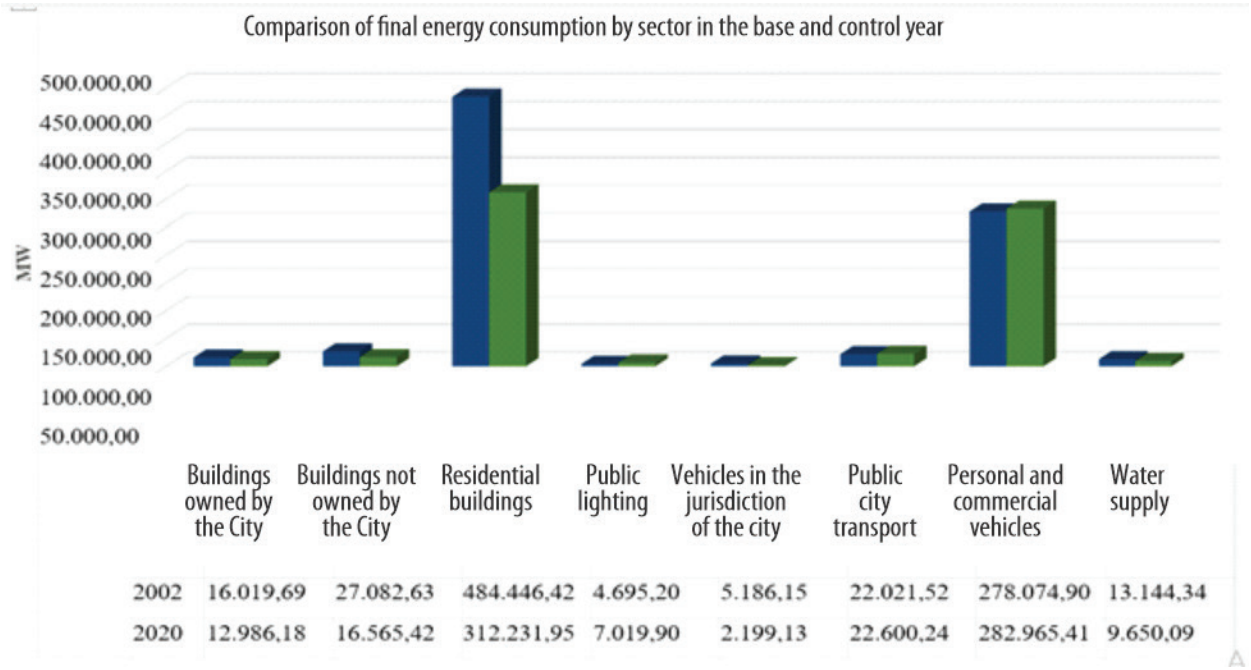
Sectoral analysis of energy characteristics, according to SECAP, is the preparation of the energy balance of the facility, or, in this case, of the city. The next step is to install an information system for monitoring available energy parameters, e.g. monitoring energy consumption/supply and other relevant parameters. Thus, the research is accelerated, the process of preparing the energy balance is direct and the goal of a reliable review of energy characteristics is achieved faster, and the preparation of energy balance data for participants in the processes, public and private companies, local and wider social community and the like. Current, reliable data on the energy balance at the

Table 4.9. Comparison of the total consumption of final energy by the considered sectors in the base and control year

SECTORS OF ENERGY CONSUMPTION	BASE INVENTORY in 2002		CONTROL INVENTORY IN 2020		ACHIEVED REDUCTION IN ENERGY CONSUMPTION	
	Final energy [MWh]	Share of individual sector [%]	Final energy [MWh]	Share of individual sector [%]	Final energy [MWh]	Reduction of energy consumption by sector [%]
CONSTRUCTION AND PUBLIC LIGHTING						
Public buildings owned by the City	16,019.69	1.88	12,986.18	1.95	3,033.51	18.94
Public buildings that are not owned by the City	27,082.63	3,18	16,565.42	2.49	10,517.21	38.83
Flat	484,446.42	56.95	312,231.95	46,87	172,214.47	35.55
Public lighting	4,695.20	0.55	7,019.90	1.05	-2,324.70	-49.51
TRAFFIC						
Vehicles in the jurisdiction of the City	5,186.15	0.61	2,199.13	0.33	2,987.02	57,60
Public city transport	22,021.52	2.59	22,600.24	3.39	-578.72	-2.63
Personal and commercial vehicles	278,074.90	32.69	282,965.41	42,47	-4,890.50	-1.76
NON-ENERGY SECTORS						
Water supply	13,144.34	1.55	9,650.09	1.45	3,494.25	26.58
IN TOTAL	850,670.85	100.00	666,218.31	100.00	184,452.53	21.68%

city level is a necessary prerequisite for the creation of energy plans aimed at the development of the entire city. Due to the number of energy consumers and suppliers who have data on energy consumption, preparing an energy balance at the city level is a very demanding task. Although some energy resources are reliably tracked (such as electricity), this is not the case for all energy sources.

There is a great need for data from consumers and most of them have a poorly developed information system, which significantly complicates the collection of data and the assessment of sectoral energy consumption. Problems surrounding the collection of data necessary for the preparation of the energy balance are present in all sectors of energy consumption, but when the number of target consumers (buildings, public institutions) is smaller, the main source of data is consumers. There



Slika 4.40. Prikaz promjena potrošnje finalne energije po razmatranim sektorima u baznoj i kontrolnoj godini

is no single national or even entity energy information system, the main source of data are invoices issued for energy consumption. The availability of bills for longer periods of time (larger number of billing intervals) is questionable if there is no procedure for monitoring energy consumption at the building/company level. A big advantage would be that the consumption of electricity per consumer can be accessed through the database of the supplier itself, which contains data for a long period. However, this is not the case for other sectors, so monitoring their consumption is only possible by the consumer himself.

Monitoring energy consumption at the level of one object can be simple even in case of unavailability of a modern information system for monitoring energy parameters. In order to achieve this, it is necessary to define procedures for monitoring energy consumption (archiving of fuel bills, reporting on energy consumption and accompanying financial quantities, etc.). However, this requires a larger number of employees compared to ICT-based energy information systems. The preparation of the structure of final energy consumption by sector (as defined by SECAP) for the city of Tuzla is very demanding due to the unavailability of the energy consumption monitoring system, as well as due to the large number of consumers whose consumption needs to be monitored. However, it can be argued that almost the entire share of petroleum products is consumed within the transport sector. A negligible share corresponds to consumption for heating needs in the service sector. District heating prevails in the building sector, while firewood and coal are dominantly used in the household sector. A small part is used in the commercial and service sectors.

Energy management should be viewed systemically. In the EU, member countries implement the directives on energy efficiency through their national regulatory frameworks. Initiatives for systemic energy management are more present at the regional and local level, where financial support for such programs is developed, promotional activities and information campaigns on energy management are carried out, in order to motivate citizens to do something themselves by a positive example.

In accordance with the findings of energy audits, energy efficiency improvement measures are initiated and implemented in certain buildings. The ultimate goal is to reduce energy consumption in buildings to the lowest possible level, continuously improving the efficiency of energy use, while ensuring optimal working and living conditions in these buildings. This process should be carried out for every

building owned by the canton, city or municipality. The goal of systemic energy management is the collection and analysis of data and the creation of a basis for deciding on measures to increase the efficiency of energy consumption. Achieving improvements is ensured by an organizational structure that supports, rewards and sustains initiatives that reduce energy consumption costs. Although energy management provides useful information about consumption, people skills are needed to convey the message of the importance of energy management and to encourage and involve all staff in achieving the goals. Systemic energy management, as one of the systems within the city, affects the organizational structure. Depending on the type of service provided, management and employees will fulfill different tasks. The flow of information towards higher and lower hierarchical levels must be open, which ensures that tasks will be carried out, problems and misunderstandings will be removed, and the project will succeed.

The possibility of an integrated system for improving energy management in buildings - The establishment of an energy management system is the responsibility of the City of Tuzla, and such a system would have a positive impact on the improvement of energy characteristics and strongly support the development and operation of this system.

There are different recommendations for the best approach to establishing an energy management system, but the most relevant are the guidelines from the International Standard ISO 50001. This standard provides guidelines for the development of an energy management system of arbitrary complexity (for a process, facility or organization), so it is the best start for cities. which need a reliable and efficient energy management system.

On the other hand, there are various solutions available on the market for energy management in buildings. These solutions are designed in accordance with the recommendations of ISO 50001, although the standard that directly relates to them is EN 15232, which deals with automation and management in buildings. These solutions are building management systems - BMS [30] and are common components of modern office buildings, but BMS can also be installed in older buildings. As standard, large and complex facilities are equipped with numerous technical systems for management, monitoring and protection. The central monitoring and control system can quickly and easily see all the data and give commands to the arrays of subsystems connected to it. This enables the smooth functioning of the building, quick elimination of faults, increase in energy efficiency and facilitates business. There are various simple BMS for residential buildings that are not financially demanding, and provide a significant improvement in energy characteristics.

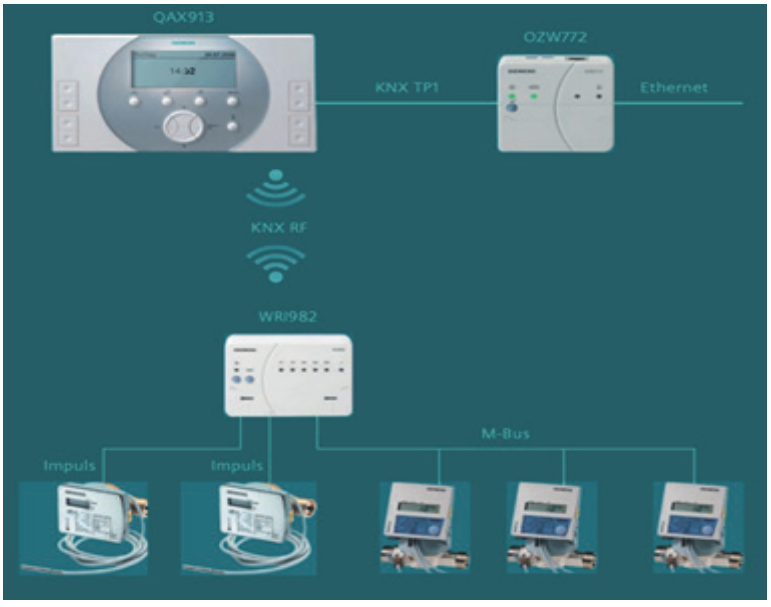


Figure 4.41. An example of a system for monitoring energy consumption [Siemens]

In Figure 4.41. a variant of the Siemens BMS system for monitoring energy consumption is presented. The possibility of monitoring and archiving energy consumption, which is free of charge, is the establishment of direct communication with energy suppliers in order to collect data from their databases. Energy suppliers usually have advanced information systems that collect and store energy consumption data for all their consumers. Information can be obtained from them after establishing an agreement between all parties. This is a simple procedure that allows access to reliable data for longer time intervals.

Access to reliable energy consumption data is extremely important for the energy management process.

The communication scheme corresponding to the BMS for one residential building is shown in Figure 4.42. The unified automation system unites all functions such as heating, ventilation, lighting, security technology, as well as the collection of consumption data. All components can be integrated via wired or wireless means in a flexible way. The system monitors end-user settings, shows limit values are exceeded and informs users periodically via e-mail or application (computer and smartphone).

An important component of the energy management system is the user interface, i.e. the software that collects, archives, analyzes and presents energy-related parameters to enable analysis and activities aimed at improving the energy performance of monitored facilities. All functions are available and great attention has been paid to the processing of graphic data to facilitate the analysis process. Energy management software is an important tool in the process of choosing measures to improve energy performance, i.e. preparing plans and other documents that are an indispensable part of any energy management system.
The connection between one of the technical systems and the BMS system is provided by the application of standard protocols (ModBus, BACnet, LonWorks...). To transfer application messages, these standards use the Internet or some type of local area network (LAN - Local Area Network). Lately, the protocol used for peripheral level communication with the BMS system server is Ethernet [30].

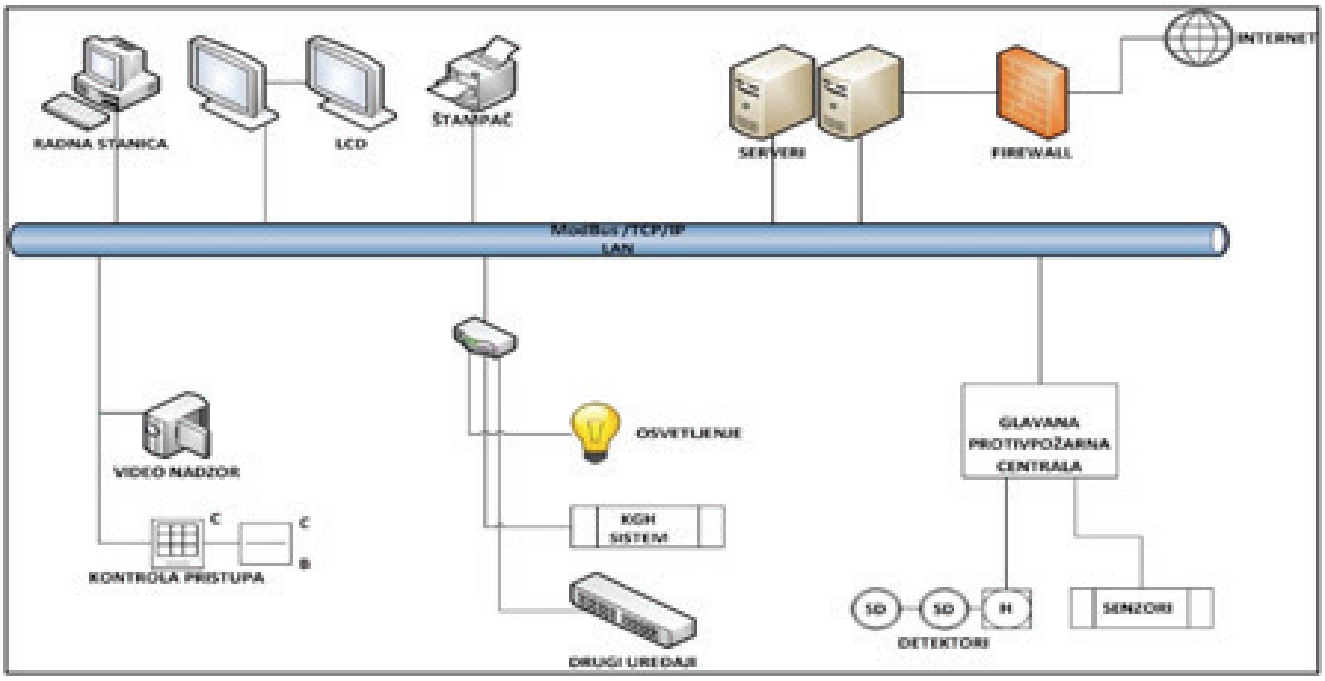


Figure 4.42. Communication links between BMS components

The reasons for introducing the BMS system in facilities are:
o Safety of people and equipment: protection in case of smoke, fire, equipment damage or burglary.
o Improvement of working conditions and comfort, in order to increase employee productivity.
o Greater reliability of the facility itself and services: proper operation of the system in general and in emergency situations,
o Improved maintainability of all systems, maintenance of error statistics, accelerated response to failures and timely planning and replacement of worn parts, etc.
o Cost reduction: optimization of electricity consumption and lighting systems.

Data from energy audits of buildings would enable reliable design of the necessary BMS, as well as financial analysis, which would result in the establishment of an energy management system.

In order to establish an energy management system, two basic requirements must be met:
1. Reliable monitoring of energy consumption (as well as other parameters of interest for energy consumption),
2. Availability of qualified labor force (technical education).

Without reliable monitoring of energy consumption, as a basic indicator of energy characteristics, it is not possible to establish monitoring of energy characteristics. Therefore, it is not possible to assess the efficiency and effectiveness of the measures proposed in the energy plans, which can lead to the choice of inappropriate measures with a low effect on energy characteristics and the budget (high investments in measures with low returns).

Also, as it is necessary to analyze data related to energy characteristics in order to assess the effects of applied measures, it is necessary to have a qualified workforce that can deal with this task. In addition, the result of the analysis of energy characteristics that the responsible employees should prepare is a set of measures for further improvement in the form of an action plan, which is the basic tool for energy management.

When qualified employees and a system for reliable monitoring of energy consumption are available, the following activities must be undertaken in order to establish an energy management system:
o Identification of the hierarchy of responsibility for the implementation and operation of the energy management system,
o Defining procedures for the establishment and operation of the energy management system,
o Defining indicators of energy characteristics that are based on monitored (measured) dynamic and available static data,
o Defining procedures for monitoring the efficiency of the energy management system, i.e., the form and frequency of reporting (energy data).

The expected results of the energy management system are:
o Higher productivity for the same consumed energy,
o Lower specific costs of energy use,
o Increasing the independence and security of energy supply,
o Greater diversification of energy resources,
o Abandoning energy resources that have a negative impact on the environment,
o Greater use of renewable energy sources,
o Raising awareness of the positive impacts of energy efficiency, renewable energy sources and energy management,
o Sustainable use of available energy resources,
o Positive impact on the budget.

4.4. Smart citizens

When we talk about Smart Cities, technological terms dominate. We are talking about how “big data”, IoT - Internet of Things, artificial intelligence, algorithms, sensors and automation, etc. will change and innovate our cities, making life better for urban citizens. Most often, when we think about Smart Cities from the perspective of new technologies, citizens are often considered exclusively users, testers or consumers. Their role as innovators and creators of smart city development is often overlooked, and the fact is that a person who lives in a city, goes through numerous situations every day, can have much more insight into the problems of his neighborhood, community and city as a

whole. This participation of citizens in the smart city system is one of the most important roles for the good functioning of the Smart City.

A “Smartivist” is a person who understands, supports and promotes the positive characteristics of Smart Cities and the implementation of innovative technologies in everyday life. A Smartivist understands the necessity of a green environment and sustainable development. Smartivists are critical and constructive, and represent one of the most valuable sources of information for implementers of smart city strategies.

A smart citizen takes advantage of all services that have been improved by the use of technologies, social and cultural aspects, and generally smarter living. In order to establish a Smart City for smart citizens, the most important aspect is to look at the fact of how citizens see a Smart City. Citizens, their needs and their demands must be in the center of attention. Citizen participation creates opportunities for citizens to be involved in decision-making processes. Citizens are increasingly demanding better and simpler access to public information, social and economic benefits as well as technological solutions.

The way in which citizens can become more involved in decision-making processes, as well as their acceptance, is reflected in:
o Development of applications for “smart citizens” with the aim of better response of citizens in procedures, for example, public debates on key documents, strategies, budgets, etc.
o Consideration of the results and adoption of objections.
o Development of applications through which citizens can consult on issues that are important to them, for example, whether the processes of providing public administration services are at a satisfactory level or not.
o Establishing a “many to many” network structure that will ensure interaction between citizens, and thus improve participation.

So, in this context, citizens are equal participants in the processes of making strategic decisions, and not persons who will provide certain inputs, information, which puts citizens in a more enviable position.

Smart citizens can be guided by the following ethical principles:
o Taking responsibility for the environment in which they live and work, and about the locations they love;
o Promotion of tolerance, not authoritarianism;
o Promotion of ethical values, not coercion;
o By helping less technologically literate people.
This set of ethical principles highlights and emphasizes the still limited possibility of interconnecting different infrastructure networks, as well as those between politicians, institutions, economies and social systems at the level of the city, region or state.

Programs related to smart citizens that can be realized can be:
o Various workshops for citizens, in different social spheres;
o Provision of space for the organization of meetings of different groups of citizens;
o Provision of education in the field of digital technologies, digital design and production.

By developing the segment of smart citizens, citizens who possess advanced digital technological skills and ideas, citizens and companies will be motivated to unlock and express their potential in the construction and presentation of innovative solutions for citizens, cities, the state and the entire planet. It can be said that the involvement of citizens in the decision-making of public administration

represents a key step in the evolution of a city. Information obtained from citizens can greatly help, for example, in defining key aspects of the city's development.

Unfortunately, the statistical indicators of citizens' participation in the work of public administration are lower than ever before.

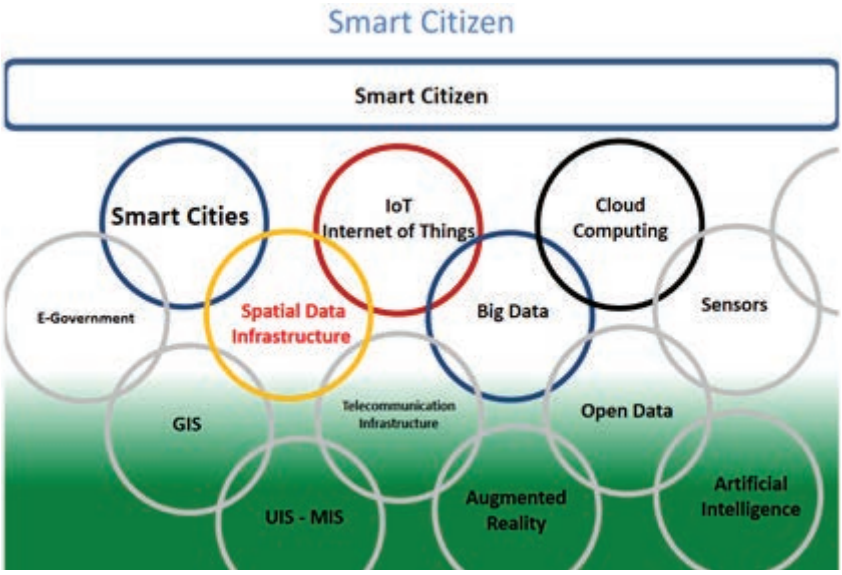


Figure 4.43. A smart citizen [50]

4.5. Smart living

A smart way of life uses technologies and systems designed to help cities reach a "smart" level of development, qualifications in a fast, sustainable, efficient and simple way, always taking into consideration the basic needs of citizens and public administrations. Smart living implies projects related to improving the quality of life. It is primarily about improving the health culture and quality of health of all age groups.

However, the projects also relate to increasing the quality of life in other different areas - housing, education, security, social inclusion, culture, sports and recreation, and sustainable tourism, as well as traffic management in motion and at rest, footpaths and infrastructure monitoring systems. The traffic aspect is particularly important here, given that 30% of urban traffic is related to finding a free parking space. In this segment, some progress has been made in public parking lots, but there is still plenty of room for improvement.

When we talk about private parking lots in the area of the city of Tuzla, they are mostly covered parking lots that have built-in digital signs, sensors and monitoring systems, which enable easy navigation to find a free parking space.

When talking about service information, cultural, sports, tourist and other information that enables better quality information and social environment, the City of Tuzla is in the process of improving the web portal https://grad.tuzla.ba/ where all service information important for the citizens of Tuzla, as well as information and schedule of cultural, sports, tourist and other events that take place in our city.

Figure 4.44. Digital signpost in the parking lot

As for the other segments of this point, which refers to the smart life of citizens, it will be dealt with in more detail in the other five segments, given that they are all interconnected.

4.6. Smart public administration

Smart, efficient and transparent city administration with intensive use of advanced information and communication technologies encourages maximum

involvement of citizens in making important decisions at the level of the city and individual city districts, while providing all relevant information for decision-making through various media and forms of information. By providing services online, processes become simpler and faster, saving time and money.

Smart Cities require Smart City administration as well as smart administrations of all city-owned companies that are primarily efficient and transparent and that, with the intensive use of advanced information and communication technologies, encourage maximum involvement of citizens in making important decisions at the level of the city, city companies and individual city settlements with providing all relevant information and key indicators for decision-making through various media and forms of information. In addition to citizens, the activities of a Smart City administration should also be aimed at developing a stimulating environment for the business of private companies - from small and medium-sized entrepreneurs to large multinational corporations. Also, the use of advanced technologies with the aim of reducing administrative-bureaucratic barriers to business, and making available data (which may be publicly available, taking into account regulations on personal data protection) that can be used for the development of innovative smart applications and solutions.

In the process of creating a Smart City, it is important to establish new administrative structures and ways of mutual cooperation/communication between various city services, departments, institutes, institutions and companies, and towards citizens. The foregoing refers to all aspects related to administration, which means that the smart administration of the city and city enterprises and institutions provides services to citizens primarily online. Modern administration can no longer be imagined without the use of modern information and communication technologies that speed up and simplify administrative processes, and such a service is more transparent and simpler for citizens. In this way, the processes become simpler and faster and significantly save time and money. Smart services in this area, thanks to unified and standardized concepts, are easy to use, easy to find, secure and certified.

The most important challenges and preconditions for the achievement of goals within this strategic area are the following:

- Financing - necessary investments for the development and application of smart tools and applications that will achieve the goals of smart city administration and city enterprises and institutions, including applications for collecting and processing large amounts of data.
- Increasing the interest of citizens (e-inclusion) - one of the key conditions for the achievement of goals within the framework of Smart City administration and city enterprises and institutions is the active involvement of key participants: a large number of citizens, private companies and entrepreneurs, but also all employees of the city administration and city enterprises and institutions. Citizens are the end users of smart tools and solutions such as e-forums, e-consultations, and the like, and the practice and experience so far, not only in the area of the City of Tuzla, but in general in cities in the EU countries, has shown that it is precisely the lack of interest on the part of citizens for participation and inclusion is one of the biggest challenges.
- Digital literacy - in order to take advantage of all the advantages and possibilities of advanced information and communication technologies and tools, basic knowledge in terms of digital literacy is necessary, and it is certain that this represents a problem for certain categories of the population (for example, the elderly population and pensioners, but also the socially vulnerable categories and unemployed). Also, in order to fully exploit all the possibilities provided by smart solutions and technologies, it is necessary to continuously raise the level of digital literacy of employees of the city administration and city companies and institutions at all levels.

The most important guidelines and effects in the field of smart city administration as well as the administration of city-owned enterprises and institutions are as follows:

a) Accelerate the development of public services for citizens and businessmen with efficient use of

digital technologies. Numerous activities in the work of the city administration often include several different services, departments, institutes, institutions and companies, and one of the main goals in the field of smart city administration is to continuously increase the level of digitization through the introduction of modern information and communication technologies, and the networking of business processes of the city administration, companies and institutions owned by the city. An increased level of digitization causes an increase in effectiveness, and a reduction in the use of resources (primarily human), along with an increase in the speed of service provision. Direct positive effects are reflected on citizens, the business sector, the academic community and other interested participants.

b) Continuous increase in the level of knowledge, abilities and innovation of the city administration as well as the administration of companies and institutions owned by the city. Increasing the level of knowledge, abilities and innovation of the city administration and the administration of city-owned companies and institutions, improving the user experience, introducing new business models as well as increasing business excellence will be constant guidelines in the development of city services, departments, institutions, institutions and companies. The development of e-Skills of employees of city services, institutions and companies will be an ongoing process within the lifelong education and e-Learning program.

c) Development of e-services - wide application of new technologies in the development of city services. One of the key tasks of the city administration and the administration of companies and institutions owned by the city is to provide support and facilitate citizens' daily activities. Submitting applications for issuing permits, reviewing land and cadaster entries, e-schools, applications for reporting various communal problems and applications for reporting irregularities in the work of the city administration are just some examples of e-services. One of the ways in which the development of applications and e-services can be encouraged is a comprehensive innovation process in all sectors and related to all infrastructure. All city economic and communal activities can be seen as a potential for innovation in which citizens and various organizations participate in the development of new e-services.

Priority measures for achieving goals in the field of smart public administration are the following:
1. Accelerating the development of digital public services and increasing the absorption of digital technologies
2. Establishment of the Management Unit (Department for Smart City) for the purpose of integral management of implementation
3. Constant improvement of the quality of city services by introducing KPIs, and research into further improvements (Learning & Innovation) in accordance with international ISO norms
4. Involvement of citizens through a public call for submission of smart city proposals
5. Creating a "mobile friendly" and "user friendly" application

In the further part of the Study, some priority measures will be explained in more detail.

<u>Priority measure: Accelerating the development of digital public services and increasing the absorption of digital technologies</u>

New technological trends, new forms of business and management present the city administration with new opportunities for managing and improving the quality of services and citizens' lives, as well as more efficient performance of economic activities. The high level of use of digital technologies and the exchange of information and knowledge through social media is a key factor that has enabled the significant development of smart concepts and solutions, where the key bearers of this concept are new business models and digital technology. The basic prerequisite for increasing the efficiency, quality and speed of service provision by the city administration is the accelerated development of digital public services that the city administration provides to citizens, businessmen and entrepreneurs with the help of digital technologies.

Activities aimed at digital networking should facilitate and encourage the exchange of data and information between key participants - city administration, citizens and businessmen. For this purpose, it is necessary to establish new or improve existing communication (digital) platforms, for example C2C (Citizen 2 Citizen) platform that provides citizens, as end users of the system, a quality communication platform for solving everyday problems, but also proposing and developing new idea and initiative to improve all parts of life in the city. As a basis for the application of activities for the establishment and management of digital networking, it is necessary to establish a mechanism for the application of relevant norms and principles in this area.

In order to achieve the stated goals, it is necessary to establish a comprehensive System for the management of public services, for which it is necessary to implement a whole series of preparatory and implementation activities/projects.

Indicative activities and projects of this priority measure are as follows:
- Establishment and continuous maintenance of the Service Catalog of the City of Tuzla
- Defining the process architecture of the City of Tuzla (BPA - Business Process Architecture) and horizontal organization for internal networking, first between the Services, and then networking towards companies and institutions with public authorities
- Establishment of a platform for the integration of services (Government Service Integration Platform), which enables the establishment of a single point of access for the exchange of data and documents, the integration of business processes, namely: G2G, automatic activation of e-Requests from the portal and a comprehensive audit of transactions
- Defining the conceptual model of the digital public service
- Defining the structure of the digital service management system, responsibilities and functionality.

In order to better utilize the potential for the application of digital technologies in the work of the city administration, as well as the potential of access to open data (Open Data), through initiatives and projects within the jurisdiction of the city
it is necessary to ensure the application of the following concepts and principles:
- Openness of data both to citizens and to all city enterprises and institutions
- Ensure citizen involvement and two-way cooperation

Priority measure: Establishment of a Management Unit (Department for Smart City) for the purpose of integral management of implementation - In order to ensure the successful execution of activities, i.e. the achievement of all goals set within the framework of this Study, it is necessary to form a special unit (for example, Department for Smart City - Smart City Department , SCD) which will be responsible for the coordination or integral management of the implementation of activities and measures. The most important task of this Department is reflected in the cooperation with all city services, departments, institutions and companies, but also with other key participants who should be involved in the implementation, to define the annual operational plan for the implementation of strategies, to continuously monitor the success of the implementation of projects and measures, to promote the Smart City Concept and encourage the application of smart solutions and the creation of innovations, and ultimately report on the implemented activities and measures. The experiences of other cities in the EU, but also in the rest of the world, which have achieved significant results and successes in the implementation of the Smart City Concept, confirm the need to establish a special management unit (in this case, a Department) with sufficient independence and authority to coordinate the implementation of measures and activities. for the coordination of all key participants. Such a management unit should coordinate the implementation not only of measures related to the area of smart city administration, but of all priority measures specified in the strategy or set goals, including promotional and educational activities. This management unit should be directly under the

authority of the mayor and may be composed of employees of the city administration.

The most important goals to be achieved through this measure are the following:
- Creation and promotion of the Smart City identity (brand).
- Promotion of Smart City activities
- Provide an executive body for monitoring the execution of goals
- Encouraging the introduction and application of Smart City concepts among city entities
- Successful execution of Smart City goals.

The implementation unit should be closely integrated with all city structures, and it is recommended that it be established as a separate department within the city service responsible for the economy and economic development.

Indicative activities and projects of this priority measure are as follows:
- Establishment of the Smart City Department, SCD
- Establishment of a PMO office (Project management office - management, planning, measurement and control)
- Promotion of Smart City projects and initiatives
- Monitoring of news in the field of smart technologies and their application in the Smart City concept
- Gathering and designing new initiatives for their application in the concept of the Smart City
- Development of virtual communities
- Organizing experiments for service development and innovation (hackathons)
- Promotion of digital technologies and 4IR (fourth industrial revolution)
- Initiatives for additions and changes to the Strategy of the City of Tuzla

This Study sets goals and defines priority measures for their achievement. Therefore, the key challenge for the success of the entire Study, i.e. the realization of the vision and set goals, is the successful implementation of priority measures. A very wide circle of participants should be involved in the implementation, and the key task, or challenge, is the coordination and active involvement of these participants. The implementation unit must therefore be sufficiently well equipped, and must have clearly defined powers and responsibilities.

Priority measure: Constant improvement of the quality of city services by introducing KPIs, and research into further improvements (Learning & Innovation) in accordance with international ISO norms - One of the most important components of the Smart City are city services and the corresponding catalog of services of the City of Tuzla, which is created by the City itself, and which includes the services of: city administration, city institutions and utility companies. The city should be efficient in its work, which means making decisions and solving problems in real time. In 2014, the International Organization for Standardization (ISO - International Organization for Standardization) adopted two standards for city management (ISO 18091 - Quality management system at the local government level, and ISO 31720 - Sustainable development of communities - indicators for city services and quality of life) which enable setting target levels of service quality and business efficiency of the City and city institutions, and monitoring progress in the construction of a Smart City.

In addition, a special technical committee (Technical Committee) was established within ISO, which has the task of defining standards for the establishment and development of Smart Cities, and a total of 4 standards were adopted on this topic (ISO 37150:2014 - Smart infrastructure - development of activities related to performance measurement, ISO 37151:2015 - Principles and requirements for performance measurement, ISO 37152:2016: Smart infrastructure - common framework for development and operation, and ISO 37154:2017 - Guidance and best practices for transport).

Constant improvement of the quality of city services must be carried out in accordance with the stated norms, as well as the best examples and practices from leading world and European cities.

The most important goals within this measure are the following:
- More efficient planning, design and delivery of city services
- Reducing the time it takes to establish a smart and sustainable city
- Facilitating the integration of different city systems
- Improvement of decision-making efficiency (based on data analyses)
- Enabling comparison (benchmarking)
- Evaluation of infrastructure projects on the overall performance of the City

Indicative activities and projects of this priority measure are as follows:
- Requirements analysis and work plan for compliance with the ISO 18091 standard
- Analysis of the requirements of the ISO 37120 standard and work plan for compliance with ISO 37120 / Certification for ISO 37120
- Defining the catalog of key indicators (KPI - Key Performance Indicators)
- Performance measurement
- Reporting
- Continuous improvement and monitoring

All procedures and processes must be clear, fast and documented, which implies maximum use of IT technologies and IT experts. In evaluating the work of the administration, one of the important indicators is speed, that is, efficiency. It is crucial to note that within the ISO 18091 norm there is also a generic process architecture of the city (BPA of the city), and a process model of development and delivery of services, which enable comparison and identification of differences in the practices of the City of Tuzla compared to the norm, and help in designing key actions for improvement of city services, as well as the identification of internal owners responsible for certain processes, services and innovations of the Smart City system. For successful, continuous management of business processes and identification of key and critical processes, it is necessary to establish a framework for process management, i.e. Business Process Governance (BPG). BP Governance should enable the establishment of the so-called End-to-End processes, rules, methodology, procedures, tools and roles, and associated responsibilities for managing business processes - which is the responsibility of which level of management. The definition of roles and responsibilities as well as the establishment of the holder of the BPG framework is the basis for a comprehensive approach to BPM, which supports the continuous improvement of processes and the implementation of process initiatives.

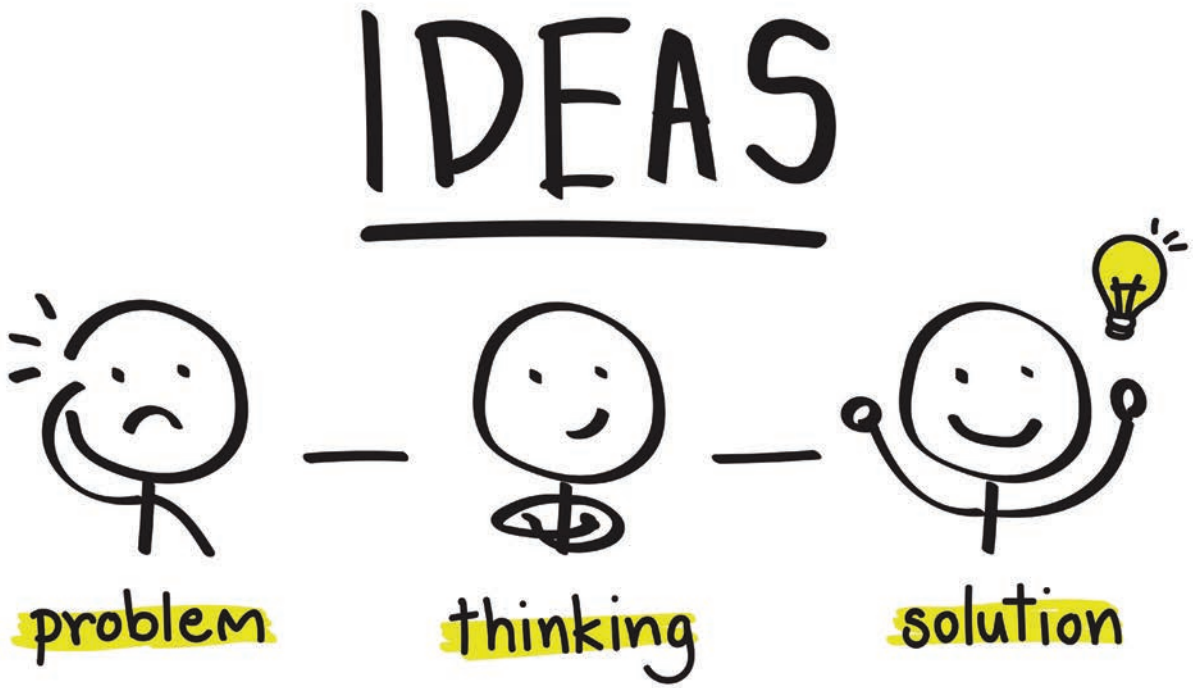
Priority measure: Involvement of citizens through a public call for submission of smart city proposals - The goal of this activity is to involve citizens as much and as actively as possible in the idea of the City of Tuzla as a city that uses smart solutions through a public call for submission of smart city proposals. Namely, as it was stated earlier, one of the main prerequisites for the idea related to the use of smart city solutions to fully take root is the active and maximum involvement of citizens, both in terms of the use of these solutions, but also in terms of new ideas and proposals. This is precisely why this one measure was an additional incentive for citizens to get involved in the whole story. A public call for proposals for new smart solutions would be financed by the City. The public call would be open to citizens and legal entities who, based on the proposal, exercise the right to have the realization of the idea financed from the city budget. On the basis of financing, the city obtains the right to use, and the proponent remains the owner of the product, which can be further distributed. In this way, the possibility of financing start-ups is realized.

Indicative activities and projects of this priority measure are as follows:
- Collecting proposals from citizens
- Evaluation of proposals
- Selection of the best solutions and preparation for implementation

The challenges that the City of Tuzla may face as part of this measure are the following:

- Willingness of citizens to join this kind of public invitation
- Objectivity in choosing the best solution
- Implementation plan and implementation of the above solution

V CONCLUSIONS AND RECOMMENDATIONS



5. CONCLUSIONS AND RECOMMENDATIONS

The study Tuzla Smart City - City of the Future provides basic guidelines in which direction the city of Tuzla should develop in order to become a Smart City. In the study, all the important information related to the projects that have been realized and related to digitization and the application of smart technologies have been collected in a unique way. Recommendations for the development of public administration were analyzed and given with the aim of creating an even better environment for the life of citizens and the development of the city of Tuzla. In preparing the study, we tried to adapt the entire work to the requirements of the UN's sustainable development goals and the EU's strategic directions of development.

In the Study, it can be seen that a Smart City contributes to a better quality of life for citizens and to improving the efficiency and effectiveness of city administration, public institutions and public companies, communal infrastructure and services, and ecological living conditions. It will also contribute to better information and involvement of citizens in decision-making processes, which inevitably leads to an increase in citizen satisfaction and greater responsibility of civil servants in working with citizens. It is very important that digitization and application of smart technologies will lead to financial savings and more sustainable business.

This Study provides an excellent basis for creating the Tuzla Smart City strategy. The strategy will provide key elements of the mission, vision and operational goals of the city's development, so it is recommended that the City of Tuzla plans to prepare this study in the coming period.

Due to the limited capacity and deadline for the preparation of the study, we did not have the opportunity to include a larger number of participants, but this leaves us with the opportunity to expand when creating a strategy, the implementation of which will make Tuzla a Smart City.

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