THE EUROPEAN JOURNAL OF APPLIED ECONOMICS

EJAE 2022, 19(1): 98 - 109
ISSN 2406-2588
UDK: 316.334.56:502.131.1
711.45:004.7
DOI: 10.5937/EJAE19-36597
Original paper/Originalni naučni rad

ECONOMIC JUSTIFICATION OF APPLYING INFORMATION TECHNOLOGIES TO THE CREATION OF SMART CITIES

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Abstract:
Modern technologies, in addition to making people's lives easier, faster and better, enable the combination of different technologies to develop solutions to various problems. Global warming is one of the biggest and most dangerous problems facing planet earth. If global warming were presented as a coin, then air pollution and climate change would be two sides of the same coin. Climate change is primarily a problem that has arisen due to the large amount of carbon dioxide (CO_2) in the atmosphere. Carbon overload occurs mainly due to the combustion of fossil fuels such as coal, oil and gas, or the cutting and burning of forests. There are other harmful gases but CO_2 stands out because it poses the greatest risk of irreversible change if it continues to accumulate in the atmosphere. This paper presents a number of different solutions by combining modern technologies for the problem of CO_2 emissions globally, where Bosnia and Herzegovina is particularly singled out as one of the countries with the most polluted air in Europe and with the highest mortality rate associated with air pollution. Smart cities use digital technologies, aim to improve the quality of human life and to enable the protection of the environment. The concept of a smart city is described as a set of modern technologies, examples of leading smart cities in the world are given, as well as the advantages of implementing such a solution.

Article info:
Received: February 22, 2022
Correction: March 18, 2022
Accepted: March 23, 2022

Keywords:
smart city,
air pollution,
climate change,
reducing carbon dioxide emissions,
global warming,
CO_2 emissions.

INTRODUCTION

Technology has always been significant and has had an impact in the development of any sector, ranging from military, police, industry, scientific research, business, and households to individual users. Over the years, technology has revolutionized our world and created tools and resources, putting useful information at our fingertips (Dirks, *et al.*, 2010). Compared to what it was like before, technology today tends toward multifunctionality and connectivity. For instance, mobile phones were mostly used

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for making calls and sending text messages, whereas today they can be used as computers, TVs and clocks. The question is, can modern technologies be used to solve major global problems affecting cities, countries, regions, continents or the entire planet? Bosnia and Herzegovina has the most polluted air in Europe. In addition to being one of the most polluted countries in the world, it is also among the top three countries with the highest percentage of air pollution-related mortality. Bosnia and Herzegovina faces a number of challenges in the field of air quality and its citizens are exposed to the level of air pollution, to which a number of different sources of emissions make their contribution, with CO_2 being the most dominant (Bomba, *et al.* 2018).

Modern technologies today allow the combination of multiple technologies to develop solutions to specific problems in any field. One of these solutions is the concept of a smart city that solves most of the problems that today's cities face. Cities have never faced greater challenges as various problems arise such as: pollution, access to infrastructure, traffic congestion, mobility, safety and health of residents. The implementation of the smart city makes a significant contribution to reducing CO_2 emissions (Curzon, *et al.* 2019). Which means that if more smart cities are implemented, significantly higher contributions will be made to reducing CO_2 emissions.

THE PHENOMENON OF SMART CITIES

Any city investing in development through the implementation of modern technologies can become a smart city. Smart cities use modern technologies to enable smart mobility where there is a strong Information and Communication Technologies (ICT) infrastructure and quality transportation conditions. They seek to connect all Internet of Things (IoT) facilities to the Internet and provide cloud-based services. The general idea is to use the Internet, smartphones and applications in combination with new technologies to help solve problems or to create solutions to most of the problems that cities are facing or are just about to face (Mishra & Chakraborty, 2019). Also, smart cities aim to make all relevant city-related information available to all citizens at your fingertips (Aelenei *et al*., 2016). The complete concept of a smart city is based on the construction of an example of a modern city whose structure can later be transferred to other cities. The use of modern technologies such as wireless networks and many internet based applications have changed the urban lifestyle that people are already accustomed to. Such technologies make smart cities a reality.

FEATURED EXAMPLES FOR SMART CITIES IN THE WORLD

The ranking of smart cities in the world is complex as it involves many different factors, and therefore there is currently no precise ranking to determine which city is currently the best smart city in the world. According to the IESE Cities in Motion Index 2019 research (Berrone & Ricart, 2019), London - United Kingdom stands out as the best smart city in the world in all dimensions. Second best is New York City - USA, and third - Amsterdam - Netherlands.

London is a well-positioned city in all dimensions and has a great overall balance. The city earned first place for human capital and international outreach (Schneider, & Stubinger, 2020). Furthermore, London is in the top 10 for dimensions of mobility and transportation, governance, technology, and urban planning (Mehta, *et al.*, 2022). On the other hand, its worst performance is seen in the dimension of social cohesion.

New York City is one of the largest cities in the world. It represents the second most populous city in North America, after Mexico City. It is the world's most important economic center and is the city with the highest GDP, with almost 7,000 high-tech firms standing out for its integrated technology services, such as LinkNYC's free Wi-Fi service (Visvizi, *et al.*, 2018). New York City has a leading position in the economic dimension, but it has succeeded in being among the top places for human capital, urban planning, international outreach, technology, and mobility and transportation.

Amsterdam is a major financial and cultural center in the country with international outreach. It also performs well overall and stands out among top 20 dimensions, especially in terms of economy, technology, urban planning, international outreach, and mobility and transportation (Patel & Doshi, 2019). There are other smart cities that stand out because they have great potential: Singapore, Zurich, Oslo, Barcelona, Paris, Tokyo, Toronto, Reykjavik, Seoul, Hong Kong, Buenos Aires, Madrid, Santiago.

BENEFITS OF SMART CITIES

The city of Bijeljina is distinguished by its geographical location, ideal size and represents a constantly developing and investing city. This type of city has the potential to apply modern technology and become a smart city (Sergi, *et al.* 2019). The reason for this is that the smart city implementation not only contributes to the reduction of CO_2 emissions at the level of Bosnia and Herzegovina, but also makes significant contributions such as cost reductions, facilitating wider service delivery, new business opportunities, easier access to information, better citizen involvement, personalized and better quality services for citizens, better relations with other cities, increased connectivity and better cooperation processes, better management and support in helping each other more effectively (Eremia, Toma, & Sanduleac, 2017). Also one of the key goals of smart cities is to attract a large number of new residents and visitors who will invest in the city which further leads to improving the quality of life and developing a good economic environment (Dahiya, & Kumar, 2017).

ECONOMIC AND CLIMATE ASPECTS OF SMART CITIES

Harmful gases and global climate change represent the latest challenges that people face on a daily basis. Carbon dioxide (CO_2) comes from a variety of sources, and the way we live significantly affects the environment. People rely on the use of energy that usually comes from fossil fuel combustion. Fossil fuel is a natural fuel such as oil, coal or gas. Combustion of fossil fuels generates emissions, including CO_2, which has a serious impact on global warming by damaging the Earth's envelope. The Earth's wrap serves as a bedding for the earth and allows heat to flow in and out of the earth. However, as CO_2 is collected in the atmosphere, heat is retained within the Earth from which global warming is slowly coming (Chauhan, *et al.* 2016). Precisely because CO_2 emissions prevent heat from coming out, this phenomenon is called the greenhouse effect. Industrialization and global human population growth have resulted in an increased demand for energy, which means that the number of emissions released into the atmosphere has risen (Abutabenjeh, *et al.*, 2021). CO_2 is one of many gases that merge with the air from natural sources and those that come from human activity such as car-driving. When looking at CO_2 emissions globally (Figure 1), we can conclude that global CO_2 emissions increased by almost 40% between 2000 and 2016, regardless of the approximately 10% decline in emissions in Europe and North America. Global CO_2 emissions are likely to increase by 10% above 2016 levels by 2040.

On the other hand, CO_2 emissions in Europe and North America are likely to fall by around 15% by 2040 compared to 2016. China has seen an increase of about 60% from 2000 to 2016, emissions will grow by 2030, after which they will be in decline and then return to the 2016 level in 2040. Emissions that are outside North America, Europe and China will increase by about 35% from 2016 to 2040, while the share of global emissions by 2040 will be 50%.

Figure 1. Global variation of CO_2 emissions

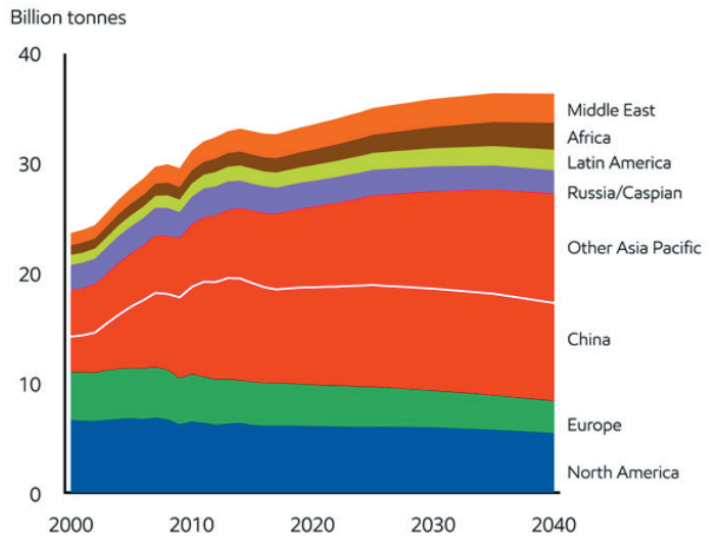
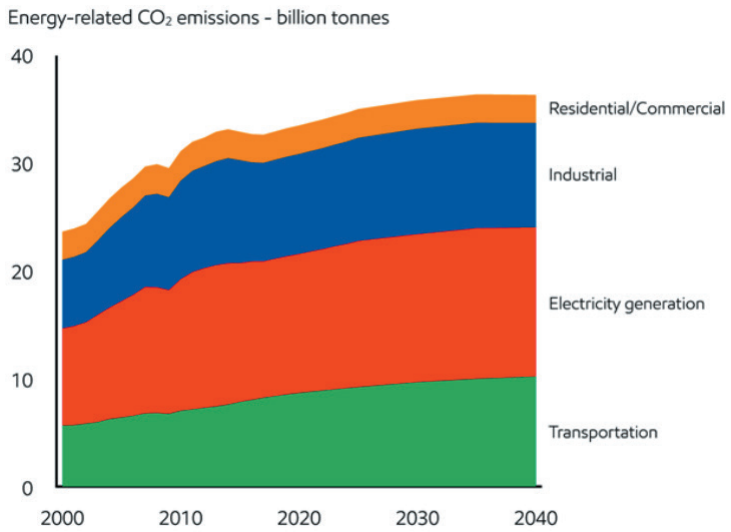


Figure 2. All sectors contributing to restrain CO_2 emissions growth



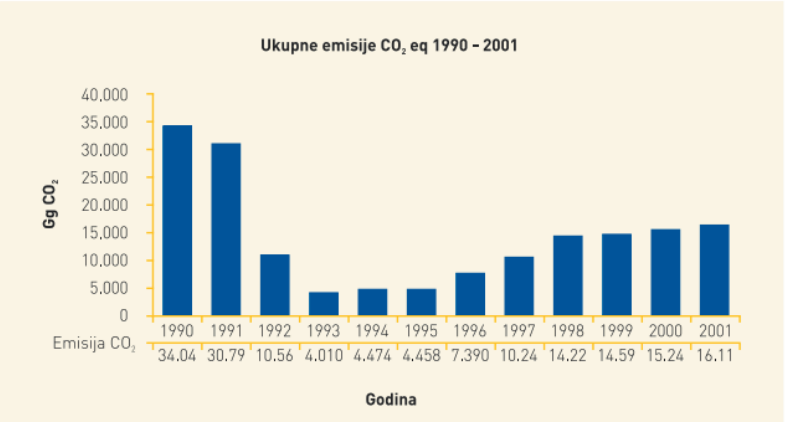
Electricity production accounts for about 40% of CO_2 emissions in terms of energy. Switching to smaller energy sources such as e.g. wind, solar, nuclear or natural gas will help reduce the CO_2 intensity of electricity delivered by more than 30%. Transport accounts for about 25% of CO_2 emissions, and is expected to experience a slight increase by 2040 due to the expansion of commercial transport activities

(Albino, *et al.*, 2015). CO_2 emissions for light-duty vehicles are expected to fall by approximately 10% from 2025 to 2040, as conventional vehicles and electric cars have a significant share. Industrial sector activities account for about 30% of CO_2 emissions, efficiency gains and growing use of less carbon-intensive energy will help reduce Gross Domestic Product's (GDP) by about 50%. The use of technology makes it possible to achieve more with less effort (Badgett, *et al.* 2019).

Global energy demand is growing more slowly than global GDP, which implies a decline in energy intensity (the amount of energy used to produce a unit of GDP). From 2000 to 2016, energy intensity dropped by about 1% per year, and the improvement rate from 2016 to 2040 is likely to approach 2% on a yearly level. Meanwhile, the carbon intensity (CO_2 content per unit of energy used) is fairly flat, with the pace of improvement likely to run from 2016 to 2040 (Caragliu & Del, 2019). The combined effect is reflected in the reduced carbon intensity of the world economy (tonnes of CO_2 per unit of GDP), which is expected to be 40% lower by 2040, while global energy demand will increase by about 25%.

Total CO_2 emissions from all fixed and mobile energy sources in BiH for 1990 amounted to about 24.9 million tonnes. In 1990, CO_2 emissions in the Republic of Srpska were estimated at around 8.1 million tonnes. Total CO_2 emissions in the Republic of Srpska in 2005 were 4.5 million tonnes or 32.3% of total BiH emissions (Government, 2012).

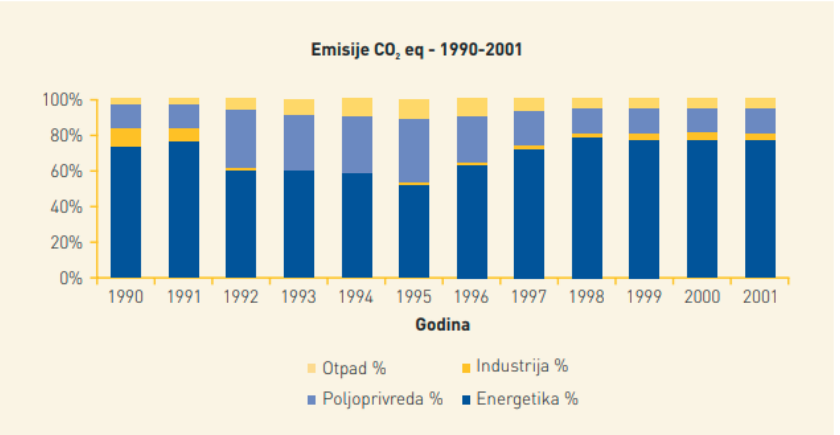
Figure 3. CO_2 emissions for the period 1990 to 2001 in Bosnia and Herzegovina



Source: (Radusin, Senad, Cero, Abdurahmanović, & Vukmir, 2013)

The graph (Figure 3) shows CO_2 emissions from 1990 to 2001. It can be seen that the analysis of this chart deviates from the charts of most countries. Instead of the normal growth of CO_2 emissions, we see a decrease in emissions here during the war period (12% in 1993 compared to the base year 1990). This graph also shows that the CO_2 emissions for 1990 in BiH amounted to about 34.04 Gg CO_2, which, if converted to tonnes, amounts to 34.04 million tonnes. If this result is compared with the previously mentioned according to which the CO_2 emissions for 1990 in BiH amounted to 24.9 million tonnes, we get a deviation. Also, according to the source (Worldometers, 2019) CO_2 emissions for 1990 in Bosnia and Herzegovina amounted to 24,446,896 tonnes which means that there is no exact number recorded, however, it is estimated that total CO_2 emissions ranged from 24 to 34 million tonnes. The latest figures are for 2016, where total CO_2 emissions were 25,674,120 tonnes. Therefore, in 2016, the level of CO_2 emissions exceeded the highest level, recorded for the first time in 1990, which is why this year was especially observed.

Figure 4. CO_2 % emissions by sector for the period 1990 to 2001 in Bosnia and Herzegovina



In 2007, the International Energy Agency (IEA) estimated that CO_2 emissions were 16.3 million tonnes. The energy sector emitted 52%, construction and agriculture 16%, transport 14%, industry 13% and households 5%. These results indicate that emissions have tripled since 1995. A 21% increase occurred between 2000 and 2004 when the economy began to recover. Coal is the leading source of emissions at 75%, followed by petroleum products at 21% and natural gas at 4% (Centar za Politike i Upravljanje, 2010).

Electricity in Bosnia and Herzegovina is produced in thermal power plants and amounts to 60% of the total energy production for 2015. Production in thermal power plants for 2016 amounted to a record 10,608 GWh, which is 1,896 GWh, 21.8% more than the year before. These thermal power plants use domestic coal and have fairly high CO_2 emissions (1.3t CO_2 / MWh) (BOSNIA AND HERZEGOVINA COUNCIL, 2017).

The following shows CO_2 emissions from 2010 to 2025, determined on the basis of final energy consumption data in both the Republic of Srpska and the Federation of BiH (Table 1).

Table 1. Overview of CO_2 emissions from different central heating systems

Administrative unit	2010.	2015.	2020.	2025.
Republic of Srpska	132,275.9	155,385.5	142,265.5	156,939.2
Federation of BiH	236,750.5	218,129.7	264,043.5	311,547.4
Bosnia and Herzegovina	369,026.4	373,515.2	406,309.0	468,486.6

Solar and wind energy, as well as other renewable energy sources, will play a greater role for the future of humans, however, oil and gas cannot be replaced immediately because it is a time-consuming process (Criado, *et al.* 2020). Therefore, it is necessary to develop a temporary solution for fossil fuels to operate in a cleaner and more environmentally responsible manner.

There are several solutions to the problem of CO_2 emissions in Bosnia and Herzegovina. The most significant source of CO_2 emissions is the energy sector, which contributes 75% to CO_2 emissions. The potential for reducing greenhouse gas emissions in this sector is greatest. Such challenges can be seen as development opportunities where:

- energy efficiency and greater use of renewable energy are introduced,
- use of clean development mechanisms,
- joining the European greenhouse gas emission trading system,
- development and application of CO_2 separation and storage technologies,
- reconstruction i.e. construction of new non-coal thermal power plants.

The implementation of a smart city structure to a particular city, such as Bijeljina, Bosnia and Herzegovina, enables increased energy efficiency and introduces greater use of renewable energy sources. Wind, water and solar energy, which are renewable resources, can be used to reduce CO_2 emissions. With such application comes the use of clean development mechanisms.

The development of the CO_2 industry is a quality solution for reducing CO_2 emissions in Bosnia and Herzegovina. The industry is based on the collection, storage and sale of CO_2 emissions (Hatcher & Hammond, 2018). The inclusion of Bosnia and Herzegovina in the European Emissions Trading Scheme allows not only the reduction of CO_2 emissions and the earning of money, but also the opportunity to bring Bosnia and Herzegovina closer to European standards.

One of the options for solving the CO_2 emissions problem is the development and implementation of CO_2 emission extraction and storage technologies (Harrison, *et al*., 2010). These technologies allow CO_2 emissions to be collected during emission and packed in tanks, which would later be transported by trucks to appropriate locations. Tanks typically release CO_2 emissions deep into the ground.

In addition, the process of air filtration, i.e. the collection of CO_2 emissions already in the air, is also one of the possible solutions to this problem for Bosnia and Herzegovina. At a time when the amount of CO_2 emissions was not so high, it was enough to pay attention when it came to CO_2 emissions, but since people did not such thing, it is now necessary to apply reverse engineering to suck up particles from the air, and also enable the storage of CO_2 emissions during broadcasting. Particle aspirators are called "Carbon capture".

Since electricity in Bosnia and Herzegovina is mostly produced in thermal power plants, the solution is to replace existing coal-fired thermal power plants with new more efficient ones, which have lower emissions and promote the use of renewable energy sources. In addition, a temporary filter setup is possible.

Apart from all these solutions aimed at reducing CO_2 emissions, lack of greenery in some cities of Bosnia and Herzegovina, including Bijeljina, is one of the causes of major air pollution. Humans exhales carbon dioxide CO_2 and inhales oxygen, while plants inhale carbon dioxide and release oxygen. Greater use of greenery, plants, trees and flowers can make a significant contribution to reducing CO_2 emissions in Bosnia and Herzegovina as well as in the city of Bijeljina. Currently, only forests contribute to clean air.

Each city should have as many trees, small and large parks as possible. Modern architects are slowly starting to design buildings that consist of greenery, such as various types of trees and flowers. Buildings like this play a big role in the implementation of smart cities. Some cities already boast buildings of this type. One of the problems of the town of Bijeljina is the large presence of buildings without parking and green spaces, the construction of a large number of buildings, while completely neglecting green spaces or removing existing ones to make room for new buildings. The number of buildings increases as the number of greenery decreases and the air gets worse. The construction of a synthetic forest that has the role of sucking in CO_2 emissions and providing oxygen to citizens also exists as a possible option for solving the CO_2 emissions problem in the city of Bijeljina and other cities across Bosnia and Herzegovina.

In 2008, an initiative to reduce CO_2 emissions was launched. Each signature created a goal to meet or exceed the EU's 20% CO_2 reduction target by 2020. The proposed projects for achieving this goal are mainly from the following sectors: building, district heating systems, local production of electricity from renewable energy sources, local transport, lighting, etc (Batty, *et al.*, 2012).

In 2013, almost 5,000 signatures were obtained across Europe, including 15 municipalities / cities from Bosnia and Herzegovina: Banja Luka, Bihać, Bijeljina, Gradiška, Kakanj, Laktaši, Livno, Prijedor, Sarajevo, Travnik, Trebinje, Tuzla, Zenica, Zvornik and Živinice.

(Table 2) shows a list of cities and municipalities from Bosnia and Herzegovina whose mayors and chiefs have signed and supported this initiative. For each city / municipality, the number of inhabitants, the date on which the initiative was accepted and officially endorsed, as well as the percentage of the overall CO_2 reduction target, are shown.

Table 2. Signatures collected from the mayors and chiefs in Bosnia and Herzegovina

Signatory	Population	Acceptance	Formal confirmation	Overall objective of reducing CO2 emissions
Banja Luka	250,000	30.01.2009.	30.03.2010.	20%
Bihać	61,287	17.12.2010.	14.06.2012.	20%
Bijeljina	153,000	21.10.2010.	04.10.2011.	31%
Gradiška	62,000	14.04.2011.	28.02.2012.	28%
Laktaši	40,000	18.03.2011.	18.03.2011.	21%
Livno	40,600	30.03.2011	22.05.2012.	20%
Prijedor	105,000	01.11.2010.	08.11.2011.	20%
Sarajevo	300,000	10.03.2009.	22.01.2011.	20%
Travnik	55,000	15.03.2011.	16.03.2012.	20%
Trebinje	36,000	30.12.2010.	07.12.2011.	22%
Tuzla	174,000	03.02.2010.	13.07.2011.	21%
Zenica	127,000	29.12.2010.	29.12.2011.	20%
Zvornik	65,000	12.05.2011.	12.05.2011.	20%

Source: (Petrović, 2014)

CONCLUSIONS

A smart solution can be found for every new challenge. The concept of a smart city is presented as a solution to any problems that current cities face or will encounter.

One of these problems, if not the biggest problem at the moment, is global warming, which is caused by the enormous amount of CO_2 emission in the atmosphere. This type of problem is a global problem and a major challenge for the whole of Europe, and especially for Bosnia and Herzegovina and its cities and citizens. Compared to CO_2 emissions globally, it is concluded that there are many different solutions to the problem of CO_2 emissions that can be used individually or collectively.

Therefore, the best and most demanding solution would be a proposal to develop a completely new industry that will be engaged in the collection of CO_2 emissions and their sale. There are two ways to collect CO_2 emissions, the first is to suck in CO_2 emissions from the air and the second is to collect CO_2 emissions during broadcast. The CO_2 emissions collected could be used in combination with hydrogen derived from water using renewable sources to produce hydrocarbons such as gasoline and kerosene, i.e. aviation fuels. After combustion of these fuels, the process is repeated, carbon dioxide is released again into the atmosphere from where it was originally collected, and CO_2 emissions are collected again. In this way, a sustainable process is achieved.

Also, the city of Bijeljina is presented as a potential city that could implement all modern technologies in order to become a smart city. This solution not only solves the problem of CO_2 emissions in the town of Bijeljina, but at the level of the entire state of Bosnia and Herzegovina, of course, on condition that this technology is applied in most cities. In addition, it enables air filtration for the population, provides an opportunity for the development of a completely new industry and the potential for job creation, better living conditions in the country, which would prevent the problem of people moving abroad in large numbers.

More urban technology projects have been implemented and planned for medium-sized cities than for small and large cities. It is best to implement smart technology for mid-sized cities that are not yet fully developed but contain all the key components needed for implementation, due to investment while they are still in the planning and construction stages. Also, because the city during this period has a simple infrastructure and because there is certainly more space to build a better quality city base. Smaller cities can also implement smart technology, but they do not benefit much from that implementation because they cannot utilize the full potential because they are underdeveloped. Again, big cities can implement smart technology, but they have complicated infrastructure and implementation would be long and demanding.

Every smart city must also have smart residents who will use the modern technologies and benefits that the smart city provides as planned. In general, there is a need to raise awareness among people about the harmful effects of environmental pollution on everyone.

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EKONOMSKA OPRAVDANOST PRIMENE INFORMACIONIH TEHNOLOGIJA NA STVARANJE PAMETNIH GRADOVA

Rezime:

Savremene tehnologije, osim što olakšavaju, odnosno čine život ljudi bržim i kvalitetnijim, takođe omogućavaju upotrebu različitih tehnologija u cilju rešavanja različitih problema. Globalno zagrevanje je jedan od najvećih i najopasnijih problema sa kojima se planeta suočava. Ako bi se globalno zagrevanje predstavilo kao lice, onda bi zagađenje vazduha i klimatske promene bilo naličje. Klimatske promene su pre svega problem koji je nastao kao posledica velike količine ugljen-dioksida (CO_2) u atmosferi. Preopterećenje ugljenikom nastaje uglavnom zbog sagorevanja fosilnih goriva kao što su ugalj, nafta i gas, ili seče i spaljivanja šuma. Postoje i drugi štetni gasovi, ali CO_2 preovlađuje jer predstavlja najveći rizik od nepovratnih promena ukoliko nastavi da se akumulira u atmosferi. Ovaj rad predstavlja niz različitih rešenja problema emisije CO_2 na globalnom nivou kombinovanjem savremenih tehnologija, pri čemu je Bosna i Hercegovina posebno izdvojena kao jedna od zemalja sa najzagađenijim vazduhom u Evropi kao i zemlja sa najvećom stopom mortaliteta, što je posledica zagađenja vazduha. Pametni gradovi koriste digitalne tehnologije, imaju za cilj da unaprede kvalitet ljudskog života i da omoguće zaštitu životne sredine. Koncept pametnog grada je opisan kao skup savremenih tehnologija, dati su primeri vodećih pametnih gradova u svetu, kao i prednosti implementacije ovakvog rešenja.

Ključne reči:

pametan grad,
zagađenje vazduha,
klimatske promene,
smanjenje emisije ugljen-dioksida,
globalno zagrevanje,
emisija CO_2.