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# INFRASTRUCTURE DEVELOPMENT AND ITS ECONOMIC IMPACT. COMPARATIVE ANALYSIS BETWEEN GERMANY, ROMANIA AND BULGARIA[1]

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Abstract. *This article analyzes the economic impact of infrastructure development, with a comparison between three European Union member states: Germany, Romania, and Bulgaria. Infrastructure, including transportation, energy, telecommunications, and water and sewage systems, is essential for economic growth and quality of life. The study highlights that Germany, with its developed infrastructure, supports a robust economy and a high standard of living, while Romania and Bulgaria would benefit from additional investments to reduce economic and infrastructure gaps. The data used in the comparative analysis are sourced from EuroStat, divided into four major infrastructure categories. The conclusions emphasize that efficient investments in infrastructure are critical for economic development, but their success significantly depends on the quality of governance. The article provides insight into the need for modernization and expansion of infrastructure in Romania and Bulgaria to achieve an economic level comparable to that of Germany.*

**Keywords:** *comparative analysis, infrastructure, economic development, quality of life, governance*

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## 1. INTRODUCTION

Infrastructure development is one of the essential elements for economic growth and improving the quality of life. The term infrastructure encompasses all the physical and organizational structures necessary for the functioning of a society or state, including roads, bridges, water and sewage systems, energy, transportation, and telecommunications.

Infrastructure is considered crucial for a country's development, which is why significant funds have always been allocated to this sector. The development of various types of infrastructure, such as transportation, information and communication technologies, energy, and water and sewage systems, contributes to economic growth and allows for the assessment of the influence of governance quality on these outcomes. Investments directed towards infrastructure development are a means of translating sustainable development goals from strategy into practice (Tagliapietra, 2024).

Basic infrastructure, which includes telecommunications, transportation, energy, and water and sewage systems, creates the conditions necessary to achieve economic development goals. It has a positive effect on the population of a state, resulting in a higher standard of living, and consequently, a more skilled, healthier, and educated population. These aspects create lower pressure on the healthcare system, higher levels of professionalism and expertise among workers, and an educated population that can contribute to building a safe and stable society.

Adequate infrastructure ensures efficient production of goods and services, reduces production costs, and leads to lower product prices. The effects of infrastructure development on the economy manifest in various sectors and over different timeframes, with short-term, medium-term, and long-term impacts (Azhgaliyeva, 2021). Additionally, infrastructure facilitates access to underdeveloped regions and improves communication, thereby ensuring the transfer of knowledge from developed areas.

Studies analyzing the economic results of infrastructure development in energy, water, and sewage are scarce. It should also be noted that investments in infrastructure networks

typically occur over several years, meaning that the effects of implementing projects may emerge with a delay.

Although all types of infrastructure influence the economy through the previously mentioned channels, the impact of each type of infrastructure on economic growth also manifests through specific channels. Furthermore, developed infrastructure attracts new flows of foreign direct investment to both developed and developing countries (Rehman et al., 2024). The lack of such infrastructure represents a disadvantage and has a negative impact, with investment flows and capital being directed to other countries with more developed infrastructure that offers lower costs and higher accessibility.

Most often, the results of infrastructure development largely depend on the quality of governance, and this relationship applies to all types of infrastructure. The real positive effect of infrastructure development on economic growth may be less than its potential due to poor governance quality. A high level of corruption can lead governments to direct infrastructure investments towards less productive projects.

Effective and high-quality governance is directly correlated with the prosperity of states, regions, cities (Stead, 2015), and rural communities, especially when prosperity is defined not only in terms of monetary wealth but also as a form of social wealth.

### 1.1. ECONOMIC IMPACT OF INFRASTRUCTURE

Studies show that infrastructure investments are a key element influencing national and economic competitiveness. Due to its public good nature, the provision of essential infrastructure—such as transportation networks, electricity supply, and telecommunications—is deeply integrated into the public sector, assigning the government the responsibility of ensuring robust and efficient infrastructure. Therefore, infrastructure investments are largely governed by government decisions and regulatory constraints. Government policy thus plays a decisive role in shaping infrastructure through decisions related to public investments and the regulatory framework.

The impact of infrastructure investments on the economy can be measured at two levels: micro (project or sector) and macro (national level). Economic infrastructure investments consist of two components: government investments in general economic infrastructure and infrastructure investments made by public corporations, together forming the total public investments in economic infrastructure within the country. As reported by Farkas (2019), the concept that institutions influence economic development is quite old; governance quality shapes the capacity for innovation, which represents a channel of influence on economic performance. In this context, government effectiveness, the rule of law, impartiality, and professionalism are fundamental characteristics of governance quality.

Infrastructure investments are one of the main prerequisites for enabling developing countries to accelerate or maintain their development pace. There is clear evidence of positive relationships between infrastructure investments, poverty reduction, job creation, and sustainable growth. Labor-intensive infrastructure construction programs, particularly in rural areas of developing economies, often generate short- and medium-term employment opportunities, thereby reducing rural poverty. Improved access to infrastructure in previously inaccessible areas, in turn, stimulates private sector investment, leading to additional job creation and economic growth (Kumo, 2012; Arif et al., 2021).

## 1.2. MAJOR TYPES OF INFRASTRUCTURE

### 1.2.1. TRANSPORTATION INFRASTRUCTURE

The role of expanding transportation infrastructure in stimulating economic growth in developed countries is complex and controversial. It can provoke debates regarding public investment in transportation infrastructure, especially when public funds are limited and there is high demand for investment in social sectors such as education, health, and social services. However, the importance of transportation infrastructure as a critical component of sustainable development is well-known (Khadaroo & Seetanah, 2007).

The transportation and logistics sector generates a considerable number of jobs. However, large traffic flows produce negative externalities for people, the environment, and consequently, profitability (Simionescu et al., 2021). Opponents of expanding infrastructure, particularly ports, airports, and roads, often highlight these negative effects and question the economic and profit benefits (Meersman & Nazemzadeh, 2017).

The impact of a transportation system on the national and regional economy depends on the level of economic development and varies between rural and urban areas (Hong et al., 2011). Due to specific characteristics of investments in transportation infrastructure, such as sustainable economic development and environmental issues, there are uncertainties related to their long-term effects under different economic and regional conditions.

Nevertheless, the general consensus is that transportation infrastructure contributes to economic growth and productivity, but not in a consistent manner over time. Transportation infrastructure facilitates business development, reduces product costs, provides access to suppliers and global consumer markets, and creates a more efficient global production process by lowering transportation costs and increasing accessibility.

An advanced transportation network provides faster, cheaper, more reliable, and more flexible transport services, which can lead to higher productivity in the manufacturing and production sectors. Public investments in infrastructure have some of the largest multiplier effects on GDP in the short term, particularly in developing and low-income countries.

Moreover, lower transportation costs facilitate access to supply and demand markets, expand markets for firms, provide access to a diverse and skilled workforce, and offer cheaper and higher-quality business services (Azhgaliyeva, 2021; Vickerman et al., 1999).

In the long term, sustainability in transportation technology and infrastructure will drive structural changes in national and regional economies, facilitating sustainable production systems, dynamic institutions, and integration into the globalization process (Farhadi, 2015; Pradhan & Bagchi, 2013).

### 1.2.2. ENERGY INFRASTRUCTURE

An effective investment strategy in energy infrastructure can bring multiple benefits by optimizing the allocation of energy resources and promoting coordinated development across regions. This can significantly reduce regional development inequalities. Facilities for telecommunications, potable water, and electricity play an essential role in boosting income in rural areas, thereby bridging the gap between rural and urban environments. In this context, we can conclude that investments in infrastructure are crucial for diminishing the differences between urban and rural areas.

Energy is a fundamental sector of the national economy, and energy infrastructure has the capacity to influence inclusive growth from various perspectives. Improving energy infrastructure not only reduces the costs of transferring energy resources but also promotes the accumulation and dissemination of productive factors across regions. This has a direct impact on social welfare by meeting basic demands for essential energy resources such as gas and electricity (European Commission, 2021).

Investments in energy infrastructure not only support economic development but also contribute to improving the quality of life for the population, particularly in disadvantaged areas. Thus, a well-founded strategy in this field can play a crucial role in creating a balanced and sustainable economic environment, reducing inequalities, and ensuring harmonious development across the entire national territory (Yang et al., 2020).

It is important to note that with the advancement of technologies and changes in energy consumption profiles, the challenges evolve. In addition to the current trend of transitioning to green energy in developed countries, developing countries face the issue of insufficient investments in modernizing and expanding their existing infrastructure (Klimek et al., 2024).

### 1.2.3. TELECOMMUNICATIONS INFRASTRUCTURE

Investments in telecommunications are increasingly recognized for their significant potential to boost economic productivity and growth. The expansion of the telecommunications sector generates positive effects on the economy, such as increased job creation. Thanks to telecommunications, companies can adopt flexible structures and locations, which contributes to the development and evolution of large, complex organizations (Rehman et al., 2024).

The convergence of Information and Communication Technologies (ICT), especially the Internet and its applications, has facilitated the low-cost spread of information technology products and numerous telecommunications services in developing economies. It is noteworthy that through increasing urban concentration on telecommunications, global telecommunications markets have enabled the development and implementation of new, competitive infrastructures (Rutherford, n.d.). This phenomenon has provided access to information and technology for a broad range of users and opened new opportunities for business and innovation.

As the telecommunications sector continues to expand, its impact on the economy becomes increasingly evident. It not only stimulates economic growth by creating new jobs but also facilitates the development of essential technological infrastructures for global competitiveness. Thus, investments in telecommunications are a crucial element in promoting sustainable economic development and reducing technological gaps between different regions of the world (Datta & Agarwal, 2004; Sridhar & Sridhar, 2009; Untari et al., 2019).

### 1.2.4. UTILITY INFRASTRUCTURE

Utility infrastructure plays a crucial role in economic development, being essential for creating a favorable business environment and improving the quality of life for the population. Investments in utility infrastructure, such as residential roads, water and sewage systems, electricity, and telecommunications, have a direct impact on economic competitiveness and sustainable growth.

Utility infrastructure forms the foundation upon which economic development is built. Strategic investments in this area not only support short-term economic growth but also create the

conditions necessary for long-term sustainable development. Countries that recognize and act on this critical link will be well-positioned to thrive in today's competitive global economy.

Access to reliable electricity and modern telecommunications allows businesses to operate efficiently, adopt advanced technologies, and improve labor productivity. Water and sewage networks contribute to public health and overall well-being, which can attract skilled labor and stimulate urban development.

Regions with well-developed utility infrastructure are more attractive to investors. Foreign direct investments are essential for economic growth, bringing capital, new technologies, and managerial know-how. Investments in utility infrastructure in rural and underserved areas can reduce regional disparities, stimulate economic development in these areas, and prevent excessive migration to cities.

Thus, effective governance can ensure efficiency in the provision of public services and, similarly, the optimal exploitation of public infrastructure capacity (Mallick, 2021), particularly concerning the broad accessibility of modern technology, provision of optimal living conditions, and creating an optimal environment for the development of a healthy society.

## 1.3. CONTEXT OF INFRASTRUCTURE AT THE EUROPEAN UNION LEVEL

Energy, utility, and transport infrastructure play a vital role in the integration and efficiency of the European Union (EU) internal market. These sectors are essential not only for the optimal functioning of the European economy but also for ensuring the mobility of citizens and goods. Furthermore, they are central to the strategic transformation of the EU towards a low-carbon economy in the medium and long term. The development of road infrastructure has significantly increased, sometimes outpacing the growth in road traffic for goods and passengers, while the expansion of electricity infrastructure has been aligned with electricity consumption, indicating an adaptation to current energy demands.

However, the availability and quality of infrastructure vary considerably across the EU. Although differences between older and newer member states have narrowed, reflecting the latter's recovery efforts, significant inequalities still persist. In some older member states, the quality of infrastructure has deteriorated due to insufficient maintenance spending and aging networks. This underscores the need for more efficient management and funding to maintain and improve existing infrastructure, thereby preventing its functional decline (Maciulyte-Sniukiene & Butkus, 2022).

Recent analysis of investment patterns in infrastructure among member states indicates signs of underinvestment in certain countries. In central Eurozone countries, there are clear signs of insufficient investment in both road and rail infrastructure, justifying the need for additional investments to ensure the optimal functioning of these networks. In the periphery of the Eurozone, there is an adjustment following a period of intense investment in roads, while in newer member states, investments in road and rail infrastructure have been higher than anticipated. This reflects the need for these countries to catch up with the rest of the EU, although their infrastructure stock remains below the EU average.

Investments in the energy sector have been dynamic in most member states, reflecting the transition to renewable and low-carbon energy sources, as promoted by the EU’s climate and energy strategy. This transition is crucial for achieving the EU's sustainability goals and reducing dependence on fossil fuels (European Commission, 2022a). Ongoing investments in energy and transport infrastructure not only support economic growth and competitiveness but also contribute to creating a cleaner and more sustainable environment for future generations. In this context, European-level coordination and efficient resource allocation are essential to ensure balanced and sustainable infrastructure development across all member states (European Commission, 2014).

Like other regions of the world, the European Union (EU) has placed significant importance on infrastructure investments, particularly focusing on transport infrastructure. These investments are crucial for achieving territorial cohesion, reducing economic disparities, and promoting economic development within the EU (Crescenzi & Rodríguez-Pose, 2012).

In recent decades, transport infrastructure across the 28 EU countries (EU-28) has experienced the fastest growth. The impact of this development on sustainability and economic growth has become a major concern for policymakers, economists, and entrepreneurs. Studies aimed at identifying the multiple impacts of transport infrastructure rely on both statistical results and fundamental economic theories (Cigu et al., 2019).

Transport infrastructure is essential for economic development and can act as a driver for promoting economic growth. However, transport infrastructure alone is not sufficient to guarantee economic growth. Transport capacities play a crucial role in small and open economies, where an efficient transport system facilitates international trade, thereby stimulating economic growth (Vlahinić Lenz et al., 2018).

Currently, the European Commission has presented a plan to ensure Europe's independence from fossil fuels from Russia by 2030, initially focusing on gas, in light of Russia's invasion of Ukraine (Yang et al., 2020). Accelerating and significantly expanding the use of renewable energy in electricity generation, industry, buildings, and transport will contribute to the rapid phasing out of fossil fuels from Russia. In the long term, this will reduce electricity prices and diminish imports of fossil fuels.

To meet the goal of producing, importing, and transporting 20 million tons of hydrogen by 2030, accelerated efforts in hydrogen infrastructure development are necessary. Although cross-border hydrogen infrastructure is still in its early stages, the foundation for planning and development has already been established through its inclusion in the revised Trans-European Networks for Energy. Total investment needs for key categories of hydrogen infrastructure are estimated to be between 28 and 38 billion euros for internal EU pipelines and between 6 and 11 billion euros for storage capacities (European Commission, 2022b).

Information and Communication Technology (ICT) encompasses "hardware, software, networks, and media for collecting, storing, processing, transmitting, and presenting information (voice, data, text, images)." According to Pradhan et al., ICT infrastructure includes "digital telephone networks, mobile phones, internet capacities, internet servers, fixed broadband, and other technologies."

At the EU level, various strategies have been adopted to enhance the use of cloud computing. While the benefits of this technology are widely recognized by researchers and decision-makers, Eurostat data indicate that only 21% of EU companies use cloud computing services (Vekeman, 2008). Additionally, there are significant differences between countries: in Finland, Sweden, and Denmark, over 40% of businesses use cloud computing, whereas in Greece, Latvia, Poland, Romania, and Bulgaria, the percentage is below 10%. This situation highlights the need for European and national policymakers to support the faster adoption of cloud computing across all sectors of the economy (Toader et al., 2018).

Water services are essential services. They support the sustainable development of our societies and are fundamental to achieving the EU Green Deal's ambition and the UN Sustainable Development Goals. However, little is known about them. This is because infrastructure is mainly underground, accessible only to a small number of service engineers, and sometimes located far from urban areas and protected for obvious security reasons. Additionally, the organization of water services varies from country to country due to history, cultural heritage, and national or local traditions, leading to specific regulatory frameworks.

Wastewater (and its by-product, sludge) contains valuable resources such as energy, phosphorus, nitrogen, other nutrients, and cellulose that can be recovered and reused in a circular economy to conserve rare or depleted resources (while minimizing associated negative impacts) and to stimulate economic growth and job creation. Treated wastewater can be reused under certain conditions. European legislation should stimulate innovation and allow the development of good practices for resource recovery. Incentives should be instituted to channel recovered resources to the market in a sustainable manner. At the same time, source control measures are essential to prevent hazardous substances from entering wastewater and threatening potential resource recovery (EurEau, 2020).

## 2. CASE STUDY: ROMANIA, GERMANY, AND BULGARIA

For a comparative analysis of infrastructure elements impacting economic outcomes, three EU member states have been selected based on their development levels: Germany, Romania, and Bulgaria.

### 2.1. GERMANY

Germany's infrastructure is distinguished by its efficiency and reliability, reflecting both the country's strong commitment to development and the results of a well-developed economy. With one of the most extensive and modern transport systems in the world, including highways, national roads, and a well-connected railway network, Germany facilitates both internal and international mobility. The country is also a global leader in renewable energy, boasting a diverse energy infrastructure and a commitment to becoming carbon-neutral by 2050. Its water and sanitation infrastructure is modern and efficient, ensuring access to clean drinking water and effective wastewater management nationwide. The construction and housing sector is marked by high standards of quality and energy efficiency, offering a range of housing options from urban apartments to rural homes.

Overall, German infrastructure reflects a deep commitment to quality, sustainability, and innovation, contributing to the country's economic success and the well-being of its population. By providing an extensive communication network and modern, well-connected infrastructure across all key areas, Germany continues to be a global example of infrastructural excellence.

### 2.2. ROMANIA

Romania has an evolving infrastructure with a focus on modernizing and expanding transport, energy, water, and communication networks. Efforts are being made to improve the highway and national road network, modernize railways and airports, and enhance both internal and international connectivity. In the energy sector, investments are directed toward expanding

production capacities and modernizing infrastructure to ensure energy security and promote the transition to more sustainable energy sources.

Projects in water and sanitation aim to improve access to clean drinking water and efficient wastewater management. Concurrently, investments in digital infrastructure are underway to support economic growth and innovation in information and communication technology. However, continued investments and modernization efforts remain essential to ensure a robust and sustainable infrastructure for the country's future.

### 2.3. BULGARIA

Bulgaria's infrastructure reflects a mix of progress and challenges, with a focus on modernization and ongoing development. The transport sector is a priority, with significant efforts to expand and improve highway, national road, and railway networks to enhance connectivity and transportation efficiency. At the same time, Bulgaria faces the need to modernize its energy and water infrastructure to support the transition to cleaner energy sources and ensure access to potable water and effective wastewater management. Investments in digital infrastructure are also underway to boost economic growth and innovation in information and communication technology.

Despite these efforts, Bulgaria continues to face challenges related to infrastructure quality and accessibility in some regions. Investments and modernization efforts remain crucial to ensuring a robust and sustainable infrastructure for the country's future.

## 3. PRACTICAL APPLICATION

To define the practical application, the three countries mentioned in the previous chapter (Germany, Romania, and Bulgaria) were analyzed. A total of 27 indicators were established to observe and analyze the situation regarding the infrastructure of these countries. In addition to the constructed physical infrastructure elements, comparative indicators were analyzed to provide

insight into the economic factors influenced by the existing infrastructure at the time of the analysis.

### 3.1. ESTABLISHING COMPARISON INDICATORS

The identified data were extracted from the existing database on the European Union website, under the name "EuroStat." For a more accurate and correct analysis, an effort was made to extract data from the same chronological periods. The extracted indicators are divided into four major categories: transport infrastructure, energy infrastructure, telecommunications Infrastructure (TIC) and utility infrastructure. The indicators are listed in the following table:

*Table 1.* ***Comparison Indicators for Infrastructure Elements***

| No. | Category | Indicator | Germany | Romania | Bulgaria |
|---|---|---|---|---|---|
| 1 | TRANSPORT INFRASTRUCTURE | Length of high-speed roads in 2022 (km) | 13 172 | 949 | 825 |
| 2 | | Length of national roads in 2022 (km) | 37 810 | 16 663 | 19 117 |
| 3 | | The length of county roads in 2022 (km) | 178 542 | 35 132 | Under 100 |
| 4 | | The length of municipal roads in 2022 (km) | 70 985 | 33 622 | Under 100 |
| 5 | | The amount of freight transported on the road infrastructure in 2022 (t) | 3 060 964 | 324 554 | 160 488 |
| 6 | | Total length of the railway network in 2022 (km) | 70 108 | 19 629 | 6 446 |
| 7 | | The total length of the electrified railway network in 2022 (km) | 43 336 | 8,500 | Under 100 |
| 8 | | Number of passengers transported by rail in 2022 (1000 people) | 2 505 856 | 70 464 | 23 065 |
| 9 | | The amount of freight transported on the railway infrastructure in 2022 (1000t) | 368 876 | 55 188 | 19 291 |
| 10 | | Number of major commercial airports in 2021 (no.) | 26 | 7 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| **11** | | Number of passengers carried by air in 2022 (no.) | 155 302 643 | 19 535 951 | 8 807 502 |
| **12** | | The amount of cargo carried on the air infrastructure in 2022 (t) | 4 938 859.1 | 47 636 | 26 457 |
| **13** | | Length of inland waterways in 2022 (km) | 7 675 | 2 763 | 470 |
| **14** | | The amount of cargo transported on maritime infrastructure in 2022 (t) | 279 177 | 60 260 | 30 731 |
| **15** | **ENERGY INFRASTRUCTURE** | Gross energy available per capita (Gigajoules/pers.) | 149.68 | 74.86 | 117.32 |
| **16** | | Energy consumption per capita in 2021 (Gigajoules/pers.) | 149.7 | 90.3 | 117.3 |
| **17** | | Energy intensity of the economy in 2021 (Gigajoules/1000 euros) | 3 837.9 | 3 125.7 | 6 329.9 |
| **18** | | Length of oil pipelines (km) | 3 112 | 2 370 | 571 |
| **19** | **TELECOMMUNICATIONS INFRASTRUCTURE** | Index of companies that have a high degree of digitization (percentage %) | 24.5% | 17% | 11.8% |
| **20** | | Index of households with internet connection (percentage %) | 91.41% | 89.41% | 87.31% |
| **21** | | Index of people who used the internet at least once in the last 3 months, according to 2022 data (percentage %) | 91.63% | 85.5% | 79.13% |
| **22** | | Index of people who used at least one e-government service in 2022 (percentage %) | 48.93% | 4.3% | 20.9% |
| **23** | **UTILITY INFRASTRUCTURE** | Investments in wastewater treatment (% of investments in water infrastructure) | 0% | 47% (795,006 million euros) | 58% (377,988 million euros) |
| **24** | | Investments in drinking water infrastructure (% of investments in | 0% | 0% | 38% (247,753 million |

| | | | | | |
|---|---|---|---|---|---|
| | | water infrastructure) | | | euros) |
| **25** | | Investments in water management and drinking water conservation (% of investments in water infrastructure) | 100% (8,774 million euros) | 53% (889,268 million euros) | 5% (29,851 million euros) |
| **26** | | The new population that benefited from drinking water in the period 2014-2020 (no. of people) | 0 | 493 167 people | 232 157 people |
| **27** | | The new population that benefited from sewerage services in the period 2014-2020 (no. of people) | 0 | 543 788 people | 292 542 people |

*Data Source: EuroStat*

## 3.2. ANALYSIS OF INDICATORS FOR EACH TYPE OF INFRASTRUCTURE IN CORRELATION WITH ECONOMIC DEVELOPMENT OF THE STATES

### 3.2.1. TRANSPORT INFRASTRUCTURE

Transport infrastructure is a critical factor for economic development. Germany, with its extensive and efficient infrastructure, supports a strong economy and high quality of life. Romania and Bulgaria, although growing, would benefit from additional investments in infrastructure to stimulate economic development and improve quality of life.

Germany clearly leads in all analyzed categories, possessing much more developed transport infrastructure and greater transport capacities than Romania and Bulgaria. Well-developed infrastructure facilitates job creation by attracting investment and promoting industrial and commercial development. Germany's extensive transport networks make it more attractive for businesses, resulting in a lower unemployment rate. Additionally, the advanced transport network significantly impacts the Human Development Index (HDI), indicating a higher quality of life supported by advanced infrastructure. Romania and Bulgaria, with high HDI but still

below Germany's, reflect differences in infrastructure and transport capacities that indirectly affect education, health, and income levels.

Romania has relatively well-developed infrastructure compared to Bulgaria but still significantly lags behind Germany in most categories. This highlights an acute need for investments in transport infrastructure to reduce the existing gap, both in terms of built physical infrastructure and to improve economic levels, ensuring a higher standard of living for each individual in the country.

### 3.2.2. ENERGY INFRASTRUCTURE

Germany is the most advanced in terms of energy and economic development, followed by Romania, with Bulgaria facing the most significant challenges regarding energy efficiency and infrastructure. Germany has the highest available gross energy and the highest per capita energy consumption, correlating with its high economic level and developed energy infrastructure. Bulgaria and Romania have lower values, reflecting less developed economies with lower energy demand.

Germany and Romania have lower energy intensities than Bulgaria, indicating more efficient energy use in economic production. Bulgaria, with high energy intensity, suggests a need for improvements in energy efficiency.

The length of oil pipelines is an indicator of energy infrastructure. Germany, with the most extensive network, can efficiently transport and distribute oil resources, supporting its industrialized economy. Romania has a considerable network, indicating a well-developed energy infrastructure compared to Bulgaria, which has the smallest pipeline network.

### 3.2.3. TELECOMMUNICATIONS INFRASTRUCTURE

Internet access is very high in all three countries, with Germany having the highest internet penetration rate in households. Romania and Bulgaria have very similar values, indicating good availability of internet connections nationwide. Germany has the highest percentage of companies with a high degree of digitalization, reflecting an advanced technological business environment. Germany leads in both company digitalization and public digital service usage, supporting its strong economy and high standard of living. Romania shows extremely low use of e-government services, indicating issues with the adoption and accessibility of public digital services.

Romania and Bulgaria have moderate digital performance, with evident needs for improvement in e-government service adoption and increasing company digitalization. Investments in digital infrastructure and digital education could contribute to economic growth and improved quality of life.

### 3.2.4. UTILITY INFRASTRUCTURE

The first observation from the perspective of edilitarian networks is that Germany has not invested in wastewater treatment and drinking water infrastructure, indicating that these systems are already well-developed and do not require additional investment. Romania has invested significantly in wastewater treatment and water management but not in drinking water infrastructure. This indicates a need for modernization and expansion of existing infrastructure to improve sewerage services and water conservation. Bulgaria has made major investments in wastewater treatment and drinking water infrastructure but very little in water management and conservation, indicating a need for development of basic infrastructure.

Since Germany already has universal coverage of these services, no new populations have been reported benefiting from water and sewerage services. In contrast, access to these services has increased in Romania and Bulgaria. These countries have significantly expanded access to drinking water and sewerage, reflecting major progress in water and sewerage infrastructure development, with a positive impact on public health and quality of life.

Germany has a well-developed water and sewerage infrastructure with a focus on sustainability and water resource conservation. On the other hand, Romania and Bulgaria are making significant progress in expanding and modernizing water and sewerage infrastructure, with a positive impact on health and quality of life.

## 4. CONCLUSIONS

Infrastructure is the backbone of economic and social development, having a profound impact on quality of life and economic competitiveness. Developing and modernizing infrastructure are essential for sustainable economic growth and reducing regional disparities. Infrastructure covers a wide range of areas, including transportation, energy, telecommunications, and civic infrastructure, each playing a crucial role in the efficient functioning of the economy and in enhancing quality of life.

Germany represents an example of excellence in infrastructure development, reflecting its strong commitment to quality, sustainability, and innovation. Germany's transportation infrastructure is among the most extensive and modern in the world, facilitating both internal and international mobility through advanced networks of highways and railways. Its energy sector is distinguished by diversification and a strong focus on renewable energy, with Germany aiming to achieve carbon neutrality by 2050. The water and wastewater infrastructure is equally modern and efficient, ensuring universal access to potable water and proper wastewater management. The construction and housing sector maintains high standards of quality and energy efficiency, contributing to the overall well-being of its population. Thus, Germany's infrastructure not only supports the country's economic success but also ensures a high standard of living for its citizens.

Romania is in a continuous process of developing and modernizing its infrastructure, yet faces significant challenges related to financing and efficient management. The transportation infrastructure, although expanding, requires additional investment to meet European standards of connectivity and efficiency. The energy sector is in a transition phase, with efforts to integrate renewable sources and modernize existing networks for more efficient energy distribution. The

water and wastewater infrastructure has benefited from significant European Union-funded projects, but significant disparities remain between urban and rural areas regarding service access and quality. Investments in housing and construction are focusing on improving energy efficiency and living conditions, although the pace of change is influenced by economic and political factors. In conclusion, Romania continues to make significant progress, but to reach an infrastructure level comparable to that of Western European countries, strategic management and effective mobilization of available resources are required.

Bulgaria is in a phase of infrastructure development, needing significant improvements to stimulate economic growth and reduce regional disparities. The transportation infrastructure, although developing, suffers from lack of connectivity and insufficient quality of roads and railways. The energy sector is marked by the need for modernization and diversification of energy sources, with an increasing focus on integrating renewable energy. The water and wastewater infrastructure has benefited from European investments, yet uneven distribution of resources and limited access in certain regions remain persistent issues. The construction and housing sector requires investment to improve energy efficiency and construction quality, particularly in rural and disadvantaged areas. In conclusion, Bulgaria must continue its efforts to modernize and expand infrastructure to ensure sustainable economic development and improve the quality of life for its citizens. The success of these initiatives largely depends on effective fund management and the implementation of coherent and sustainable policies.

In summary, infrastructure development is crucial for economic growth and improving quality of life. Strategic investments in transportation, energy, telecommunications, and civic infrastructure are fundamental for the efficient functioning of the economy and reducing regional disparities. Effective and responsible governance is critical to maximizing the benefits of these investments and ensuring sustainable and balanced development.

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