UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

AN ANALYSIS OF SMART ENERGY AND SMART MOBILITY IN CITIES: A COMPARISON OF LJUBLJANA AND SKOPJE

Ljubljana, February 2025 TEODORA KOCHISHKA

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LIST OF ABBREVIATIONS

BRT - Bus Rapid Transit
CEO - Chief Executive Officer
CO2 - Carbon Dioxide
CSR - Country Specific Recommendations
CSRD - Corporate Sustainability Reporting Directive
DCI - Digital Cities Index
DCS – Danfoss Climate Solutions
EBD - European Best Destinations
EBRD - European Bank for Reconstruction and Development
EEA - European Environment Agency
Ele.C.Tra - Electric Transport in Cities
EPDs - Environmental Product Declarations
ESG - Environment, Society, and Governance
EU - European Union
EV - Electric Vehicle
HVAC - Heating, Ventilation, and Air Conditioning
ICT - Information and Communication Technology
IoT - Internet of Things
ITSs - Intelligent Transportation Systems

JSP - Javno Soobrakjajno Pretprijatie
Km/h - Kilometres per hour
LCA – Life Cycle Assessment
LED - Light Emitting Diode
LPP - Ljubljanski potniški promet
MOL - City Municipality of Ljubljana
PM - Particulate Matter
QR - Quick Response
SBTi - Science Based Targets Initiative
SURS – Statistični urad Republike Slovenije

1 INTRODUCTION

In the face of global urbanization and environmental challenges, the need for sustainable urban development has never been more critical. Cities are under pressure to innovate in order to meet the growing demands for efficiency, environmental protection, and improved quality of life for residents. One of the most promising approaches to addressing these challenges is the development of smart cities and urban areas that leverage advanced technologies and innovative strategies to enhance sustainability, mobility, and energy use (Kozlowski & Suwar, 2021). This thesis explores the implementation of smart city strategies, focusing specifically on smart energy and smart mobility initiatives, through a comparative analysis of two mid-sized European cities: Ljubljana, Slovenia, and Skopje, North Macedonia.

In tackling urban challenges, smart mobility and smart energy have emerged as critical components of the smart city framework. Smart mobility refers to environmentally friendly and accessible transportation solutions that combine innovations such as car sharing, bicycle sharing, and electric scooter sharing (Bıyık et al., 2021). In addition to these efforts, smart energy programs aim to optimize energy production, distribution, and consumption using modern technology such as smart grids, renewable energy sources, and real-time energy management systems (Pandiyan et al., 2023). By examining the technologies, policies, and stakeholder involvement in these cities, the thesis seeks to uncover best practices, highlight barriers to implementation, and propose recommendations for improving sustainability and quality of life in urban environments.

Both Ljubljana and Skopje are uniquely positioned as case studies due to their similar geographical location within the Balkan region and comparable size, yet differing in their approach and progress towards urban sustainability. Many Balkan cities are still in the "planning" or "pilot" phases without fully adopting or evaluating smart city innovations. Ljubljana is one of the few Balkan cities moving faster toward the "act" phase, with concrete results and feedback integrated into smart initiatives. In contrast, Skopje's smart city policies are evolving at a slightly slower pace, which aligns with the assessment that many Balkan cities struggle to progress beyond early planning due to limited funding and stakeholder engagement, primarily because they are not part of the European Union (Nincević Pašalić et al., 2021). Ljubljana, a recognized European Green Capital, has implemented numerous successful smart city initiatives, particularly in areas of green mobility and energy efficiency (City of Ljubljana, n.d.). In contrast, Skopje faces more significant challenges, including high levels of air pollution and a slower adoption of smart technologies (Sofeska, 2017). However, both cities provide valuable insights into the successes, limitations, and future potentials of smart city initiatives in mid-sized cities.

This study employs both primary and secondary research methodologies, gathering primary data through interviews with key stakeholders, including developers and users of smart city services in Ljubljana and Skopje. The interviews provide critical insights into the real-world challenges and successes experienced during the implementation of smart city projects. Additionally, secondary data from existing literature and case studies will help contextualize the findings within the broader smart city landscape.

The purpose of this thesis is to explore best practices and key barriers in smart city initiatives and recommend improvements for enhanced sustainability and urban quality of life. The goal of this thesis is to analyze and compare how Ljubljana and Skopje have approached smart city development, particularly in the domains of smart energy and smart mobility. By selecting these two cities, the study provides insight into the differing strategies employed in similar urban settings within the Balkan region, offering a unique perspective on the obstacles and successes each city encounters. The research seeks to answer several key questions:

- What strategies have been most effective in achieving sustainability in smart mobility and smart energy?
- How have Ljubljana and Skopje adapted to the challenges posed by limited resources, infrastructural constraints, and citizen resistance to new technologies?
- How can these cities improve in terms of smart cities?

The next section introduces the concept of smart cities, providing definitions, dimensions, and categories, and further explores smart mobility and smart energy as key components of this thesis. Chapter three explores Ljubljana's smart city projects, emphasizing its position as Slovenia's capital and an EU member, along with improvements in smart mobility and energy sectors. Chapter four presents Skopje’s journey toward becoming a smart city, highlighting the challenges it faces in terms of sustainability and infrastructure. The fifth chapter conducts a comparative analysis between Ljubljana and Skopje, offering insights from interviews and key findings on smart mobility and energy in both cities. Finally, the thesis concludes with a discussion of the lessons learned, findings, and future recommendations for advancing smart city strategies for Ljubljana and Skopje.

2 SMART CITIES

The rise of smart cities is an interesting yet complex trend in urban sustainability. Even though smart cities are becoming increasingly popular, there is still a lot of confusion about what they really represent. This chapter looks at how to define smart cities and group their different concepts.

2.1 Smart city definitions and categories

Smart cities are hard to define because of their multidimensional nature, and so far, a universal and commonly accepted definition of a smart city has not been developed. Most smart city definitions emphasize the importance of advanced technologies, education, institutions, and human orientation. This approach allows us to establish four distinct categories, each based on the primary topic that most smart city definitions center around (Nam & Pardo, 2011).

The first category consists of descriptions that associate the city with various forms of technology. The incorporation of cutting-edge ICT (information and communication technology) and other forms of technical infrastructure into city planning and management is what gives this definition its technological edge (technological orientation). A possible definition of smart city refers to a well-defined geographical area in which advanced technologies such as ICT, logistics, and energy production cooperate to create benefits for citizens in terms of prosperity, inclusion, participation, environmental quality, and intelligent development. The future city center will ensure safety, protection, eco-friendliness, and efficiency by designing, building, and maintaining all its structures (such as power, water, and transportation) with high-tech materials, sensors, electronics, and networks that link to computer systems equipped with databases, tracking tools, and decision-making algorithms (Hall et al., 2000).

The second category focuses on education, learning, and human knowledge, which certain authors identify as crucial determinants of urban development (human orientation). In the context of human experience, a smart city can be defined as a location that encourages innovation and personal growth among its residents by fostering the exchange of ideas, culture, and life. A smart city emphasizes metropolitan areas, with a large share of the adult population having a higher education and using it for the greater welfare (Rios, 2008).

The third category covers smart city definitions that emphasize the institutional factors of urban development. From an institutional standpoint, the term smart city refers to cities that undertake various initiatives to improve environmental, social, and economic conditions of life, as well as their appeal and competitiveness. It is an interconnected system where human and social capital collaborate, employing technology to effectively attain sustainable development and a superior standard of living through the collaboration of all stakeholders.

The fourth and final category encompasses definitions of hybrid orientation. They connect the institutional, human, and technological aspects of smart cities. The term smart city refers to:

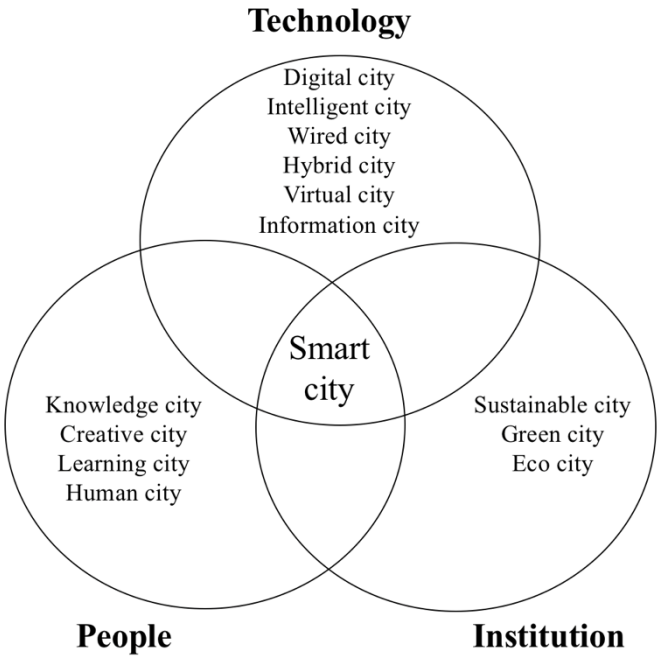
- a city where investments in human and social capital as well as traditional (transport) and modern ICT infrastructure lead to long-term economic growth and a high standard

of living, while natural resources are wisely managed and people have a say in how the city operates (Caragliu et al., 2011).

- A sustainable and effective city with a high quality of life aims to solve urban problems by utilizing its infrastructure and services, fostering collaboration among its main stakeholders (citizens, universities, government, and industry), integrating its core areas (environment, mobility, governance, community, industry, and services), and investing in social capital (Mosannenzadeh & Vettoriato, 2014).

Some argue that using adjectives like "digital," "intelligent," or "wired" instead of "smart" adds to the ambiguity in defining a smart city. It is essential to emphasize that the label defining a municipality signifies the technological (e.g., digital city), human (e.g., learning city), or institutional (e.g., eco-city) character of the framework employed in the municipality's advancement. By integrating multiple labels, as shown in Figure 1 (Nam & Pardo, 2011) with the concept of the smart city, it becomes evident that, while there is some degree of overlap, their interpretations vary. The smart city concept frequently incorporates terms that relate to more specific and exclusive levels of urban development.

Figure 1: Fundamental components of smart city



Source: Nam & Pardo (2011)

Building a smart city development plan is crucial because cities play a significant role in social and economic phenomena. The smart city has caught the attention of municipal authorities, communities, public institutions, and businesses in many cities, regardless of their size, geographical location, or cultural environment. However, the smart approaches that these entities adopt vary widely. This is due to factors such as cultural variety, social

awareness, investment in the research sector, and the degree of socioeconomic growth in the country, region, or city, all of which are linked to the resources available in smart city regions. Despite the fact that cities' experiences with implementing the smart city idea reveal varying approaches to smart initiatives, local governments share a common goal. They strive to improve both the quality of public services and the overall quality of life in cities. A city is smart if it improves its quality of life through the engagement of high-quality human and social capital, modern transportation, and ICT infrastructure (Kozlowski & Suwar, 2021).

2.2 Smart city dimensions

Although there is no universal definition of a smart city, there is currently a broad consensus regarding the acceptance of a six-dimensional smart city concept. It leads to the idea that a smart city is a city that combines economy, people, living, environment, government, and mobility using current information and communication technology. In continuation, let's delve deeper into the six-dimensional approach:

1. Smart economy refers to the city's competitiveness in terms of innovation, entrepreneurship, trademarks, labor market productivity and flexibility, and integration into the domestic market. ICT is used to advance e-business and e-commerce, as well as to expand prospects for production and service delivery, as well as to create new goods, services, or business models.
2. Smart people refer to the city's residents' education as well as social contacts connected to integration, public life, and openness to the world. ICT improves people's creativity and invention while also increasing the availability of education and training.
3. Smart governance is defined primarily by effective and efficient public administration, the quality of public services, and the engagement of people in local decision-making. E-administration makes use of information and communication technology to promote democracy and service delivery, as well as to assist public-sector choices.
4. Smart mobility includes the availability and accessibility of services, as well as information and communication technologies and sustainable transportation.
5. Smart environment refers to the natural circumstances of city life (e.g., green spaces), pollution and resource management (e.g., resource reuse and replacement), and environmental protection. Smart environment solutions include better waste management, the use of renewable energy sources, and green urban design.
6. Smart living encompasses all aspects of a high-quality life. City officials should prioritize residents' health, safety, culture, and living circumstances. Promoting tourism and disseminating information about entertainment events, leisure activities, and nightlife also plays a significant role (Patel, R. K., & Bhagat, S. S., 2019).

The smart city dimensions demonstrate that city growth is not solely dependent on concrete infrastructure (physical capital). The availability and quality of intangible capital (human and social capital) also play a big role. The city needs modern information and

communication technologies. Its operation is dependent on access to a communication network, mobile devices, and the infrastructure that connects them. In addition, ICT enables cities to adapt faster to changing resident needs and requirements, as well as optimize services.

In Southeast Europe, smart city research employing the six-dimensional approach has shown specific patterns and variations across these dimensions. According to Nincević Pašalić et al., cities in that area, including the main focus of this thesis, Skopje and Ljubljana, are implementing smart city frameworks, although their focus differs significantly. Regional environmental concerns and governance rules often highlight the importance of smart governance and smart environments. However, elements such as the smart economy and smart people remain undeveloped due to insufficient funding, limited public involvement, and infrastructure constraints. This is consistent with the wider European framework but also emphasizes the distinct regional issues that impact each dimension's implementation. Applying this six-dimensional approach to Balkan cities such as Skopje and Ljubljana gives a methodical way to assess both strengths and opportunities for improvement within smart city efforts.

Furthermore, the progress of smart city initiatives across Southeast European countries uses the Plan-Do-Check-Act (PDCA) framework. The PDCA framework is used to evaluate the maturity and progress of smart city projects. It demonstrates that most cities are still in the early "planning" stages, with few projects progressing to completion or follow-up phases. This lack of practical implementation is due to a number of problems, including, as mentioned, insufficient money, infrastructure constraints, and poor public participation. Later on, the thesis emphasizes the need for increased participation from private sector players and local communities to bridge this gap and advance projects. In this manner, Southeast European countries can strive to achieve the same efficiency and effectiveness as other European countries (Nincević et al., 2021).

2.3 Digital Cities Index

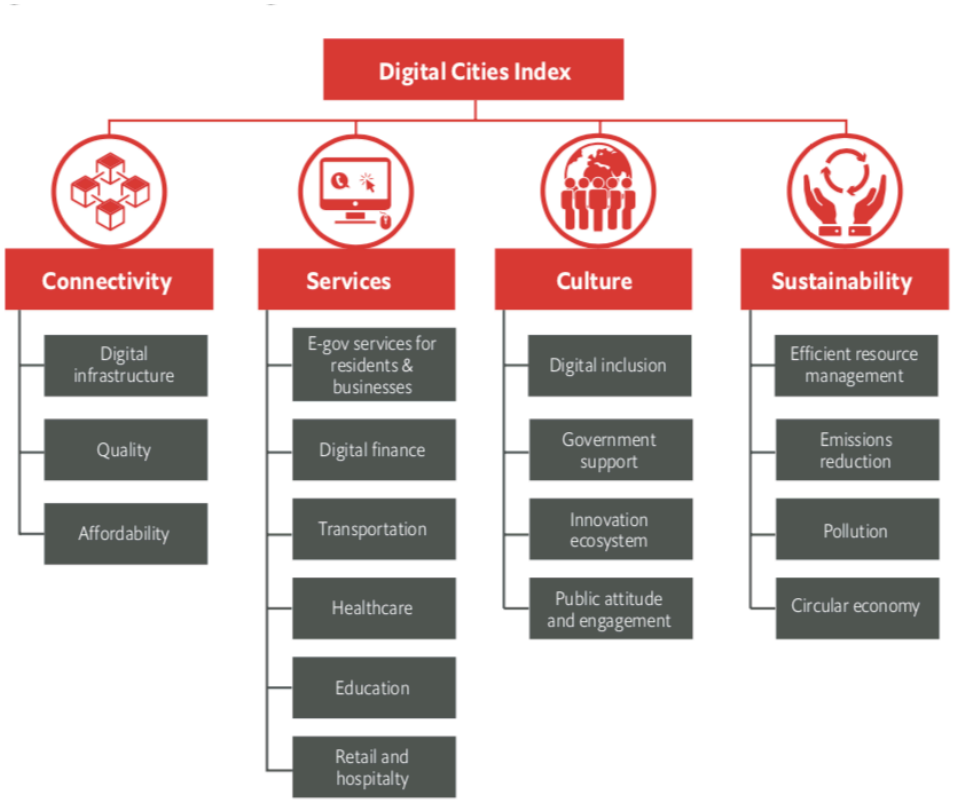
One of the metrics that helps measure the success of smart cities is the Digital Cities Index (DCI). The DCI provides a global ranking of 30 cities across four pillars: connectivity, services, culture, and sustainability. The index is a combination of most of the measures that determine the rank of the city. The process includes quantitative and qualitative analysis and a survey of 3,000 residents across all 30 participating cities in the DCI.

The Digital Cities Index includes the metrics listed below:

- Connectivity: This metric shows how well a city's infrastructure allows it to connect to online tools. It has three main parts: the actual infrastructure, the quality, and the cost of the infrastructure.

- Services: This metric aims to determine the extent to which individuals in the city can derive benefits from digital services and appreciate their ease of use and convenience. It also includes the integration of various services on digital platforms, as well as the openness and interoperability of digital service providers.
- Culture: This metric evaluates the degree to which technology has impacted people's lives. Things like the support of laws and institutions, the technology itself, and people's comfort level with digital tools all contribute to the ecosystem's ability to support and spread new technologies. This pillar also evaluates data security and privacy in cities.
- Sustainability: This metric measures the extent to which digital technologies promote environmentally friendly growth by optimizing resource management, reducing waste, reducing emissions, and transitioning to a circular economy. The Economist, 2022, evaluates different areas of the city based on their ability to utilize advanced digital technologies, such as digital twins in construction and smart monitors in air pollution and farmland, to optimize resource utilization and reduce waste production. Whole framework of Digital Cities Index can be seen in Figure 2 (Economic Impact, 2022).

Figure 2: Framework of Digital Cities Index

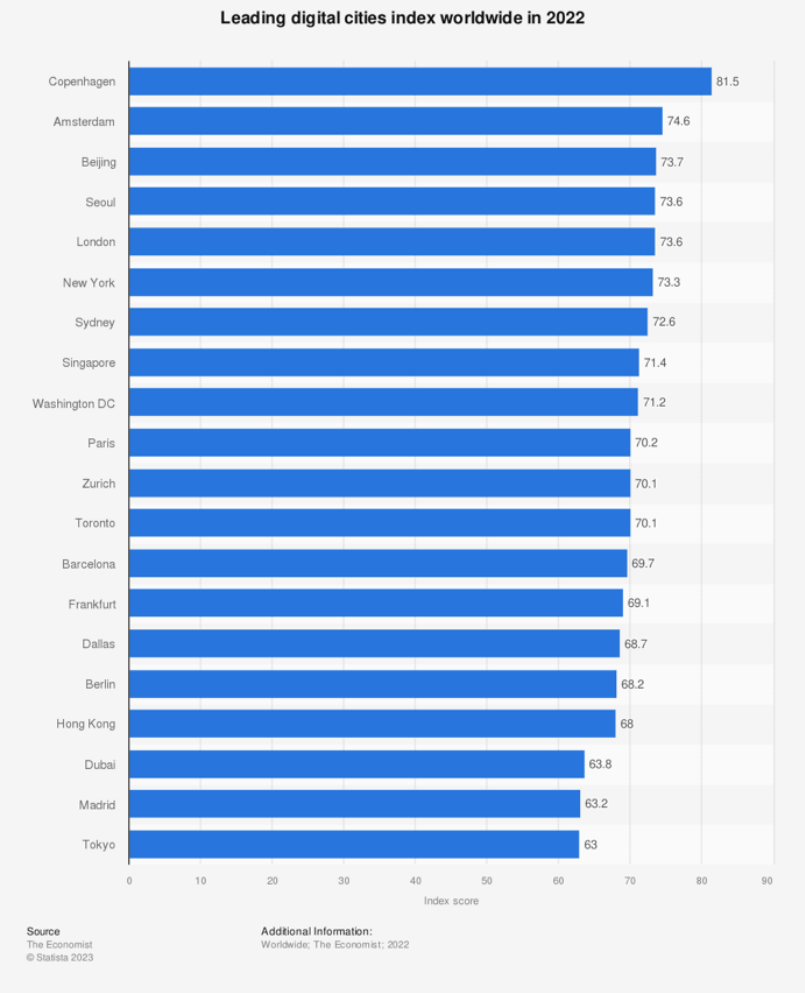


Source: Economic Impact (2022)

To get the scores shown in Figure 3, each of the four pillars (connectivity, services, culture, and sustainability) is broken down into a series of 48 quantitative and qualitative indicators. These indicators are first converted to a common scale and then weighted based on their

relative importance in measuring a city's overall digital maturity. In addition to objective data, such as internet speeds, adoption rates of digital services, and environmental metrics, the index also considers subjective insights from a survey of 3,000 residents across the 30 participating cities. By combining both measurable performance and user insights, the DCI aims to present a holistic picture of how effectively each city is leveraging digital tools to improve quality of life, foster innovation, and promote sustainability (Economic Impact, 2022). As for the top-performing cities in the DCI 2022, we have Amsterdam, Beijing, London, and Seoul. Copenhagen performed very well in all aspects, except for culture. The sustainability and connectivity pillars drove the high ratings of Amsterdam, Beijing, and Seoul, while London excelled in the sustainability pillar (Statista, 2023).

Figure 3: Leading digital cities index worldwide in 2022



Source: Statista (2023)

2.4 Smart mobility

One of the main focuses of this thesis is smart mobility. As with the explanations of smart cities, this section will guide you through the definitions and pillars of smart mobility. The

chapter highlights the potential for smart mobility solutions by looking at bus transit, car sharing, bicycle rental, and electric scooter services.

2.4.1 Smart mobility definitions

The overall idea of smart mobility relates to a mode of transportation that is comprehensive, eco-friendly, and sustainable. Urban mobility is improved through the implementation of Intelligent Transportation Systems (ITSs) and novel concepts made possible by the Internet of Things (IoT).

Particularly in big cities, traffic congestion and air pollution pose severe issues that are not sustainable in the future. Globally, urban transportation faces issues such as air pollution and inefficient resource utilization, which may hinder economic growth. Smart mobility, as a critical component of a smart city, has the ability to decrease traffic congestion, commute times, and road accidents while also allowing passengers to modify their travels. Building dependable, accessible, safe, and comfortable transportation networks connected to ridesharing technology and other channels is the first step.

The following factors influence the adoption of smart mobility technologies (Bıyık et al., 2021):

- Technological advancements: The rapid development of ICT
- Infrastructure: Availability and quality, such as transportation networks, digital connectivity, and intelligent transportation systems
- Stakeholder engagement: The engagement and participation of numerous stakeholders, including governments, city planners, residents, and enterprises
- Policy and regulation: Designing rules and regulations that promote and enable the use of smart transportation technology. This involves resolving legal and ethical concerns, as well as data privacy and security concerns
- Funding and investment: Sufficient financial resources and investment
- User acceptance and behavior: Embracing new technology and adjusting travel behavior
- Environmental and sustainability considerations: Influence on decreasing congestion, pollution, and increasing energy efficiency
- Education and awareness: Raising the public's awareness of the advantages and possibilities of smart mobility technology
- Data analytics: Effective data collection, management, and analysis provided by smart mobility technology.

This thesis focuses on bus transportation, car sharing, bicycle rental, and electric scooter rental. The services are often interrelated, which helps to design integrated and sustainable transportation solutions within smart city frameworks. However, we must keep in mind that

such technological advancements are evolving and will continue to influence, change, and extend the landscape of smart mobility services.

2.4.2 Bus transportation

Growing populations, rapid urbanization, and rising travel demand highlight the need for reliable public transit networks. A reliable bus service develops a larger, more satisfied, and more devoted customer base. The service should provide an affordable choice for daily passengers, particularly low-income and disadvantaged commuters (students, the elderly, and the physically challenged). Easy access to public transportation and trustworthy information regarding arrival, departure, and journey time attract more commuters. To promote sustainable mobility and enhance transit use, local authorities are attempting to combine diverse forms of transportation and reduce reliance on privately owned cars.

Delivering reliable public transportation can be challenging. It could be due to a variety of factors, such as traffic dynamics, differences in passenger demand, driver behavior, route unfamiliarity, and so on. Similarly, transit arrival information allows users to be better informed and utilize transportation networks in a safer, more coordinated, and smarter manner. However, in reality, unforeseen conditions pose challenges to journey duration prediction and the arrival of transit systems, particularly buses. It could be due to road geometric characteristics, variations in travel demand, incidents (crashes, mechanical breakdown of vehicles, construction activity, special events, weather, and so on), signals, bus stop locations, driving behavior, weather, and seasonal variations.

The following are some of the obstacles that citizens may experience while utilizing bus transportation (Mishra et al., 2023):

- Bus service may be unpredictable and inconsistent, resulting in delays and missed connections
- Buses might get stopped in traffic, leading to longer journey times and less dependable timetables
- Some places may have limited bus routes or irregular service, making it difficult for residents to readily utilize the bus system
- Bus stations may be difficult to reach for those with mobility issues, such as those in wheelchairs
- Some residents may feel insecure when waiting at bus stops or riding buses, especially in regions with high crime rates or poor lighting on streets
- Bus stations may be lacking in facilities such as shelters, benches, or real-time information monitors, making waiting unpleasant
- The cost of bus tickets may be expensive for certain residents, particularly those with low incomes or who depend on public transit regularly

- Bus service may not be available late at night or on weekends, restricting individuals' transit alternatives during certain times
- A lack of connection between buses and other means of transportation, such as trains or bike-sharing programs, may make multi-modal journeys difficult for residents to arrange
- Citizens may struggle to get accurate and up-to-date information regarding bus routes, timetables, and service disruptions

In spite of the drawbacks and challenges that residents often draw attention to, bus transit remains an essential form of transportation for both urban and rural locations. It is crucial to consider public feedback to ensure that the bus is perceived as a convenient, fast, and enjoyable mode of transportation. Naturally, it is important to follow the trends, such as the introduction of electric buses, fleet renovations, and new applications for tickets, all to ensure maximum comfort. Proving that public transit can be a convenient, quick, and environmentally friendly alternative can persuade even car owners to use it—after all, taking the bus is always a more affordable and sustainable choice.

2.4.3 Car sharing

Urban mobility and transportation play an important role in the city's well-being, but they can also cause a number of issues, such as polluting the air, insufficient appropriate car spacing, traffic, and noise pollution, all of which have negative effects on the environment, city welfare, and citizens' well-being. To help solve urban mobility difficulties, practical measures include supporting alternatives to carbon-fueled private automobiles and ideas that envision low-carbon modes of transportation. People have viewed smart mobility as a solution to reduce traffic, reduce car accident rates, enhance air quality, reduce carbon footprints, and establish a low-carbon economy in recent years.

Smart mobility facilitates real-time access to public information, leading to shorter travel times and more efficient journeys. It also fosters the development of a low-carbon economy by organizing shared commuting and promoting the use of EVs (electric vehicles). People view car sharing as a solution for sustainable urban mobility, as it reduces the number of owned cars through increased usage, thereby reducing carbon emissions and fostering more environmentally friendly transportation modes and urban environments.

The following are some of the major variables influencing the adoption of electric car sharing services (Vătămănescu et al., 2023):

- Environmental consciousness: Individuals’ views towards environmental sustainability, concerns about environmental protection, and lowering carbon emissions play a role in the choice to use electric car sharing
- Technological embracement: Those who are more open to new technologies are more likely to accept electric car sharing as a smart transportation option

- Perceived benefits of car sharing: Convenience, cost, comfort, and flexibility were recognized as major variables affecting the adoption of electric car sharing. Individuals who value these advantages are more likely to use electric vehicle sharing services
- The importance of smart mobility: People who emphasize smart mobility are more likely to choose electric car sharing as a mode of transportation.

Car sharing has many advantages, but it also has limitations (Vătămănescu et al, 2023):

- Initial investments and operational costs: Car-sharing services involve considerable upfront investments in cars, technological infrastructure, insurance, and maintenance
- User behavior and trust: Car sharing requires responsible vehicle usage and compliance with terms and conditions. Vehicle damage, theft, or abuse may harm service trust and raise vehicle maintenance and repair costs
- Competition and market saturation: Many car-sharing firms compete for market share
- Infrastructure limitations: Car-sharing services need electric car charging outlets, parking, and designated drop-off and pick-up sites. Poor infrastructure may impede car-sharing businesses' growth and user access.

As shown by Abouee-Mehrizi et al., 2021 EVs can only be implemented if the charging speed, the number of charging stations, and the range of EVs are high enough. The most crucial factor is the charging speed, and the number of charging stations is more significant than the range of EVs. This is due to the fact that if there aren't enough charging stations, then people would not like to either own or rent these EVs because the car's battery wouldn't last enough for longer rides. There are also scenarios where people may rent these EVs with only half-charged batteries, leading to a question about whether the EV would even last on short journeys. The same applies to charging speed; if it takes too long, people may be short on time and lose a significant amount of time waiting for the car to recharge. Therefore, charging stations and recharging speed play a crucial role in providing people with a valid reason to switch to EVs instead of traditional cars (Abouee-Mehrizi et al., 2021).

Supported by real-time technology, encouraging the use of electric cars and car-sharing services may improve the general well-being of city residents and result in more effective, sustainable urban mobility. Car sharing operators, legislators, regulators, and other interested parties need to collaborate to overcome these issues and create an atmosphere that supports environmentally friendly transportation. And most importantly, create a transportation system that will support the needs of citizens so that they can easily use this service and bring greater benefits to their busy daily schedules.

2.4.4 Bicycle sharing

The demand for bicycle-sharing systems as a sustainable alternative for transportation is increasing. These systems combine the benefits of biking—affordable cost, autonomy, flexibility, accessibility, and health benefits—with the benefits of renting rather than

owning. Significant expertise has already been gathered in the areas of security, insurance, and liability, bicycle distribution, information technology system applications, planning, management, and pre-launch considerations (Efthymiou et al., 2013).

Bicycle sharing programs have arisen as a practical and ecologically beneficial mode of transportation in cities worldwide. Research on bicycle sharing strategies is expanding at a rapid pace, but important gaps remain. For example, usage rates in many cities continue to fall short of expectations, and governments are concerned about the long-term viability and supportability of these bike-sharing systems. As a result, corporations and academics are starting to investigate not just use trends but also users' and potential users' opinions of bicycle sharing in order to find strategies for increasing utilization.

Some obstacles to adopting bicycle sharing systems (Wang et al., 2018):

- When compared to alternative means of transportation, users may not see enough value in adopting bicycle sharing programs
- Users may find it hard to utilize the system if it is not readily accessible or if there are problems with bike availability or station placement
- Users may be unwilling to embrace the system if the perceived quality of the bicycles or the whole system is poor
- Additional costs connected with utilizing the system, such as membership or use fees
- Unfavorable weather conditions, such as rain or excessive heat
- The availability of bike lanes, parking facilities, and support from public and private entities
- System management issues, such as bike maintenance, station capacity, and bike balance.

Despite the inevitable challenges, people have increasingly embraced bicycle-sharing programs because of the freedom they provide. Instead of owning a bicycle, you can rent one at any time, leave it at any station, and not have to worry about storage, theft, or maintenance since a rental is always available when needed. Even people who own bicycles would find it comforting to be able to rent one when necessary.

2.4.5 Electric scooter sharing

Electric scooter sharing systems have proven to have several advantages for both people and society since their introduction in 2017, including simple green mobility, especially over short to medium distances, and decreased travel costs. People see them as potential solutions to various transportation-related environmental challenges, such as noise and air pollution. Furthermore, they provide several benefits, such as convenience of use, ease of access, and cost-effectiveness; fewer demanding criteria for parking and moving space, similar to shared bicycles; and the ability to increase access to transit stations and parking lots.

There are specific challenges that individuals face when adopting electric scooters (Samadzad et al., 2023):

- Concerns about privacy and invasion of personal space may influence people's willingness to use electric scooters. Users may have privacy issues about the collection, storage, and analysis of their movement data, as well as the sharing of their personal information
- When it comes to electric scooters, safety is a major issue. Users may be concerned about accidents with other cars or pedestrians
- Electric scooters often have a limited battery life, which may be difficult for users who depend on them for longer distances or for lengthy periods of time. It might be annoying to have to recharge or locate available scooters with a suitable battery
- Some people may struggle to utilize the internet interfaces or apps linked to shared e-scooter services
- Although people typically perceive electric scooters as more environmentally friendly than fossil fuel-powered cars, concerns may still exist regarding their overall environmental impact. Concerns about the sustainability of battery manufacture and disposal may influence individual adoption choices.

Electric scooters are a relatively new concept that will take some time to gain broad acceptance and usage. Regardless, their goal is to deliver simpler, faster, and more sustainable transit around the city. Electric scooters may become an important part of urban transportation solutions by solving issues such as safety, battery life, and environmental effects.

2.5 Smart energy

The other core topic of this thesis is smart energy, a more technical aspect of modern technology that aids in reducing emissions and promoting smarter energy usage. Smart energy development relies on both public and private enterprises, with municipalities optimizing infrastructure and promoting sustainability, while private companies drive innovation through energy-efficient technologies. They ensure the integration of renewable energy sources, reduce carbon emissions, and enhance energy management systems. Throughout this thesis, we will see how Skopje and Ljubljana have different influences and successes in this field.

2.5.1 Smart energy definitions

Smart energy is the optimization of energy production, distribution, and consumption through the use of cutting-edge technology and creative ideas. It entails the integration of digital technologies, such as smart meters and smart grids, to allow for more sustainable and effective energy management. The goals of smart energy are to lower greenhouse gas

emissions, boost the integration of renewable energy sources into the electrical grid, and improve energy efficiency. Smart grids, smart meters, and energy-saving systems are a few examples of smart energy technology. With the use of these technologies, people and cities can more accurately monitor, manage, and comprehend their energy use, which will minimize energy waste and pave the way for a more sustainable energy future.

Managing energy consumption in cities presents several challenges. One of the main issues is the imbalance between energy supply and demand. As cities grow, so does their energy consumption, resulting in a mismatch between energy supply and demand. Increased energy production often fills this gap, potentially leading to increased carbon emissions and environmental damage. Furthermore, city energy infrastructure is often outdated and inefficient, resulting in large energy losses during transmission and distribution. This inefficiency gets worse with a lack of real-time energy monitoring and management systems, which may make identifying and addressing energy inefficiencies difficult. Finally, cities must deal with unpredictable energy costs as well as a lack of proper financing for energy infrastructure projects, which may hinder the adoption of new energy technology. In order to maximize energy production, distribution, and consumption in smart cities, technical breakthroughs are necessary to tackle these obstacles. Renewable energy integration, smart grid development, energy-efficient building and appliance usage, real-time energy monitoring, and management system installation are all examples of these innovations (Gimpel et al., 2020).

Technological advances in recent years have significantly addressed the problems of smart energy management in smart cities. The following are a few significant technical developments in the field:

- Smart grids: Designed to monitor and control the distribution of electricity across the grid. Smart grids make use of sophisticated sensors, communication technologies, and clever algorithms. They make it possible to monitor energy supply and demand in real time, which enables efficient energy distribution optimization that reduces waste
- Renewable energy sources: Another crucial development in smart energy management is the use of renewable energy sources, including solar, wind, and geothermal energy. These energy sources are economical, environmentally friendly, and contribute to lowering carbon emissions
- Energy storage: Another essential component of smart energy management has been the creation of economical and effective energy storage technologies. In times of high energy demand, we can store and consume excess energy from renewable sources, ensuring a consistent and reliable energy supply
- Smart buildings: Since buildings account for a significant portion of urban energy consumption, the creation of energy-efficient structures is crucial for smart energy management. Smart buildings utilize advanced energy management systems like HVAC

(Heating, Ventilation and Air Conditioning) and lighting controls to optimize energy efficiency and reduce waste

- Electric vehicles: EVs have the ability to reduce carbon emissions and enhance city air quality. The development of EV charging infrastructure and the incorporation of renewable energy sources to power these cars are critical for intelligent energy management
- Smart home: A smart home is one that has internet-connected appliances to automate, optimize, and regulate many aspects of life, such as lighting, entertainment, security, and temperature. For residents, it offers convenience, energy efficiency, and a higher standard of living
- Data analytics: Another important development is the use of data analytics in smart energy management. In order to identify inefficiencies, optimize energy usage, and reduce expenses, data analytics enables the collection, analysis, and comprehension of energy use data.

In general, technical developments provide a variety of advantages, including enhanced efficiency, lower prices, and improved sustainability. Smart cities may improve energy production, distribution, and consumption by integrating these technologies into energy management systems, resulting in more livable, sustainable, and efficient urban settings (Pandiyan et al., 2023).

2.5.2 Smart energy public enterprises

Every city has its own public institution that takes care of activities that affect citizens' well-being. In this thesis, the main focus is Skopje and Ljubljana. Institutions like the City of Skopje and MOL (City Municipality of Ljubljana) represent the local administrative bodies responsible for governing their respective cities and play a pivotal role in the development of smart energy systems in cities by integrating energy planning into broader urban and territorial management. Their responsibilities include optimizing energy infrastructure, ensuring the utilization of renewable energy sources, and aligning energy systems with sustainability goals. This involves coordinating across sectors such as residential, industrial, and transportation to create a unified, efficient energy network. The idea is to use the technology in a smart way to have cleaner air, less traffic, and satisfied citizens.

Moreover, municipalities motivate citizens to engage in specific training programs to enhance their knowledge on the crucial subject of smart energy. They strive to promote smart energy as a tool that will ease and improve citizens' lives. Additionally, they offer various incentives, such as free bus rides so they don't use polluting cars, discounts on electric vehicles, free installation of air conditioning chimney replacements, discounts for incorporating a smart mobility system into your home, and similar initiatives, all aimed at fostering the development of energy-efficient and self-sustaining communities. Obviously, any such initiative can backfire—for example, in Slovenia and Macedonia, free public transport for retirees led to congestion on buses.

Municipalities support pilot projects and smart energy demonstrations, which test technologies like smart grids and energy storage. Beyond the technical aspects, municipalities also address social and economic factors such as energy poverty, ensuring that smart energy systems are both affordable and inclusive. The main drawback of these public projects is their reliance on public funds, which can often result in lengthy wait times or disruptions due to government changes (Ceglia et al., 2020).

2.5.3 Smart energy private enterprises

Another way to utilize and develop smart energy solutions is through private corporations. Private companies in the smart energy sector play a crucial role in driving innovation and the production of energy-efficient technologies. For this thesis, we used Danfoss as an example. These types of companies typically focus on developing advanced products that help reduce energy consumption. By producing key components such as thermostatic controls, energy-efficient heating and cooling systems, and smart energy management solutions, they contribute to the broader goals of sustainability and decarbonization.

In addition to their technological contributions, private companies in the smart energy sector often lead the way in global efforts to transition to greener technologies. They provide essential products and services that support energy management, helping cities and businesses implement smart energy solutions that reduce costs and minimize environmental impact. Through their efforts, they play a pivotal role in advancing the smart energy agenda and supporting the shift toward more sustainable energy systems.

Being a private company offers benefits such as increased independence in making financial and project decisions. The intriguing thing about these corporations is their freedom to start as a local family business, and since the world is so open now, there are countless opportunities for expanding that business in other countries. By doing so, the newly opened company in another country will have the privilege of leveraging the experiences of the foreign company to enhance its performance in that particular field, in this case, the smart energy sector (Erlandsen & Svendsen, 2023).

3 LJUBLJANA SMART CITY

Ljubljana, the capital of Slovenia, is one of the cities chosen for this thesis analysis. I chose Ljubljana for my master's thesis because, despite its high population and tourist visits, it manages to maintain a high level of cleanliness and sustainability. Through an analysis of Ljubljana's green initiatives, the chapter dives into its approach to being a green city, environmentally friendly, having car-free zones, and engaging citizens in smart city initiatives.

3.1 Ljubljana green capital

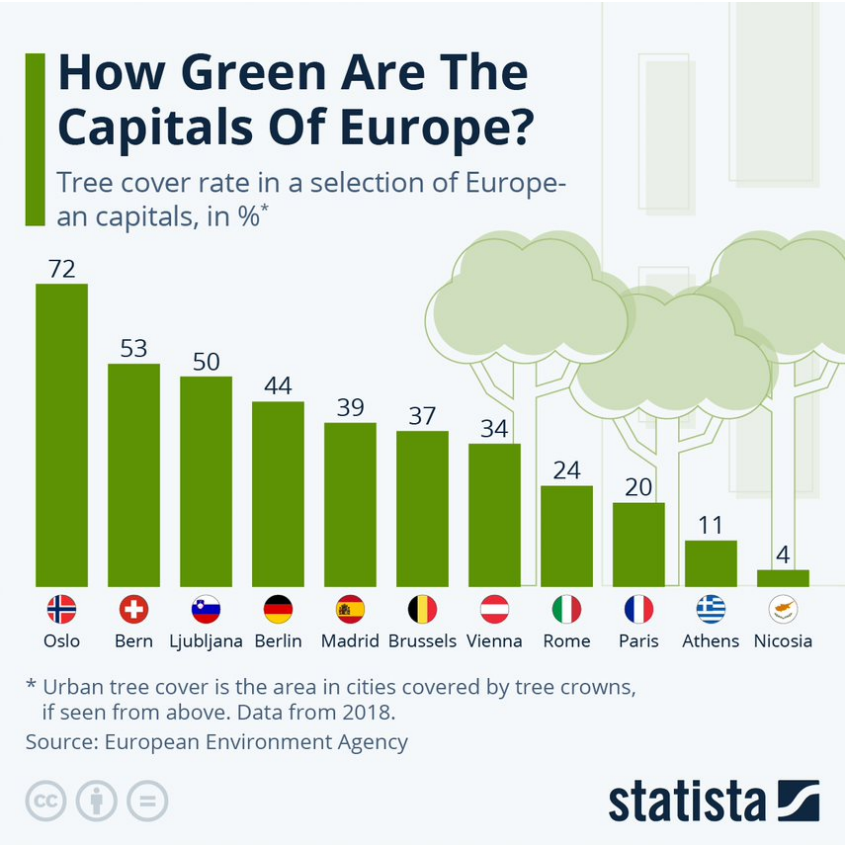
This section highlights some of the city's green projects over the past few years. Despite its modest size, Ljubljana has made efforts to become one of the leading cities in Europe in promoting sustainability. The city’s many efforts include recycling, keeping the city clean, innovative public transportation, smart mobility rental options, and innovative smart energy technologies.

Dating back to 2016, Ljubljana, the capital of Slovenia, earned its first title of European Green Capital, a recognition by the European Commission for its dedicated efforts to enhance the environment, economy, and overall quality of life. This initiative aims to acknowledge cities that strive to meet environmental standards, establish goals for further sustainable development, and serve as inspiring models for others to follow. Ljubljana's green program involved activities such as waste management, local self-sufficiency, sustainable tourism, and biodiversity. District communities, public institutes, schools, and various organizations actively participated, organizing over 220 green activities within their respective areas. The recognition as a European Green Capital not only positioned Ljubljana prominently on the European and global map of sustainable cities, but it also contributed to the promotion of a higher quality of life for its residents (City of Ljubljana, n.d.).

Urban areas should have green spaces for a number of reasons. In addition to offering communities spaces to unwind, exercise, and interact, they also attract wildlife and aid in the battle against global warming by storing carbon dioxide. Trees, with their ability to provide shade and evapotranspiration, reduce a city's temperature by several degrees during heat waves. When looking at 38 of Europe's cities from above, trees occupy 30% of the area on average, according to statistics from the EEA (European Environment Agency). Oslo, the Nordic city, has the highest percentage of green space at 72 percent, followed by Bern, Switzerland, at 53 percent, and Ljubljana at 50 percent, as is shown in Figure 4 (Fleck, 2022).

In 2021, Ljubljana reached its peak and climbed to the top of the ranks. European Best Destinations ranked the city number one among the 20 Best Green Capitals in Europe. The EBD (European Best Destinations) organization evaluated a number of sustainability factors, including air and water quality, zero-emission public transport, the number of kilometers of cycle paths, green spaces per resident, the percentage of people who walk, cycle, or take public transportation to work, and quality of life, in order to compile its new list of the 20 Best Green Capitals in Europe. For 2022, Ljubljana was the top choice. In addition to its ranking as the number one European Green Capital, Ljubljana is the only European city to have been included six times on the Sustainable Destination Top 100 list.

Figure 4: How green are the capitals of Europe?



Source: European Environment Agency (2018)

Since 2008, Ljubljana Center has been car-free, with over 542 square meters of green spaces, including the Bee Trail, which takes in 4,500 hives placed around the city and offers free access to a bike-sharing scheme for up to an hour. Ljubljana is a bike-friendly city, with almost 200 kilometers of bike routes and the highest percentage of home garbage separation in the EU (European Union) at 70% (GOV.SI, 2021).

3.2 Ljubljana smart mobility

Smart mobility services that are available for use in Ljubljana address a variety of new efforts aimed at transforming urban mobility. For the past few years, Ljubljana has been embracing sustainable mobility solutions, including efforts by LPP (Ljubljanski potniški promet d.o.o) to improve public transportation, Bolt's introduction of electric scooters, Avant2Go's eco-friendly car-sharing service, and BicikeLJ's bicycle-sharing system. The overall goal is to create a greener and more accessible urban environment while using fewer cars, which pollute cities and cause enormous traffic on a daily basis.

3.2.1 LPP

LPP promet is the main bus company in Ljubljana. The primary objective of the public company LPP is to make sure that public transportation in the MOL and sixteen neighboring municipalities is safe, reliable, and effective. LPP primarily focuses on promoting buses as a superior and more popular alternative to private cars. The idea is to eliminate the use of private cars in cities to reduce traffic and air pollution. LPP strives to achieve its goals through strategic initiatives, including the acquisition of new, modern, air-conditioned, and environmentally friendly buses.

As the owner and creator of LPP d.o.o., JAVNI HOLDING Ljubljana d.o.o. shows how important public transportation is to the city's infrastructure. LPP offers a contactless payment system using the Urbana reusable card, eliminating the need for single-use tickets. You can use the Urbana single city card as a contactless smart card to quickly and easily pay for Ljubljana city bus rides without cash. It can also be used for cable car rides to Ljubljana Castle, parking fees in white zones, lots run by Javno podjetje Ljubljanska parkirišča in Tržnice, and services at the Ljubljana City Library. Ljubljana was one of the first cities in Europe to use a single payment method for all city services (Ljubljanski potniški promet, n.d.).

People who already have an Urbana Single City Card can switch to the new Urbana mobile app, which turns their phones into virtual cards. Users can buy interstate bus tickets without having to talk to the driver, easily let drivers know about disabled riders that need assistance, and pay for parking online. The app also lets users check their account amounts, see their confirmation records, see when buses are coming and going, plan their trips around the city, and get useful journey information (Dnevnik, 2023).

LPP has made efforts to enhance the quality of its services by upgrading the bus fleet, improving the bus arrival system, and introducing separate bus lanes on major roads. By introducing separate bus lanes, the buses would be a faster alternative to cars that cause most traffic during peak hours. Additionally, the introduction of an electronic payment system in 2010 has provided valuable data on passenger behavior, allowing for data-driven insights that help in analyzing travel patterns and making informed decisions for future improvements to the transport network (Koblar & Mladenovič, 2020).

3.2.2 Bolt

Bolt, an Estonian mobility company, started renting out electric bikes in Ljubljana in July 2022. As a result, the city became part of Bolt's network of urban mobility options. As a smart mobility service, Bolt aims to simplify transportation and improve the environment through the use of electric scooters instead of cars.

Since scooters have proven to be somewhat risky, Bolt prioritizes safety and has established some ground rules for users to follow. The aluminum-made scooter boasts safety features like front and back lights for enhanced visibility, inflated tires for enhanced grip, and additional safety features in the app, including a beginner mode for new users. To use the service, users must have the Bolt app, register, and link their Bolt account to a credit card or Apple Pay. Bolt's project in Ljubljana fits with its mission to provide sustainable and easy-to-use urban transportation options, which helps reach the larger goal of making towns in Europe more welcoming to people and easier to get around (Bolt, n.d.).

So even though e-scooters have rapidly grown in popularity across cities worldwide, people have started questioning whether they are a “delightful slalom” or “injury epidemic” (Janikian et al., 2024). A significant increase in injuries and fatalities has accompanied this rise, raising public health concerns. E-scooter use is associated with several risky behaviors, including low helmet usage, alcohol impairment, underage riding, two people driving one scooter, speeding, and rider distraction. Various environmental factors, such as crash locations (e.g., sidewalks, bike paths), parking issues, road surface conditions, and insufficient nighttime visibility, all play a role in e-scooter safety. Additionally, design limitations, like brake failures and stability issues on rough terrain, contribute to the risk of accidents. There is a need for policies and interventions to address these safety issues, such as enforcing helmet use, regulating alcohol use, implementing speed limits, and improving rider education and enforcement (Janikian et al., 2024).

With the launch of Bolt electric scooters in Ljubljana, the city has joined a larger network of sustainable urban transportation alternatives. Although these scooters aim to serve as a practical and environmentally friendly option for short journeys, there is still a significant need to implement safety measures when using this service. Some people are still skeptical about using this service, while others are reckless while driving the scooters. However, given the recent introduction of this invention, more time is required to utilize these scooters effectively.

3.2.3 Bicikelj

The BicikeLJ bicycle-sharing system in Ljubljana offers a convenient and eco-friendly solution for urban mobility. People can easily rent bikes for short rides of up to an hour from self-service stations placed around the city center. To enhance user convenience, renters can return their bikes to the closest docking station within an hour, wait for a period of approximately five minutes, and then rent a new one at no cost again.

Since its inception in May 2011, the BicikeLJ self-service bicycle rental system has played a pivotal role in providing residents and visitors of Ljubljana with an accessible alternative for urban transportation. The system has witnessed steady growth, expanding from 30 stations with 300 bikes in 2011 to 82 stations with 820 bikes in recent times (2023). A

dedicated team operates the self-service bicycle rental system around the clock, ensuring its smooth functioning and addressing maintenance needs *(*City of Ljubljana, n.d.).

The BicikeLJ system is affordable and simple to register. You have to register online for free, and there is a small subscription fee of €1.00 weekly or €3.00 annually to use the system. Terminals at docking stations provide information on available bicycles and the locations of other BicikeLJ terminals. Upon registration, users authorize the system provider to charge their credit card up to €350 as a deposit in case of bicycle damage, disappearance, or failure to return it within the specified timeframe.

Bicikelj is part of a public-private partnership between Europlakat d.o.o. and the City of Ljubljana. The services contribute to Ljubljana's status as an eco-friendly city by promoting sustainable transportation alternatives, reducing reliance on private cars, and promoting a bike-friendly urban environment. The system provides locals and tourists with an accessible and affordable way to navigate the city (BicikeLJ, n.d.).

Ljubljana recently introduced a new bike-sharing system called Nomago bikes. Nomago Bikes is an electric bike-sharing service that offers residents and visitors in Ljubljana access to bicycles for short-term use. Individuals can easily rent those bicycles through a similar system. Nomago Bikes poses a potential threat to Bicikelj, suggesting that Bicikelj should consider implementing electric bikes themselves. These past few years, the topic of e-bikes has been very popular, purely because it is easier to drive them without getting tired, and you arrive faster from point A to point B. People choose e-bikes for a variety of reasons, including the fact that most cities, such as Ljubljana, have a lot of hills that may tire you out in the first few minutes, especially with bikes as heavy as the Bicikelj ones (Dnevnik, 2022).

While BicikeLJ has become a popular mode of transportation in Ljubljana, it faces various limitations. The system primarily covers the city center and important routes, rendering suburban and rural inhabitants inaccessible. This restricted reach limits its utilization outside of major cities, while excessive demand in popular areas often results in bike imbalances, especially during peak hours. Addressing these distribution difficulties is critical for improving availability and user experience across the city. Although BicikeLJ improved Ljubljana's public transportation system, extending station sites and combining with other transit alternatives might improve "first and last mile" connections (Bauchinger et al., 2021). The emphasis is on installing stations in high-traffic locations such as supermarkets and office buildings, ensuring that people can easily hire bikes for a variety of reasons, such as going to work, school, or just going to the supermarket. This proactive approach would resonate with Bicikelj's objective of smoothly integrating sustainable mobility into the city's citizens' daily routines (Dnevnik*,* n.d.).

3.2.4 Avant2go

Avant2Go is a car-sharing service that envisions a greener and more sustainable urban landscape. The vision is a city where emissions and noise are minimized through the use of the latest technology—electric vehicles. The core idea is to make driving hassle-free, with efficient parking solutions and expenses incurred only when needed, thereby saving both time and money.

Car-sharing services' idea is to free people from the responsibilities of owning a car, as well as reduce the world's reliance on polluting fuels. Companies can optimize their vehicle fleet and cut mobility costs by avoiding the financial burdens of vehicle ownership. Avant2Go promotes an environmentally friendly approach, with a fleet consisting of 100% electric vehicles, free from harmful CO2 (Carbon Dioxide) emissions and adaptable to renewable energy sources. Individuals can use vehicles only when needed, leading to significant cost savings and the potential elimination of kilometer allowances (Avant2Go, n.d.).

Although Avant2Go and almost all car-sharing systems are effective in reducing urban congestion and pollution, they face several challenges that hinder their effectiveness. A typical concern is a lack of parking places, particularly in populated regions, which may make car-sharing less practical than private vehicle ownership. Furthermore, consumers often encounter variable vehicle availability since demand varies throughout the day, resulting in shortages in high-demand regions and surpluses in low-demand ones. Another big difficulty is monitoring user behavior, such as inappropriate parking and failure to return cars to approved areas or charging stations. These practices lead to operational inefficiencies and reduced service dependability (Tkaczyk & Awdziej, 2017).

Avant2go is in competition with Sharengo, another car-sharing service, for a 20-year concession to operate electric car sharing in Ljubljana's dynamic environment of sustainable urban transportation. This competition demonstrates the rising need for shared mobility options in a city that seeks to decrease individual vehicle ownership, reduce traffic congestion, and decrease environmental impact. As Ljubljana develops as a potential center for shared services, strong competition is normal for encouraging innovation and satisfying the different requirements of its citizens.

Avant2go, much like Bicikelj, is committed to expanding its service accessibility by adding new stations for electric vehicle rentals. The focus is on key locations such as supermarkets, office buildings, shopping centers, and other frequented areas where users can conveniently access electric vehicles for their daily commute, school runs, or grocery shopping. Notably, the placement of stations in the city center addresses the challenges associated with private car usage, such as expensive parking fees and limited parking spaces (Jankovič, 2022).

3.3 Ljubljana smart energy

For my research on smart energy strategies in Ljubljana, I have focused on a specific company that provided significant support for my research. The company is called Danfoss, a global company committed to sustainability and energy efficiency. Danfoss, as a market leader, is committed to decreasing emissions and producing energy-efficient solutions, which effectively aligns with the goals of smart energy applications. Danfoss plays an important role in promoting energy-saving technology and growing their company globally, thereby contributing to the general sustainability and growth of Ljubljana's energy industry.

While Danfoss serves as the primary focus of this study due to the benefit of having direct contact with its employees, it is important to note that Ljubljana's smart energy landscape includes other companies as well. For instance, companies like GEN-I and Petrol also contribute to the development of innovative energy management solutions and smart grid technologies. Their presence underscores a broader commitment to smart energy in Ljubljana, enriching the local smart energy projects and supporting the initiatives led by market leaders such as Danfoss.

3.3.1 Danfoss, its background and initiatives

Danfoss is a global company that provides technical and technological solutions. Since its formation in 1933 in Denmark, Danfoss has emerged as a market leader in the development, manufacturing, and distribution of energy-efficient and innovative products and services. Danfoss works in a variety of sectors, with a particular emphasis on energy efficiency, climate solutions, and infrastructure. Some important aspects of their business include refrigeration, drives and controls, power solutions, district energy, and power electronics.

Danfoss's Core and Clear strategy 2025 lays out its strategic plan with sustainability at its core. The goal is to make the company the best partner for customers working to reduce carbon emissions. This creates long-term value for every stakeholder, including consumers, employees, shareholders, and partners. Danfoss plays an important role in accelerating the green transition due to its commitment to sustainable innovation and in-depth understanding of its applications. The company assists its clients in their decarbonization efforts while also furthering its own trajectory. The idea that "the greenest energy is the energy we do not use" emphasizes the need for energy efficiency in meeting global climate and energy goals. Danfoss operates on the philosophy of "energy efficiency first," pioneering innovative and cost-effective solutions for client decarbonization as well as reaching carbon neutrality in its operations by 2030. Danfoss’s big plans for 2030 are to make a positive impact on ESG (Environment, Society, and Governance). They want to be a top choice for customers working to reduce carbon emissions. The company has set specific targets, supported by scientific methods, to reduce greenhouse gas emissions not only within their own operations but also throughout the entire business chain (Danfoss, n.d.).

Prior to the establishment of the current Slovenian Danfoss Trata, Yugoslavia had only one Trata company, a leading player in technology. After Slovenia's post-Yugoslavian market transition, Trata needed a strategic partner; thus, Danfoss acquired it in 1995. Before the acquisition, Trata was heavily dependent on the Yugoslav market, holding a 90% market share for district heating controls and air conditioning. Through the acquisition, Trata became a part of Danfoss's District Heating Business Area and started the process of becoming a "center of excellence" for district heating and regulating components research and development. Even after the acquisition, Danfoss faced the challenge of restructuring Trata's operations to align with its global standards. This involved transferring various district heating-related activities from Denmark, Sweden, and Germany to Slovenia, which required significant organizational changes. Employees had to acclimate to Danfoss's efficiency-focused work culture, a common practice for every acquisition, which requires time to adjust to new changes that could potentially benefit the company (Prašnikar & Cirman, 2007).

Danfoss Trata in Slovenia is an example of the company's commitment to local adaptation and innovation. As a subsidiary, Danfoss Trata has not only become an important component of Danfoss's European operations, but it has also adopted a hybrid management style that mixes Danish and Slovenian organizational elements. Despite the challenges posed by Slovenia's rigid institutional structure and tax regulations, Danfoss Trata has established itself as a competitive and creative player in Europe. Danfoss Trata aligns its emphasis on energy-efficient solutions and the development of motivated employees with Danfoss's Core and Clear 2025 strategy, thereby contributing to the company's carbon neutrality ambitions and upholding its reputation as a pioneer in sustainable engineering.

3.3.1.1 Key smart energy definitions related to Danfoss' strategy

Sustainability is increasingly becoming a central focus for businesses aiming to align with global climate goals and regulatory standards. This section explores key definitions and frameworks that are prevalent among companies, such as Danfoss, to understand their environmental strategies and commitments. This thesis involves an explanation of sustainability terminology and practices to contextualize the interview that will follow in a later chapter with a Danfoss employee.

Let us begin by defining the greenhouse gas emission reduction goals. One of them is the SBTis (Science Based Targets Initiative), designed to align with the Paris Agreement's objective of limiting global warming to well below 2°C, ideally 1.5°C, above pre-industrial levels. Companies adopt SBTs to align their operations with global climate goals, enhance their reputation, future-proof their businesses against climate risks, and drive innovation and efficiency. The primary aim of SBTs is to ensure that corporate climate actions contribute meaningfully to global efforts in mitigating climate change. However, SBTs face limitations, including a lack of transparency and standardization in target-setting methods, potential for symbolic rather than substantive actions, and lower adoption rates in certain sectors and

regions. Additionally, while SBTs encourage voluntary corporate action, they cannot replace the need for strong governmental climate policies, which are essential to achieving the necessary global emission reductions (Bjørn et al., 2022).

The EU proposes the European Green Deal (EGD) as a comprehensive strategy to achieve climate neutrality by 2050, building on the need for robust governmental policies. The objective of this initiative is to establish Europe as the world's first carbon-neutral continent and to substantially reduce greenhouse gas emissions, with a minimum reduction of 55% by 2030 compared to 1990 levels. In addition to environmental objectives, the EU Green Deal prioritizes the reduction of regional and social inequalities, the promotion of economic development, the establishment of employment opportunities, and the maintenance of price stability. Substantial public investments are anticipated to accomplish these objectives, with an emphasis on the implementation of complementary measures in education and health, the improvement of the innovation system, and the retrofitting of structures (Wolf et al., 2021).

While policies like the European Green Deal (EGD) set broad regional goals, businesses require specific tools to measure and report their environmental impact. EPDs (Environmental Product Declarations) serve this purpose by providing standardized documents that detail the environmental impact of products. They are based on LCA (Life Cycle Assessment), which assesses a product's environmental impact across its whole life cycle, from raw material extraction to manufacturing, usage, and disposal. EPDs assist businesses and consumers in understanding a product's environmental footprint and comparing it to others, fostering transparency and informed decision-making in the pursuit of more sustainable products (Del Borghi, A., 2013).

To support accurate Life Cycle Assessments, software tools like SimaPro play a critical role. SimaPro is useful because it offers a comprehensive platform for calculating and analyzing environmental consequences across several databases and impact assessment methods. This enables companies, researchers, and governments to find potential for lowering environmental footprints, increasing sustainability, and making informed decisions about product design, manufacturing processes, and supply chain management (Herrmann & Moltesen, 2015).

Building on these assessments and tools, the Ecodesign Directive further supports sustainability efforts by setting specific environmental performance standards for energy-related products within the EU. Its primary objective is to mitigate the environmental impact of products throughout their entire lifecycle, from production to disposal. Initially focused on energy efficiency, the directive has expanded to include material efficiency aspects like durability, reparability, and recyclability, promoting a circular economy. By limiting the sale of products that do not satisfy these standards on the EU market, the directive contributes to the reduction of energy consumption and the minimization of waste (Bundgaard & Huulgaard, 2023).

Collectively, these policies and tools serve as an illustration of the multifaceted strategy necessary to achieve corporate sustainability in accordance with global and regional objectives. They provide a framework for companies to measure, report, and improve their environmental impacts while also meeting regulatory requirements. Moving forward, these concepts will play a pivotal role in understanding the practical insights obtained from the primary research, emphasizing the implementation of these strategies in a real-world context.

3.3.2 GEN-I

GEN-I is a Slovenian energy company that provides integrated energy solutions, with a strong commitment to sustainability and innovation. Similar to Danfoss's emphasis on energy efficiency, GEN-I focuses on leveraging renewable energy sources and optimizing smart grid technologies. The company plays a pivotal role in the local energy landscape by delivering modern, digitalized solutions that enhance reliability and efficiency across the energy supply chain.

The company's flagship initiative, GEN-I Sonce (GEN-I Solar)**,** enables households and businesses to transition to solar-powered energy systems. By offering solar solutions, GEN-I contributes to decentralizing energy production and supports the broader objective of reducing greenhouse gas emissions in Slovenia. Additionally, through its FutureFlow project, an EU-funded innovation effort, the company explores the potential of integrating renewable energy sources with the real-time balancing of electricity systems across borders, showcasing the company's role in shaping a smarter, more interconnected European energy grid.

GEN-I's commitment to smart energy emphasizes transparency, customer empowerment, and education. With tools like their own called MOJ GEN-I, a digital platform for energy management, customers gain real-time insights into their energy use, enabling them to optimize consumption, reduce energy costs, and actively participate in shaping a more sustainable energy system in Ljubljana (GEN-I, n.d.).

3.3.3 Petrol

Petrol is another Slovenian energy company, traditionally known for its fuel, electricity, and natural gas supply. In recent years, Petrol has shifted its focus toward sustainability by expanding its portfolio to include renewable energy production, smart mobility solutions, and digital energy services. This evolution reflects the company's commitment to modernizing its energy infrastructure while continuing to serve the changing needs of its customers.

Petrol's smart energy initiatives consist of integrating digital technologies with energy management. For example, the company is actively developing a network of charging

stations for electric vehicles and implementing digital solutions that allow consumers to monitor and optimize their energy consumption in real time, similarly to what GEN-I is doing. Through their projects like the one called Energy Management 4.0, Petrol leverages data analytics and IoT technologies to optimize energy flows and improve operational efficiency across its services. Petrol is investing in smart grid technologies that enhance energy distribution efficiency and reduce waste, thereby contributing to a sustainable energy system in Ljubljana and throughout Slovenia (Petrol, n.d.).

4 SKOPJE SMART CITY

Skopje, the capital of North Macedonia, finds itself in a difficult position as it strives to strike a balance between its historical legacy and the demands of modern growth. The city's rapid growth has led to issues such as traffic congestion, pollution, and insufficient infrastructure. This chapter delves into the challenges that Skopje faces and the potential projects aimed at improving the city's development.

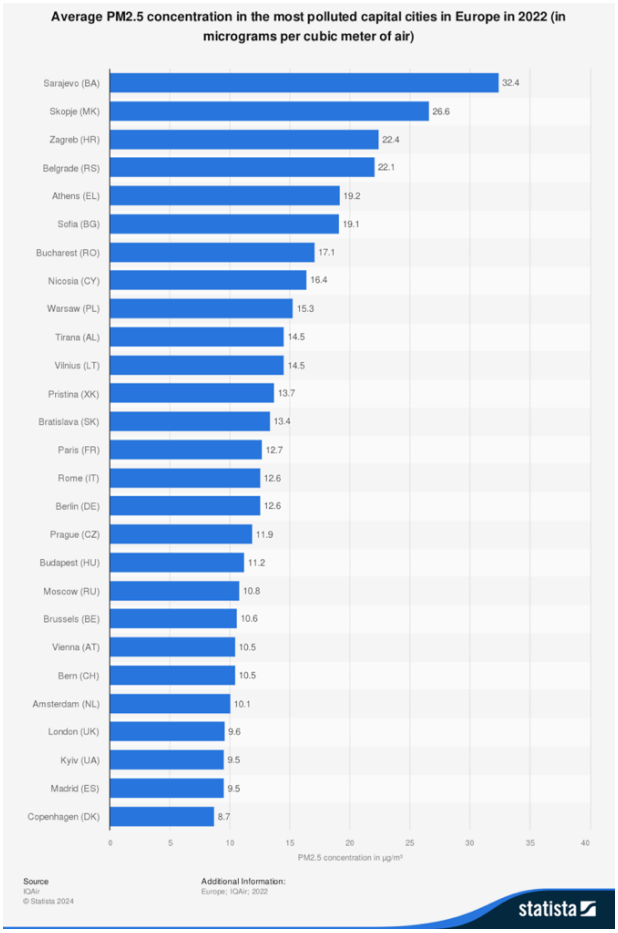
4.1 Challenges in developing a sustainable future for the city of Skopje

The quest for sustainable development and a green urban future has become imperative for Skopje, given the rapid urbanization and challenges associated with degradation, pollution, and overpopulation. Recognizing the need for a livable city, researchers emphasize the importance of focusing on various aspects of urban development, including urban structure, energy, mobility, climate, and smart technology.

The fact that Skopje is a transportation hub on foreign routes makes it even more important to find new and long-lasting ways to improve cities. As the city grows faster than usual in terms of size, functions, and population, it faces problems like inadequate transportation, high energy costs, and the social issues that come with having so many people living in a small space. Skopje is one of the most polluted cities in the world. The city is facing serious air pollution problems, with PM2.5 concentrations being the most problematic. Discussions and efforts to prevent this issue from recurring are ongoing because of how persistent it is. List of most polluted capital cities in Europe in 2022 can be seen in Figure 5 (Statista, 2024).

To address these challenges, Skopje is embracing sustainable initiatives in urban planning, emphasizing the integration of green technologies, smart urban solutions, and citizen-centric approaches. Pilot projects based on research findings play a pivotal role in establishing a more livable and sustainable urban environment (Sofeska, 2017).

Figure 5: Most air polluted capital cities in Europe in 2022



Source: Statista (2024)

4.1.1 Skopje's air pollution

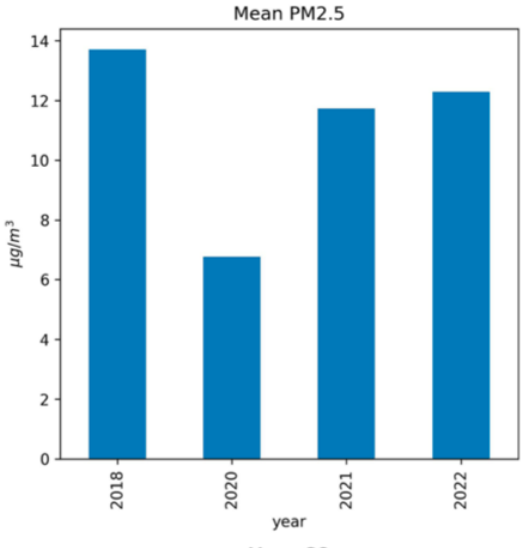
Severe air pollution primarily affects Skopje due to its geographical location and a variety of human activities. The city is located in a valley, which causes pollutants to be trapped near the ground, particularly during winter when temperature shifts take place. These atmospheric inversions, when combined with consistent atmospheric conditions, restrict the movement of air and result in elevated levels of pollutants. The climate, characterized by cold winters and hot summers, further influences pollution levels, with higher (PM2.5) (Particulate Matter) concentrations typically observed in the colder months due to increased heating needs.

The main causes of PM2.5 pollution in Skopje are biomass burning, traffic, and the combustion of fuel and residual oil. The primary source of biomass burning, particularly during winter, is household heating through the use of wood stoves and boilers. This activity accounts for around 32–33% of the total annual PM2.5 levels. Traffic is the second most significant contributor, accounting for 18–23% of the total, primarily due to vehicle emissions, the wear and tear of tires and brakes, and the dust generated by the road.

Additional factors include the combustion of fuel and residual oil, which originate from industrial activities and heating systems and account for 12–14% of the total. Soil or mineral dust, especially from building activities and the resuspension of dust, is more common during the warmer months (Mirakovski et al., 2024).

During the COVID-19 epidemic, Skopje experienced significant improvements in air quality as a result of the implementation of lockdown measures and limitations aimed at controlling the spread of the virus. The substantial decline in road traffic and transportation, along with fewer industrial operations, resulted in a notable drop in the emissions of pollutants such as PM2.5. The data from 2020 indicates that the lockdown resulted in the lowest levels of these pollutants, thus illustrating the direct influence of human activity on air pollution. Moreover, due to a fall in the number of people commuting and a decline in economic activity, it is very probable that there was a reduction in energy consumption and heating demand, which further contributed to the decrease in air pollution. Figure 6 shows the average concentration of PM2.5 pollutants from year 2018 to 2022 (Srbinovska et al., 2024).

Figure 6: Average concentration of PM2.5 pollutants by year



Source: Srbinovska et al. (2024)

These modifications provide a temporary but clear demonstration of how human actions impact the air quality in urban regions such as Skopje. The decrease in emissions seen during the epidemic highlighted the potential advantages of implementing proactive measures to regulate pollution that results from transportation and industrial activities. This period of improved air quality underscores the importance of adopting long-term strategies to reduce emissions and enhance urban environments, suggesting that even partial reductions in everyday pollution sources can significantly impact overall air quality (Srbinovska et al., 2024).

4.1.2 Skopje’s urban structure

Skopje, as a demographic hub, deals with issues like illegal construction, inadequate planning legislation enforcement, and density-related problems. Unplanned construction negatively impacts the quality of life in impacted communities, leading to issues such as inadequate utilities, the inability to modify existing structures, and poor living conditions due to proximity to busy highways and other disruptions. People describe Skopje's housing structure as diverse, ranging from individual freestanding buildings to multi-family blocks. The planned housing development aims to enhance living conditions in various city areas, optimize spatial utilization, and increase the density of urban land use. However, there are still issues with illegal construction taking over urban land, particularly because many people from smaller cities prefer to live in Skopje, resulting in an increasing population density in the city.

For Skopje to become a convenient place to live, we need to address many factors. That includes safety, economic stability, education, health care, environmental quality, public transportation, and architectural excellence. There is also a rising need for context-specific urban development in collaboration with the public. The goal is to promote decentralized economic activities and create new urban villages in Skopje for a better quality of life. Also, the city underscores the importance of increasing green areas, including avenues, parks, and squares.

It is important to note that Skopje has an infrastructure that is well-suited to the construction of modern urban transportation systems like trams or bus rapid transit, which are common in major cities. However, the city confronts major challenges in making this infrastructure a reality. On one hand, a lack of resources could hinder the project's launch; on the other hand, unanticipated obstacles could arise, leading to unexpected pauses in the implementation process. Although Skopje has a potential infrastructure in place, the implementation of particular smart city solutions faces several challenges, impeding the smooth development of such efforts (Sofeska, 2017).

4.2 Skopje smart mobility

The smart mobility scene in Skopje is changing. JSP (Javno Soobrakjajno Pretprijatie) Skopje and BinBin are two ways for locals and tourists to get around town. The city's public transportation company, JSP Skopje, runs a network of buses with the goal of making them more accessible while also making traveling easier. BinBin's electric scooter service, on the other hand, contributes something new to city transportation by making short trips easier and better for the environment.

4.2.1 JSP

JSP Skopje serves as the public enterprise responsible for public transportation in Skopje. JSP Skopje provides a large network of buses and other public transportation services, with the goal of making it easier for citizens to commute across the city and nearby regions on a daily basis.

In addition to its regular city bus routes, JSP offers a variety of other services. JSP has standard buses, double-decker buses, and city tours for tourists. Another feature is the cable car that takes you to the cross of Vodno mountain in Skopje. JSP Skopje offers free bus passes to pensioners, students, and people with disabilities. Furthermore, similarly to the Urbana card, JSP Skopje developed and offers useful payment options, such as utilizing mobile phones or buying and topping up cards at local tobacco shops.

Many things about JSP Skopje's public transportation services are solid, but one thing that users often complain about is how old and rarely updated their services on the main website are. Currently, the website provides updates on bus routes during holidays and reports on potential disruptions to cable car operations due to storms or other similar events. However, users express concerns about the website's limited features, outdated information, and unfriendly interface, indicating a need for a more modern and user-friendly online platform (Јавно сообраќајно претпријатие Скопје, n.d.).

The "Skopska" project seeks to enhance the appeal of public transportation by ensuring its regular, reliable, on-time, and efficient operation, an area where Skopje's public transportation system has historically struggled. The release of the mobile application marks an advancement in upgrading and transforming Skopje's public transportation system, which previously lacked sophisticated payment methods, and, as previously mentioned, the website itself did not fulfill its intended purpose. This application allows passengers to buy tickets online and verify them right away on JSP-Skopje buses. Passengers can easily purchase electronic tickets by filling up their e-wallet with a credit card. One of the program's elements is the use of contactless technology for bus ticket validation, which speeds up boarding procedures. The "Skopska" app also offers users information like timetables and journey routes around the city of Skopje (Јавно сообраќајно претпријатие Скопје, n.d.).

Skopje faces several challenges in its public transportation system, largely due to its reliance on diesel buses. This causes severe air pollution, as diesel emissions continue to be a significant source of particulate matter, which is particularly problematic given Skopje's geographical location in a valley that traps air pollutants. Traffic congestion further exacerbates the system’s inefficiency, with an average bus speed of under 20 km/h due to narrow, overcrowded streets. These conditions, combined with outdated infrastructure, have made public transportation slow, inconvenient, and environmentally taxing (Cingoski & Petrevska, 2018). This thesis will further address these issues through participant interviews and define a shift toward a sustainable transportation model, specifically through the

potential introduction of the Bus Rapid Transit System. However, the next chapters will delve into further findings.

4.2.2 BinBin

The European Union initially proposed a project known as Ele.C.Tra to help Skopje evolve into a smart city. European Union programs fund the Ele.C.Tra project (Electric Transport in Cities), which aims to promote electric mobility in urban areas, specifically through the use of electric scooters. However, certain challenges emerged, like waiting for the final funds, changing public perceptions, addressing safety on busy roads, and creating necessary infrastructure, such as charging stations (Dimeski et al., 2019). All of this required a significant amount of time, yet BinBin responded more quickly. Thus, while the government planned projects such as Ele.C.Tra, it was BinBin, a private company, that ultimately established the electric scooter rental service in Skopje.

Skopje officially welcomed an addition to its urban transportation in 2023 with the launch of BinBin, a smart scooter service that quickly gained popularity in the city. Operated by the Turkish company BinBin, this service allows residents and visitors to rent electric scooters for short-distance trips around the capital city. The official launch of BinBin in Skopje addresses the need for micromobility solutions in urban transportation. After expanding globally from its base in Turkey, the company BinBin wants to explore chances for future growth in Skopje and other Macedonian towns, with Ohrid and Bitola also being considered.

BinBin assures consumers that their dedicated staff works around the clock to quickly resolve and manage small occurrences of damage and vandalism, such as throwing and breaking scooters. The scooters feature three riding modes (Eco, Drive, and Sport) with a maximum speed of 25 km/h (kilometers per hour). Furthermore, shock absorbers function to alert users if the road becomes uneven or bumpy, thereby preventing crashes. For the rental of this service, there is an easy-to-use application. Users can scan the QR (Quick Response) codes on scooters, start and end rides using the app, and finalize the process by taking a picture of the scooter. Customers can easily manage their transactions using bank cards by making payments via top-up credits (BinBin, n.d.).

The introduction of BinBin electric scooters in Skopje has been a positive development. However, several obstacles have emerged, despite the efforts of staff to manage the scooters when users damage them or leave them in inappropriate locations throughout the city. Despite BinBin's assurances that illegal usage without the smartphone app is difficult, the public has raised concerns about theft and vandalism. Additionally, locals have expressed concerns about road safety, especially with a large number of scooters operating simultaneously (Jordanovska, 2023). Furthermore, there are concerns about minors renting and operating scooters, which could potentially pose a safety risk on crowded streets and boulevards. Finally, citizens have emphasized the necessity of regulations or legislation

governing scooter use in Skopje, urging authorities to set standards to ensure the safety of all road users, a measure already under consideration (Nikolovska, 2024).

The launch of BinBin electric scooters in Skopje generated public skepticism, indicating that this new mobility service would need time and adjustment. Over time, citizens have gradually adapted to the convenience of electric scooters and acknowledged their usefulness as a practical mode of transportation within the city. We will further emphasize the community's resilience to new smart city solutions in the practical interviews with participants from Skopje, as the emerging perspective demonstrates a successful shift from skepticism to integration.

4.3 Skopje smart energy

In this chapter, the focus is on exploring the initiatives of Grad Skopje, the central organization overseeing all smart city activities in North Macedonia's capital. We will address all the departments responsible for these smart city initiatives, with a primary focus on understanding the pivotal roles played by the Environmental Protection Department and the Department of Energy, Energy Efficiency, and Renewable Energy Sources. The goal is to uncover their strategies and contributions to advancing sustainability, tackling air pollution, and promoting renewable energy alternatives within the city through direct interactions with key stakeholders in these departments, a topic we will delve into further in the comparative analysis chapter.

4.3.1 Environmental protection departments

Grad Skopje, with its Sector for the Protection of the Environment and Nature, adopts various approaches to protecting the city's ecological integrity and strengthening its resistance to environmental issues. Several departments lead this sector, each with specific tasks critical to the city's well-being. The next paragraphs will offer brief summaries of the responsibilities undertaken by these departments.

The Department for Noise, Ambient Air Quality, Climate Change Adaptation and Reduction, and Non-Ionizing Radiation Protection protects Skopje's atmosphere by constantly looking for risks and taking steps to reduce them. Through monitoring of the air quality, this department tries to protect public health and reduce pollution for the people who live in the city. Additionally, the department adapts to climate change by devising strategies to safeguard Skopje from the increasing risks posed by shifting weather patterns. The department also works to clean up noise and non-ionizing radiation pollution, making sure that cities are safe and peaceful places to live in.

Skopje's natural assets and the creation and maintenance of green spaces in cities are the responsibilities of the Department for the Protection and Promotion of Nature and Greenery. Through careful planning, this department strives to improve wildlife and bring people

closer to nature. It tries to increase the variety of plants and animals that live there by encouraging gardening practices and planting trees. At the same time, the Department for the Protection and Prevention of Water and Land Pollution is in charge of keeping Skopje's waterways and land clean. This department tries to keep Skopje's water sources clean so that they will be available for future generations. They accomplish this by monitoring and enforcing environmental laws.

One of the most important parts of Grad Skopje's environmental governance system is the Department for Strategic Environmental Management, Planning, and Raising Public Awareness about the Environment. By creating strategy plans and project papers, it establishes the framework for comprehensive environmental management. This helps different City of Skopje departments and sectors work together more effectively. It also actively participates in public marketing and knowledge programs that give people the tools they need to take care of their surroundings and promote green living (Град Скопје, n.d.).

4.3.2 Department of Energy, Energy Efficiency and Renewable Energy Sources

The Department of Energy, Energy Efficiency, and Renewable Energy Sources in Grad Skopje is essential for creating the city's energy landscape and promoting sustainable growth. The department strives to increase the city's resilience to climate change by suggesting methods to reduce and adapt to its repercussions. Through monitoring and analysis of energy-related data, it finds opportunities for improvement and develops strategic plans that optimize energy consumption.

One of the department's primary objectives is to find best practices in the fields of energy, energy efficiency, and renewable energy sources. Drawing on worldwide knowledge, it tailors creative solutions to Skopje's particular circumstances and needs. Furthermore, the department is responsible for planning and directing all of the City of Skopje's capabilities in accordance with energy regulations. Through strategic planning and project management, it develops and manages a variety of energy initiatives aimed at improving the city's energy infrastructure and encouraging renewable energy use.

The department pursues chances to exhibit Skopje's commitment to sustainable energy and attract external funds and expertise by participating in international competitions and preparing expert-analytical papers for municipal committees. Overall, the Department of Energy, Energy Efficiency, and Renewable Energy Sources drives sustainable development, shapes Grad Skopje's energy future, and plans yet more to be done in the near future (Град Скопје, n.d.).

Government-owned public entities like Grad Skopje, which rely on funding for smart energy initiatives, primarily control Skopje's market. However, if we take as an example a private enterprise like Danfoss, it faces considerable obstacles to acquisitions in cities like Skopje. Macedonia's political instability and inadequate institutional structure pose risks, including

ineffective contract enforcement and property rights protection. Bureaucratic inefficiencies complicate the business environment, and a shortage of workers in technical positions worsens the problems. When combined with economic obstacles such as high unemployment and low consumer buying power, acquisitions by foreign companies in this area become extremely challenging (Prašnikar & Cirman, 2007).

5 COMPARATIVE ANALYSIS AND FINDINGS

For this thesis, I used a qualitative research methodology, primarily through semi-structured interviews. The approach aimed for open, non-recorded conversations, leading to a more relaxed environment in which interviewees felt comfortable providing honest and candid responses. Despite not recording most interviews to keep openness in the conversation, we did record a few due to the technical nature of the discussed topics, necessitating a re-listen of the conversation for accuracy.

In most cases, I took notes during the discussions, noting down their answers and thoughts. Depending on the interviewee's preference and nationality, I conducted the questions in Macedonian, English, and Slovenian. I prepared the questions before the interviews and usually started off the interviews with the same questions and then let the conversation continue itself naturally. In some situations, all of the questions were answered, and the interview was more structured; in others, the discussion started off as all the others, but then went on in a natural way of being a conversation between two people, and in other situations, for example, developers were not allowed to share information about some questions I had prepared, and we had to skip them. Despite sometimes not receiving answers to all pre-prepared questions, the informal and flexible nature of the interviews often resulted in valuable insights and discussions.

In addition to individual interviews, I also conducted a few focus group discussions where the idea was for participants to exchange thoughts and debate the different questions and answers provided. I started off the focus groups with an introduction to the topic, used the questions I had prepared in advance, and then left room for discussion within the participants. I also had access to some public sector representatives, such as deputy CEOs (chief executive officers), department heads, and domain experts, with whom I kept the conversation more formal and structured and took into account the fact that not all questions can be answered due to the more professional and confidential nature of the companies. Lastly, I faced challenges engaging with private companies such as Bolt, BinBin, and Avant2Go. Their lack of response was likely due to the confidential nature of their operations. The appendices provide a detailed overview of the interviews, including participant roles, interview dates, and key questions (Appendix).

5.1 Ljubljana: Lessons learned and findings from interviews

In this first part of the chapter, I present the lessons learned and findings from primary research conducted in Ljubljana, which involved a series of interviews with both users and developers from key companies, including LPP, Bicikelj, Avant2Go, and Bolt as representatives in the smart mobility sector, and Danfoss as a representative in the smart energy sector. On the user side, I've managed to gather resources from a few people who use all of the smart mobility services in Ljubljana. As for developers, I had the opportunity to speak with employees from LPP and Bicikelj, both of which are publicly owned companies. For Avant2Go and Bolt, conducting interviews was a challenging task due to their private nature and tendency to maintain confidentiality.

5.1.1 Smart mobility insights

The smart mobility focus is on the insights from discussions with both users and developers of mobility services in Ljubljana, such as LPP, Bicikelj, Avant2Go, and Bolt. This section describes each service's achievements, challenges, and future goals, emphasizing projects such as LPP's usage of hydrogen buses, Bicikelj's expansion of bike stations, Avant2Go's expansion of car stations and implementation of new rental cars, and Bolt's overall new e-scooter sharing system. I also include user opinions and experiences, providing a comprehensive overview of urban mobility enhancements and future growth prospects in Ljubljana.

5.1.1.1 *LPP*

For Ljubljana's public transportation LPP, I had the opportunity to speak with the deputy CEO, who described current successes, challenges, and future potential for Ljubljana buses. Firstly, he began to discuss how, despite facing a significant decline in public transportation usage following the COVID-19 pandemic, LPP has seen a remarkable increase in passenger numbers. In 2019, the urban (mestni) line transport accounted for 36,347,028 trips, while the interurban (medkrajevni) line transport recorded 2,996,088 trips. As a result, the total number of trips for LPP in 2019 amounts to 39,343,116 (LPP, 2019). Subsequently, as the virus-related restrictions gradually eased, the number of trips gradually increased. According to the latest annual report from LPP, the number of journeys, specifically for city line passenger transport, increased to 34,368,492 in 2023. This is an increase from the 2022 figure, which was 28,050,798 journeys, as seen in Figure 7 (LPP, 2024).

Figure 7: Number of trips

City scheduled passenger transport	Year 2023	Year 2022	Year 2021	Year 2020
Kilometres traveled	11.624.900	11.111.965	10.386.025	8.185.556
Number of trips	34.368.492	28.050.798	19.086.895	16.090.625
Average number of buses	217	217	215	217
Number of drivers (as of December 31)	470	458	465	503
Intercity passenger transport	Year 2023	Year 2022	Year 2021	Year 2020
Kilometres traveled	3.867.048	3.840.361	3.681.220	2.751.124
Number of trips	2.651.727	3.068.288	2.363.381	1.468.320
Average number of buses	61	63	58	59
Number of drivers (as of December 31)	90	90	90	87

Source: LPP (2024)

With plans to add hydrogen buses to its current fleet, the company has started the process of becoming more electric-oriented. And even though Ljubljana may not have as many electric buses as some European countries, LPP's dedication to lowering CO2 emissions through different fuels shows that they are eager to act as a company for a greener future. Since 2009, Ljubljana has pioneered the implementation of a card similar to the Urbana card, as elaborated in Chapter 3. This card provides access to a variety of municipal services, including public transportation, parking, public libraries, and the Bicikelj rental system (Ljubljanski potniški promet, n.d.). Ljubljana recently released the second generation of Urbana cards in the form of a custom application, differentiating itself as one of the few cities to employ Bluetooth recognition on buses. The Urbana app has received great responses, with an over 90% user satisfaction rate and over 100,000 downloads (City of Ljubljana, n.d.). Plans are in the works to develop the app further, with regular updates and enhancements to the user experience. Students who want to transfer their cards to the Urbana application, however, face constraints due to unique student subsidies and limits. Furthermore, to prevent abuse, safeguards against theft or fraudulent use limit the Urbana card to the option of either having one physical or electronic version per person.

During the interview, we also talked about issues with employment. The respondent stated that LPP is currently dealing with a driver shortage, which is a common problem not only in Ljubljana but across Europe. Approximately 300 drivers are required, indicating a severe recruiting issue despite the good salary. Unfortunately, bus driving is no longer as appealing as it once was. However, LPP ensures that all employees are well-trained by requiring annual courses covering topics that could teach them how to tackle everyday situations while driving the buses. The respondent stated that new drivers go through a 14-day training program that focuses on behavior in different scenarios and emphasizes interpersonal skills.

The interviewee shared that LPP is currently working on various initiatives, one of which is the introduction of new buses, a top priority for the next five years. Furthermore, there are plans to expand the number of yellow lanes to improve traffic flow and reduce the number of crowded streets, especially during peak hours. They are also designing a smart controller

for traffic signals to optimize bus routes and enhance overall efficiency, with the ultimate goal of increasing bus speeds. These efforts are only a few of the many active projects aiming to improve public transportation in Ljubljana. However, it's important to remember that the interviewee only had permission to share a select few with me, given that some projects have not yet received approval or remain confidential to the public for now.

I have also completed interviews with people who utilize Ljubljana's public transit, and overall, respondents were satisfied with Ljubljana's public transportation system, highlighting improvements in cleanliness, accuracy, and availability over the past few years. They considered the release of LPP's new application to be the most beneficial tool for public transportation, parking, and other activities in Ljubljana. While some users had difficulties with payment methods, such as being unable to pay with a cell phone in particular areas, the updated application has already addressed some of these concerns. The new payment card system received positive feedback from users, but they voiced worries about the inability to use both the physical Urbana card and the application at the same time. However, we previously clarified that this feature is limited due to security concerns. In terms of the daily experience of utilizing public transportation, consumers generally praised the buses' cleanliness, punctuality, and comfort, with particular appreciation for their commitment to assisting handicapped and elderly passengers. While most users considered the buses to be regular and timely, others proposed changes such as an increased frequency of bus lines in more rural areas and the introduction of night buses. Generally, in every European capital, buses run every few minutes during the day and occasionally at night, although this depends on the city's size.

Given the largely positive response from the interviews, the most important piece of advice from the users for LPP's future improvements was to strengthen and professionalize control procedures on buses to efficiently handle problematic situations. If people choose to ride the bus instead of using their own car, bicycle, or electric scooter, they should feel safe. Many respondents expressed dissatisfaction over the excessive cost of the subsidized monthly passes for students, priced at 20 euros. They pointed out that tickets cost less in many other European countries, indicating the need for affordable pricing choices in Ljubljana. Considering numerous news stories and papers, such as the one mentioned in this thesis by Koblar and Mladenovic (Koblar & Mladenovič, 2020), significant efforts and changes have already been made in the field of public transportation, and LPP are on the right track.

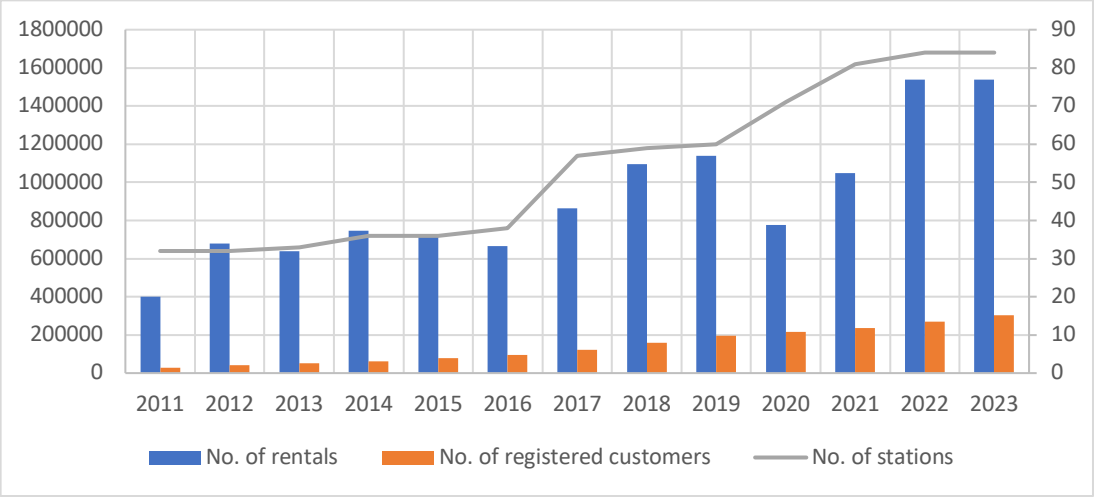
5.1.1.2 *Bicikelj*

I had the opportunity to speak with the company Europlakat, which operates Bicikelj, the bicycle rental system in Ljubljana. Europlakat has a public-private partnership agreement with the Municipality of Ljubljana, and they provided me with the statistics consisting of the number of rentals, the number of registered customers, and the number of stations since Bicikelj's implementation back in 2011. After analyzing the data provided annually for the

number of rentals, registered customers, and installed stations, it is clear that the bicycle rental business has undergone significant growth.

Bicikelj's official operations began in May 2011. By the end of that year, the total number of rentals had reached 401,830, with 26,562 registered consumers and 32 stations. Over time, the service expanded its coverage area, with the number of stations constantly increasing. By 2023, the number of stations had increased to 84, suggesting a significant infrastructure expansion to meet the rising demand for bicycle rentals. Furthermore, the number of rentals and registered clients has steadily increased, proving the service's popularity and effectiveness among both locals and tourists. They recorded over 1.5 million rentals and more than 300,000 registered customers in 2023 alone. Based on information from the company Europlakat, I have summarized the data in a table. Figure 8 shows the steady introduction of Bicikelj, the decline in bicycle rentals due to COVID-19, and the increase in rentals, stations, and registered customers (Figure 8).

Figure 8: Bicikelj statistics



Europlakat (2024)

As for the user interviews conducted, they shed light on the different experiences and viewpoints of citizens who use the Bicikelj service in Ljubljana. While some respondents were initially enthusiastic about the concept, others found themselves drawn to owning their own bicycles due to the convenience of having them always available, eliminating the worry about whether a bicycle would be available for rent. However, despite rare technical difficulties, respondents highly praised the simplicity of the renting procedure, followed by the mobile app and customer service.

During the interviews, the availability of bicycles emerged as a significant concern, especially during peak hours and in favorable weather conditions, when bicycles are usually

in high demand. Interviewees proposed a solution to this issue by setting up more stations in busy areas, which would facilitate easier access to bicycles when needed. This aligns with Bauchinger's position in the paper "Developing Sustainable and Flexible Rural-Urban Connectivity through Complementary Mobility Services," which advocates for the development of new station locations and their integration with other transit options to enhance connections in the city (Bauchinger et al., 2021). Concerns about the quality of the bicycles, particularly their breakage and weight, also surfaced. The bicycles are made of heavy metal, have no gears, and have a coaster brake. There were also several comparisons made with other rental systems, such as Nomago bicycles (Dnevnik, 2022), which demonstrate trade-offs between convenience of use and cost-effectiveness. Although the electrical nature of Nomago bicycles makes them easier to ride, their higher rental prices make them less appealing for frequent use than Bicikelj.

I conducted the majority of the interviews with international residents of Ljubljana, who were excited about this service and eager to use it immediately, primarily due to its limited availability in all European countries. They wanted to express how taken aback they were by the strict bicycle use regulations, which include driving on the correct side of the street and prohibiting using headphones or making phone calls while driving. Although this is unfortunately not as widespread in other countries, the presence of such restrictions creates an almost stress-free commotion around the city, eliminating the worry of dealing with reckless drivers. What the interviewees found fascinating was that the word-of-mouth strategy for Bicikelj spreads quickly and effectively. Everyone in Ljubljana, or everyone planning to come there, knows about it, which means that they have a solid marketing campaign, and everyone highly recommends the service.

Overall, the statistics provided by Europlakat and insights from interviews with users demonstrate Bicikelj's effectiveness as a sustainable and efficient form of transportation in Ljubljana, adding to the city's efforts to promote eco-friendly mobility alternatives while decreasing traffic congestion. What is important to highlight is that Bicikelj is constantly planning on implementing new stations; the last one they opened was back in June 2024, and it was the 85th station, as stated in one of the news stories on the City of Ljubljana website (City of Ljubljana, 2024). Typically, Bicikelj strives to establish a station in close proximity to every newly opened supermarket, shopping center, or tourist attraction.

5.1.1.3 *Avant2Go*

For the car-sharing service in Ljubljana, it was difficult to gain interviews or information directly from privately held companies like Avant2Go. As a result, I have relied on publicly accessible data obtained from their website, news, and articles. In this section, I will also present insights gained from interviews I conducted with people who had several direct experiences with this car-sharing system.

The respondents provided information on their travel routines and Avant2Go interactions. Some individuals depended on a mix of public transportation, bike-sharing systems, and Avant2Go, while others mostly utilized Avant2Go as a substitute for having a personal vehicle. This was usually dependent on the individual's status, whether they are a student, a student who works part-time, or a full-time employee. While some of the respondents were eager to try out this form of transportation, others were initially skeptical about the concept of renting a vehicle, mostly because it was quite an unknown fact to rent vehicles to them. Overall, they highlighted the ease of registration and use of these cars.

But of course, some of the interviewees shared negative experiences they had. One user encountered problems with the mobile application during registration, which required resolution by customer support. Avant2Go's customer support has proven to always be available, helpful, and quick. Some voiced their displeasure with the few parking spots at Avant2Go's stations, recommending the establishment of additional parking lots, particularly in locations with high traffic and demand.

In the past, users were accustomed to operating manual and gas-fueled cars, but they generally perceived the Avant2Go cars as simple to drive and well-maintained because they are fully electric and automatic. Avant2Go also offers short trips within the city, which means that you can rent it for several days or even weeks for longer journeys. Although the company's introduction of electric cars garnered positive feedback, some customers expressed dissatisfaction with the frequent charging requirements, especially during longer rentals. Abouee-Mehrizi et al., 2021, support this by stating that the implementation of EVs can only occur when the charging speed, number of charging stations, and range of EVs are sufficiently high (Abouee-Mehrizi et al., 2021). The positive news is that Slovenia and most other EU countries have installed electric car chargers at every gas station and in high-traffic areas, ensuring a smoother journey when renting Avant2Go vehicles for longer trips. However, the car still requires a significant amount of time to charge.

Some respondents mentioned the competition in the car-sharing business, naming Sharengo as one of their rivals. It is quite normal that one company will start the business of car-sharing and car-rental services in one particular city, and then many other companies will follow. Most people had never used Sharengo and only heard of Avant2Go. The primary reason for this, similar to the case with Nomago bicycles, is the high cost of Sharengo rental cars and the monthly or annual fees associated with registering to use the service.

Regarding the primary benefit of car sharing, many interviewees expressed satisfaction with the service's convenience for short trips around the city. However, some also appreciate the opportunity to rent these vehicles for longer journeys, which aligns with the benefits outlined in the paper "Integrating smart mobility and electric car sharing adoption in a common framework" by Vătămănescu et al. (Vătămănescu et al., 2023). When renting a car, you don't need to worry about parking, cleaning, maintaining, refueling, or charging the vehicle by yourself all the time. Some respondents, however, said that they preferred to have their own

vehicle, pointing to benefits like lower costs for longer trips or more freedom in terms of trip planning. These comments were usually from full-time employees. On the other side, some of the interviewees were students, and they stressed that in these student years, when your biggest focus is to complete your university studies, a car-sharing service is the most beneficial and affordable way to go around the city. When you start working, earn more money, and have more time to manage your priorities, most respondents prefer having your own vehicle.

Regarding advancements, the participants proposed some modifications to make the Avant2Go service more effective and intuitive. These included improved user-friendly registration and user manuals, enhanced server reliability to avoid vehicle unlocking and locking problems, and more affordable pricing alternatives. Furthermore, they emphasized the extension of the stations to enhance user accessibility and convenience, especially in rural regions and locations further away from the city center. Given that the majority of the interviewees were frequent users, they proposed the introduction of discount club cards, which would offer benefits to regular users, as an alternative to charging 4 euros or more for each ride. Overall, given that this car-sharing service is quite a new and modern concept, they are satisfied with it and would recommend it to anyone.

5.1.1.4 *Bolt*

In relation to Avant2Go, a similar situation occurred during an attempt to contact the electric scooter sharing company Bolt in Ljubljana. Unfortunately, Bolt, a privately held company, was unable to provide substantial information regarding the developer side. The research related to this service in this thesis is based on data acquired from their website, news sources, articles, and interviews done with users of this recent service in Ljubljana.

Interviews with Bolt scooter users revealed a variety of perspectives on the experience and usefulness of the electric scooter sharing service in Ljubljana. Some individuals travel mostly by public transportation, car, or bicycle, while others utilize scooters on occasion for certain tasks like doing errands or making quicker trips across the city. It's interesting to note that a number of respondents had previously used scooter services of a similar kind in other European cities, indicating a rising trend in urban mobility options around the continent. Even though most interviewees were familiar with scooter sharing, only a few had actually used the service due to their skepticism about this modern concept. This skepticism stemmed from concerns about data collection during application registration, safety during driving, and sustainability during battery disposal. As previously mentioned in Chapter 2, this electric scooter rental service faces numerous setbacks, primarily due to people's initial fear of new innovations (Samadzad et al., 2023).

Users in Ljubljana generally thought renting and using Bolt scooters was an effortless and quick experience, with most of them highlighting that the registration and overall customer service were positive. Several challenges emerged, including the requirement to return the

scooter to designated locations, which thereby limited the flexibility of possible routes. However, Bolt recently announced that in the near future, you will have the ability to leave the scooters wherever you wish. This could result in either a more flexible method of returning the scooters or a chaotic situation where the scooters block certain passageways. However, the interviewees' opinions on the quality of the scooters varied and will continue to vary. Some reported positive experiences with the application and overall experience, while others encountered issues with malfunctioning scooters that either broke down or drained the battery too soon. Interviewees also raised issues with code scanning and trip cancellation, highlighting potential areas for improvement in app functioning and scooter maintenance.

Bolt and overall electric scooters represent a modern approach to a smart city that requires time for acceptance. Although Bolt scooters are an easy and quick way to get around Ljubljana, there is still space for development when it comes to app functionality, accessibility, and scooter maintenance. While some customers express a desire to acquire their own scooter in order to increase the flexibility and convenience of their daily commute, others recommend the service for its overall value, flexibility, and simplicity of use, which includes the ability to quickly run errands or use the scooter to, for example, reach the nearest bus or train station. Essentially, the same conclusion applies to car and bike sharing services: owning a car, scooter, or bicycle implies more responsibility, but short-term rentals reduce stress and attachment to the service.

5.1.2 Smart energy insights

One of the most insightful conversations I had was with an employee at Danfoss Trata, specifically in the DCS (Danfoss Climate Solutions) division, where their major purpose is to encourage sustainable practices by demonstrating products that consume less energy yet produce higher quality. During the interview, I learned about the employee’s role as a sustainability expert on the global market, the software he utilizes, the overall goal of this segment within the Danfoss organization, and several studies on sustainability practices that were previously unknown to me. The first portion of the interview was more general, with an emphasis on particular rules and reporting requirements to meet sustainability targets. The second section focused on the challenges that arose and how Danfoss addressed them.

A leading player in the sustainability domain with such products, Danfoss has set out to reduce its environmental impact by using a comprehensive strategy. A commitment to a lifecycle strategy, which means closely examining every aspect of operations from upstream to downstream, is fundamental to its sustainability initiatives. This comprehensive strategy targets a 25% reduction in CO2 emissions for purchased goods and services, as well as a 15% reduction across the entire value chain relative to 2019 baseline levels. It includes the computation of scope one, two, and three emissions and closely adheres to the strict criteria

established by the SBTi (Bjørn et al., 2022) to ensure compliance with the ambitious targets of the EU Green Deal (Wolf et al., 2021).

The basis of Danfoss's sustainability approach is responsibility and transparency. The corporation gives top priority to EPDs (Del Borghi, A., 2013) and CSR (Country-Specific Recommendations) databases, among other third-party verifications of its sustainability initiatives. Verifying industrial processes, such as the development of EPDs, is another way that this dedication to transparency ensures the dependability and credibility of environmental reporting. Danfoss actively participates in product design projects meant to reduce the impact on the environment throughout the product's lifetime, in addition to its dedication to transparency. These initiatives aim to promote circularity by raising the percentage of recycled materials in goods, reducing energy usage, and setting up reliable take-back programs for end-of-life items. Danfoss not only reduces waste, but it also helps its goods last longer by integrating circular economy ideas into its design processes.

Using cutting-edge technologies and procedures to evaluate and maximize environmental performance is essential to Danfoss's sustainability plan. The company uses advanced LCA technologies (Del Borghi, A., 2013) like SimaPro (Herrmann & Moltesen, 2015) to compute carbon footprints, energy usage, and product circularity. These instruments enable Danfoss to make data-driven decisions and identify areas for improvement across its diverse product range. One more pillar of Danfoss's sustainability plan is compliance with legal requirements. To guarantee compliance with developing environmental standards and best practices, the organization follows both internal and external rules, like the CSRD (Corporate Sustainability Reporting Directive) and the European Ecodesign Directive (Bundgaard & Huulgaard, 2023).

The second portion of the interview gave important insights into Danfoss's strategic methods for addressing sustainability concerns. The respondent underlined the need for extensive databases and background information, stating that although basic calculations are available to everybody, the true value is in the full data on industrial methods and environmental implications particular to their suppliers. This data facilitates well-informed decision-making and ensures adherence to changing regulations, like the European emissions standards, which are gradually reaching smaller businesses.

Furthermore, the respondent spoke about the creation of personalized tools, such as procurement assessments, to ease engagement with suppliers and simplify sustainability evaluations without burdening them with excessive data requirements. One important factor that the respondent highlighted was the contrast between the potential and hazards present in sustainability projects. Making comparisons to risk assessment techniques, the respondent underlined the existential danger that climate change presents and the need for preventative action. The respondent stated that “Sustainability is more than just an economic strategy; it is also a moral necessity for the company's survival and the welfare of society”.

The interview offered essential insights into the company's strong sustainability approach. Danfoss' dedication to lowering environmental impact through a lifecycle strategy, commitment to strict guidelines, and focus on transparency and accountability demonstrate its leadership in the sustainability arena. Danfoss exemplifies how companies can integrate environmental responsibility into their fundamental goals while maintaining a high level of caution. Sustainability, climate change, and smart energy are highly sensitive topics. While public enterprises and municipal institutions are actively addressing these issues, private companies typically take the lead due to their independent decision-making and faster response times (Erlandsen & Svendsen, 2023).

5.2 Skopje: Lessons learned and findings from interviews

This section presents the lessons learned and findings from primary research carried out with people living in Skopje. The focus is on the interviews with both users and developers from smart mobility services such as JSP, Bolt, and the Department of Energy, Energy Efficiency, and Renewable Energy Sources at Grad Skopje. While I was able to gather information from users of different smart mobility services, communicating with developers proved challenging. Similar to the scenario in Ljubljana, getting answers from private companies was difficult due to their highly confidential projects. As a result, I focused mainly on user experiences with smart mobility services. On a more positive note, I spoke with the head of the Department for Energy, Energy Efficiency, and Renewable Energy Sources, who shared useful insights into public institutions' attempts to promote smarter and more sustainable energy policies within Skopje.

5.2.1 Smart mobility insights

The interviews with Skopje citizens who use smart mobility services provide a complete overview of the city's public transportation system, highlighting a variety of perspectives and experiences. Each group, from retirees who rely on buses for daily activities to students dealing with the constraints of crowded commutes, provides important insights into the current system's strengths and limitations. Furthermore, the introduction of new alternatives, such as BinBin's electric scooters, indicates a potential move toward more sustainable and efficient forms of urban transportation. By diving into these various experiences and objectives, this chapter provides insights into the accessibility, convenience, and environmental effects of transportation in Skopje.

5.2.1.1 *JSP*

In my interviews with Skopje citizens, I spoke with a diverse group of people, including retired citizens, individuals with disabilities, as well as students from universities and high schools. The goal was to learn about their respective roles as citizens, as well as their experiences and perceptions of the public transportation services offered by JSP. The

questions addressed several elements of their interaction with public transit, including their modes of transportation, satisfaction levels, use of JSP phone applications, payment methods, daily commute scenarios, and perspectives on recent and possible future improvements.

Retired people primarily use buses, taking advantage of days when pensioners can travel for free in Skopje. Throughout their lives, they have adapted to this mode of transportation, often using it for visiting family, running errands, and attending appointments. While pensioners were generally pleased with the service, they highlighted the importance of renovating buses and replacing older models to improve comfort and efficiency. They sometimes encountered situations such as overcrowding and a lack of respect among passengers. For instance, they observed that the custom of reserving a bus seat for the elderly has changed. Furthermore, their lack of preference for alternative modes of transportation, such as owning a personal vehicle, suggests that they will continue to rely on public transportation for mobility. This type of mindset represents a shift from simpler times, when people were content with modest comforts. In this scenario, using a bus as a transportation service was more than enough.

I also conducted an interview with an individual with disabilities. People with disabilities in Skopje mostly rely on buses for transit, frequently taking advantage of the privileges afforded by free annual bus passes for people who are members of certain disabled organizations. During the interview, we discussed several challenges, including the lack of wheelchair user assistance on Skopje's buses, constant road construction that causes dust around the city, concerns about funding potential projects, and the availability of suitable infrastructure to support them. As demonstrated by Mishra et al., individuals with mobility issues, particularly those using wheelchairs, may find it challenging to access bus stations (Mishra et al., 2023). The interviewee confirmed that this issue is indeed present in Skopje and that there hasn't been any progress in this area in years. However, the interviewee has still seen some improvements in other fields in recent years, such as an increased focus on hygiene and increased use of air conditioning on city buses.

The last round of interviews was with a focus group of students from universities and high schools who use JSP in Skopje. They revealed a mix of convenience, dissatisfaction, and potential areas for improvement. Many students choose buses over cars because of concerns about parking availability and the overall traffic jams in Skopje. While some students have been using JSP's smartphone applications for years, others are unaware of or dissatisfied with them, citing concerns about incorrect bus schedules and malfunctions while using the app. Many see top-ups with card payments as a more convenient and faster alternative to traditional methods, but there was still a lot of skepticism amongst them. Interviewees stated that they primarily use their free JSP cards due to their benefits as students in the city. If they had a car, they would probably not even use the bus, and a couple of them confirmed that they have recently gotten their driver's license and stopped using bus transportation. In

Skopje, there are no bus lanes, so you drive at the same speed and in the same lane as cars, which means you'll always get stuck in traffic. Several suggestions for improvement emerged from the interviews, including the implementation of enhanced driver training, a feature uncommon in Skopje's public transportation, an increase in bus frequency, and, crucially, the enhancement of sanitation standards and bus renovations.

After completing these interviews with various age groups, it is interesting to note the differences in experiences between interviewing elderly people and younger generations. Elderly people often adhere to traditional methods such as purchasing tickets in tobacco shops and taking buses, indicating their preference for simplicity. In contrast, younger generations are more likely to use mobile applications. JSP must strive to provide training to drivers, create separate bus lanes, maintain their mobile application, and work on the bus schedules. The goal is to encourage individuals to utilize public transportation, rather than relying solely on personal vehicles that contribute to city pollution and excessive traffic, particularly during peak hours.

5.2.1.2 *BinBin*

BinBin's entry into a small city like Skopje is a crucial step toward transforming urban transportation while emphasizing efficiency. I carried out multiple interviews with users of this service and gathered insights that allowed me to go into what individuals thought at the start of the service's introduction and how they eventually adapted and began using it on a daily basis.

Participants in the interviews shared a variety of viewpoints on their transportation patterns and experiences with smart services in Skopje. Some people depended heavily on personal cars for their daily journeys, while others took public buses or taxis. There was a noticeable interest in investigating alternate forms of mobility, especially among individuals who had recently begun using electric scooters provided by BinBin, the city's first rental service of this type. While some users found the service comfortable and cost-effective for short-distance travel, others encountered difficulties, such as identifying available scooters during busy hours or technical issues with the smartphone application. Furthermore, most users found the mobile application registration simple, but still, some expressed concerns about the checkout procedure's efficiency and occasional payment errors.

BinBin stated from the start that you could rent and leave a scooter anywhere. While some participants found scooters easily accessible in their area, others struggled to locate fully charged scooters or had to deal with damaged ones. Despite efforts to maintain and monitor the fleet, participants expressed concerns about the need for more scooters and improved repair infrastructure to address the many issues that appeared at the beginning. Participants also talked about their usage habits and safety concerns while riding electric scooters. While some participants opted for dedicated bike lanes, others chose to ride through city streets and pedestrian walkways, indicating that rules and regulations are not a significant factor in

a city like Skopje, as reported in many Skopje news stories. All of the challenges with this service align with the insights from Samadzad et al., 2023, which include limited battery life, safety concerns, and, most importantly, adapting to a new innovation such as renting electric scooters (Samadzad et al., 2023).

The respondents emphasized the importance of designated scooter stations in each neighborhood, which could reduce theft and increase the overall organization of scooters. Also, making the mobile application more user-friendly, particularly in terms of payment processes, is necessary in order to ensure stress-free credit top-ups. Furthermore, participants emphasized the need for targeted marketing activities to promote service awareness and foster positive public opinion. Collaborating with local authorities and focusing on education and outreach programs can be beneficial measures toward promoting the adoption and long-term use of electric scooters in Skopje. When you show people how efficient this service could be with an appealing campaign, it might catch their attention quicker.

The findings from interviews with BinBin electric scooter users provided useful perspectives on the service's benefits and drawbacks. Even though there are ongoing issues to address, citizens are slowly realizing the value of these scooters and are beginning to follow the rules of driving on bike lanes, not using headphones while driving, and similar. By tackling these difficulties through collaborative efforts between stakeholders and policymakers, electric scooters have the potential to provide citizens with a more efficient, environmentally friendly, and accessible mode of transportation around busy cities like Skopje.

5.2.2 Smart energy insights

The pursuit of sustainable energy solutions resonates with Skopje, which deals with significant environmental difficulties, most notably extensive air pollution as mentioned in previous chapters. The interview with the head of the Department for Energy, Energy Efficiency, and Renewable Energy Sources revealed an endless number of viewpoints on active projects, persistent roadblocks, and the projected future of the city's sustainable energy efforts. The conversation shed light on the challenges of negotiating barriers, such as financial limits and governmental restrictions, and the aspiration to move forward toward a greener, more resilient urban environment.

The department's representative began by shedding light on the successful projects completed over the past few years. They highlighted the construction of solar power stations in schools as an example of a proactive approach to solar energy collection, as well as the city's efforts to promote energy-efficient solutions in public buildings as an example of a diversified approach to reducing energy consumption and environmental impact. For instance, solar power is one of the technical advances in smart energy, which is considered a renewable energy source (Pandiyan et al., 2023).

Skopje's governance system, which underscores the complexity of coordinating renewable energy programs, is the driving force behind all these efforts. However, department staff initially noted that each municipality operates independently and has its own budget, demonstrating decentralization. While the City of Skopje oversees projects for major institutions and secondary schools, local municipalities are in charge of elementary and kindergarten facilities. An important fact is that the city's jurisdiction encompasses various public companies, including community services and public utilities for the supply of water, energy, and other primary needs in every household. Communication difficulties between central and local governments, particularly during administrative changes such as elections, often jeopardize the continuation and finalization of projects.

Moreover, the interview underscored Skopje's struggle with air pollution, widely known as one of the most severe worldwide. The main causes of air pollution in Skopje are biomass burning, traffic, and the combustion of fuel and residual oil (Mirakovski et al., 2024). To address this critical problem, the city has developed a number of initiatives targeted at lowering emissions and improving air quality. These initiatives include bicycle and electric scooter subsidies, as well as the construction of highly efficient pellet stoves, air conditioners, and chimney cleaning operations. In addition to these ongoing initiatives, the interviewee suggested that the city should offer free bus transportation during peak pollution hours to encourage residents to utilize public transportation instead of driving their own cars. The interviewee also emphasized the significance of smart traffic control technology, particularly automated regulation software and roundabouts. Smart grids, another technological advancement in smart energy, link to these technologies, which enhance traffic management, reduce congestion, and reduce pollutants (Pandiyan et al., 2023).

The city has introduced a variety of energy-efficient techniques in transportation, buildings, and other sectors. In buildings, these actions include adding energy-efficient facades, replacing wooden windows with new ones, and using energy-efficient LED (Light Emitting Diode) lighting. To reduce energy consumption, schools also use renewable energy and secondary heating regulation. To conserve energy and reduce air pollution, they have converted street lighting to LEDs and used gas as an alternative energy source. Other initiatives include encouraging the use of eco-friendly boilers, building green roofs to decrease heat islands in cities, and investigating new approaches such as painting asphalt white to reduce heat absorption. All these solutions are aimed at achieving smart buildings. However, Skopje still confronts enormous obstacles in its search for sustainable energy solutions. Shaped like a basin or bowl, Skopje frequently experiences air pollution due to topographical factors trapping pollutants and preventing their dispersal. But this doesn’t mean that there is no solution to air pollution. The biggest obstacle to resolving these challenges in Skopje is budget and staff member restrictions, which are interdependent and limit the scope of energy-saving programs. If we secure the project's funding but fail to properly pay the staff, or if we pay the staff but fail to receive the project's budget, we risk years of idle waiting.

Grad Skopje employees stressed the importance of education in promoting sustainable practices and strived to provide training programs through information centers. These projects aim to educate people and workers about renewable energy and energy-efficient practices, establishing a culture of environmental care and responsibility. Grad Skopje invites every resident to visit these centers, educate themselves, and ask any questions they may have about how to use energy in the most efficient and sustainable manner possible. As stated before in this thesis, a lack of education at a young age can lead to a negative mindset, making it more challenging to influence and alter someone's perspective later in life. However, these trainings provide little hope or motivation for the citizens of Skopje to effect change.

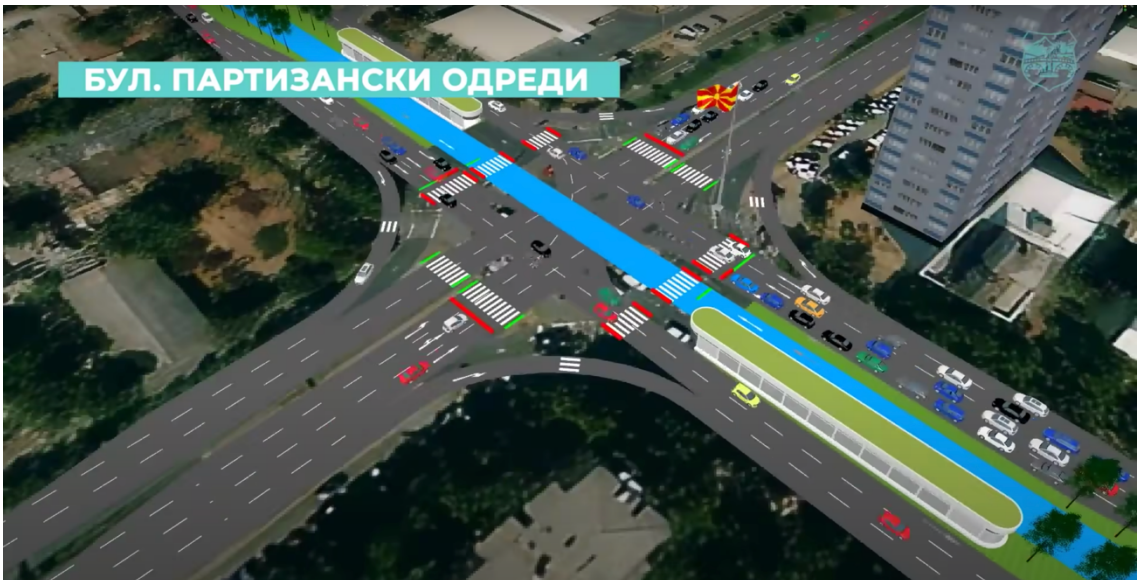
5.2.3 Bus Rapid Transit

In most of the interviews with Skopje users and developers, the Bus Rapid Transit project was a significant topic of discussion. Respondents shared their thoughts on this recent project in Skopje, emphasizing both its potential advantages and challenges. Given the widespread discussion about this project among Skopje's citizens and the technical understanding of the smart energy sector at Grad Skopje that I interviewed, it made sense to bring the topic up in the conversations with the interviewees and include it in my research for this thesis.

BRT (Bus Rapid Transit) is a flexible and efficient public transportation system that offers the speed, capacity, and efficiency of rail transit while still providing the flexibility and cost advantages of buses. The system operates on designated lanes, using modern stations to minimize delays and improve the overall passenger experience by taking them faster from point A to point B. As a result, it enhances urban mobility and fosters the growth of sustainable transportation. This is why many countries lacking the resources to construct trams or metros view BRT as a viable alternative to achieve their goals of smart mobility and smart energy (Levinson et al., 2002).

One of the popular projects for public transportation in Skopje is BRT. Cities like Skopje developed BRT as a public transportation system to address their issues. With dedicated lanes and faster service, BRT is a feasible answer to the city's traffic congestion and air pollution problems. The City of Skopje is embarking on a transformative effort to improve its urban transportation system by implementing this service. The project is funded by the EBRD (European Bank for Reconstruction and Development), and the plan is for the municipal-owned public transport operator, JSP, to manage the operation of the BRT lines. The idea is for the BRT lines to run through the city in the middle of the streets by having a dedicated lane for buses. Figure 9 represents a 3D presentation of how the BRT Skopje project would look like.

Figure 9: Bus Rapid Transit Skopje (3D presentation)



Source: Град Скопје, (n.d.)

The project's initial proposal includes two phases. Phase one of the project focuses on the development of BRT Line 1, which spans 12.81 kilometers and has 21 bus stops, servicing roughly 65,000 passengers each day. The corridor will run through Skopje's metropolitan landscape from west to east, increasing connectivity and accessibility. The installation of low-floor BRT vehicles intends to improve accessibility, particularly for people with limited mobility. The anticipated benefits include a 50% reduction in journey times, with peak-hour bus frequencies of 3–4 minutes each. The second phase comprises the construction of BRT Line 2, which will run north to south. This phase, which covers 10.4 kilometers and features 20 bus stations, complements Line 1's services, further improving the city's public transportation network. Overlapping along a predetermined portion, both lines will meet at the "Novo Lisice" (area in Skopje) depot. The idea is to deploy additional BRT vehicles to ensure consistent service delivery across the expanded network. Considering all the challenges discussed in this thesis and research on public transportation, BRT could potentially be the solution to all these problems.

The development and construction of BRT lines is expected to offer numerous benefits, including:

- Improved public transportation services with high frequency, safety, and reliability, which are expected to encourage increased use of public transit.
- Improved passenger comfort by the introduction of new BRT vehicles equipped with high-quality features, such as accessibility measures for disabled people.
- Air pollution mitigation and public health gains, as well as a reduction in greenhouse gas emissions, particle emissions, and noise levels, all with the idea of contributing to a

cleaner and healthier urban environment (European Bank for Reconstruction and Development, 2020).

Despite not having the opportunity to speak with JSP representatives or any of the departments directly financing this project, the Department of Energy, Energy Efficiency, and Renewable Energy Sources in Grad Skopje provided valuable insights into the BRT project, since they are also part of the public sectors and projects around the city. Despite the abundance of information available online, it was beneficial to hear from a professional about the potential benefits of these projects and the reasons for their suspension. Overall, they explained that experts from several countries initially accepted the project, but it went through several iterations and didn't advance to the realization phase until the new government reopened it. What impacted the project negatively was the concerns about potential damage to the main water pipe, situated beneath the planned bus lanes. It is important to note that this pipe is a crucial water source that supplies the entire city. This strongly connects to the points made in Sofeska's paper: Skopje has a robust infrastructure and the potential for bus rapid transit lines, but it also faces numerous challenges, such as the pipe situation, as well as a lack of resources, funding, and governmental changes that impact the project's actual implementation (Sofeska, 2017). Although the project has not yet officially begun, the government remains committed to its foundation and has secured crucial funds, which is a positive and important starting point. Following the construction of these lines, the government plans to introduce new electric buses and redesign the system for building out BRT routes, indicating ongoing efforts to expand the project and hopefully successfully complete it.

Furthermore, during the interviews, I asked smart mobility users from Skopje what they thought of this potential project. Many have already seen the news, articles, and videos released over the last couple of years but haven’t seen any progress with the project. While many saw the project's potential as an ideal answer to the city's traffic and pollution problems, many were concerned about its practical implementation. Users expressed a general sense of dissatisfaction, mainly because of Skopje's past activities, which usually lead to delayed prior development projects, even in scenarios where funds were provided. Another skeptical thought from the users' side was the fact that governmental changes happen so regularly and that they impact the realization of such projects very often.

All in all, even though BRT can bring many benefits, there is no doubt that the project in Skopje ran into problems because of the way politics operate and because the city leadership changed. The project's slow progress demonstrates the complexity and riskiness of urban development projects, as changes in government policies can influence decision-making processes. However, there are still ongoing discussions about revitalizing the BRT project and its role in addressing Skopje's transportation issues.

5.3 Comparison of smart mobility strategies in Ljubljana and Skopje

When comparing how Skopje and Ljubljana manage smart mobility strategies, three major factors stand out: infrastructure, mentality, and funding, which correlate to the factors mentioned in the paper from Bıyık et al. that influence the adoption of smart mobility technologies (Bıyık et al., 2021). Even though both Skopje and Ljubljana are small cities, Ljubljana has made more progress due to its increased EU funding and citizen awareness of smart mobility's benefits for individuals and the environment. Ljubljana offers all four mobility options: public transportation, bicycle rentals, car rentals, and electric scooters. In contrast, Skopje currently provides only two options: public transportation and electric scooter rentals, and it has issues with citizens accepting and maintaining these services in an efficient way.

Interviews with users and developers on smart mobility topics provided valuable insights into the absence of bike or car rental services in Skopje. The majority of interviewees found the car-rental option more useful due to Skopje's culture, which is oriented towards everyone owning one vehicle. They were also aware that the city is unfortunately not suitable for driving bicycles due to road construction, a lack of bicycle paths, and, most importantly, a lack of culture when driving around. However, this doesn't change the fact that car travel has become extremely inefficient, particularly as the city's pollution levels continue to rise daily. In fact, having the opportunity for people to rent cars to move around the city would eliminate the majority of parking concerns and air pollution. However, Skopje lacks the infrastructure to support such a large number of charging stations for electric vehicles. In addition, the majority of the interviewees expressed their preference for owning their own vehicle and bicycle, but they would also value the option to rent, provided the price was reasonable.

During the interviews, it came to light that there was a pilot project in Skopje in the past with approximately 500 bicycles available for rental. Similar to Bicikelj, the idea was to have stations where you could rent bicycles for short routes around the city. Unfortunately, the residents' mentality led the project to failure, resulting in most of the bicycles being stolen or damaged, a scenario similar to the early days of scooter rentals (BinBin) in Skopje. The main issue in Skopje is the people's mindset and a lack of educational opportunities. As stated before, a person's education must begin at an early age, and if Skopje is to move forward and advance in the same way that other European countries have, it will require a lot of knowledge on important topics like this one beginning in primary school. We don't give enough attention to the important and sensitive topics of smart cities and sustainability. The reality is that Skopje has a lot of potential, but it has been troubled by unpleasant events for quite some time now. We can attribute these events to a lack of funding, governmental changes that have impacted the process, or a lack of acceptance and utilization of newly introduced services. There is still hope, as current and future generations will become even more knowledgeable about digitization and smart services, given the ongoing advancements

in technology and the growing interest in its use. Interviewees about Skopje smart services consistently concluded that a positive shift in culture could significantly improve the city's performance.

Though there are certain differences between the two, Ljubljana and Skopje are both capitals of small Balkan countries when compared to other European cities. Despite its ambitions, Skopje is not an EU member and lacks the money to carry out certain smart city initiatives. Ljubljana, on the other hand, adheres to stricter EU rules and regulations. Most people go to Slovenia for work or education, but they follow the laws, unlike in their hometown. This doesn't mean that other Balkan countries don't have laws and regulations; it just means that the chances of getting a fine for driving on the wrong bike line are far smaller than the chance of getting one in Slovenia. The police and administration in Ljubljana have made a significant effort to explain the importance of adhering to such restrictions, as disregarding them can result in high fines. Usually, individuals only follow such rules when there is a cost associated with breaking a law.

What also plays a significant role in accepting and adapting to these smart services is the mindset of elderly people, who usually stick to traditional and simple ways of living. The younger generations are the ones who strive to use smart services and AI as beneficial tools rather than as sources of fear. However, the majority of younger generations relocate from Skopje to Ljubljana, which has led to a decrease in the number of young individuals who have traveled throughout Europe and gained knowledge about sustainable practices but are unable to implement them in their own city. There are around 40,000 foreigners living in Ljubljana, according to recent statistics shared from SURS (Statistični urad Republike Slovenije). Still, the majority of the population chooses to live outside of the city, usually in smaller cities, because of the daily traffic and commotion in Ljubljana. In Skopje, the situation is reversed. The 2021 data from the State Statistical Office of North Macedonia indicates that North Macedonia had a population of approximately 1,836,713, and Skopje had 526,502 inhabitants. In comparison, the second most populated city, Kumanovo, has only 75,051 inhabitants, and the third, Bitola, has 69,287 inhabitants (State Statistical Office of the Republic of North Macedonia, 2021). Unfortunately, there is no recent data available, but based on the interviews I conducted with respondents, it is evident that this rise in population in the capital city has continued. The majority of people from smaller cities or villages have migrated to the capital city, with the primary goal in recent years being to construct as many buildings as possible to provide housing for everyone, which has led to an increase in pollution.

By considering all the thoughts and discussions, a couple of points can be concluded from the interviews. First and foremost, being in the EU makes a significant impact for every country, since without funds, you cannot achieve anything. Second, even though most of the people interviewed would prefer their own vehicle, bicycle, or scooter for flexibility, smart city services are practical and helpful in many situations and relieve the burden of

maintaining your own vehicle. Finally, many of the interviewees from Skopje were unaware of smart city initiatives such as car sharing and bicycle sharing until they had the opportunity to travel to other EU countries and experienced the benefits of these services. Many cities, including Ljubljana, try to educate children from a very young age, starting in kindergarten or primary school. When you start early, educating yourself about the importance of understanding why we should use more public transportation options, leading to less pollution, and being physically active, you begin to have an indirect positive impact on the globe and, more importantly, on your own well-being. Table 1 below contains a summary of all the findings from the smart mobility interviews (Table 1).

Table 1: Smart mobility findings

Aspect	Ljubljana	Skopje	Key insights	Suggested improvements
Smart mobility infrastructure	Offers all four mobility options: public transport, bicycles, cars and scooters.	Limited to public transport and scooters; lacks bicycle and car-sharing services.	EU membership aids funding for infrastructure in Ljubljana, whereas Skopje lacks sufficient resources and infrastructure.	Ljubljana: Expand charging stations for EVs, parking spaces, and integrate services and improvements for a seamless user experience. Skopje: Focus on funding for pilot projects with robust maintenance and security measures.
Cultural acceptance	Awareness and acceptance of smart mobility benefits.	Cultural resistance and lack of education on benefits.	Early education and cultural shifts are critical to fostering acceptance of smart city initiatives.	Ljubljana: Continue community education campaigns and reach out to elderly populations. Skopje: Launch public awareness programs and incentivize smart mobility use.
User preferences	Flexibility in using shared mobility options appreciated.	Preference for personal vehicles; cost-sensitive towards shared options.	Education and exposure to shared mobility benefits in other countries around Europe positively influence acceptance.	Ljubljana: Offer subsidies or discounts (loyalty programs) for shared mobility services to keep the users. Skopje: Introduce affordable pricing models to encourage adoption and rewards in exchange for using more smart services that pollute less than owning old vehicles.
Environmental concerns	Citizens are more aware of environmental impact; stronger enforcement of laws.	Pollution is increasing due to high vehicle ownership, mainly old, unserviced vehicles, and weak enforcement of regulations.	Awareness campaigns and policy enforcement are effective tools for environmental sustainability.	Ljubljana: Enhance green public transport infrastructure. Skopje: Implement stricter pollution control policies and expand public transport options.
Challenges in implementation	Strong legal enforcement and adherence to EU policies.	Lack of funding, weak law enforcement, and informal approaches.	Being part of the EU has a significant positive impact on policy implementation and funding.	Ljubljana: Address gaps in rural mobility to ensure inclusivity. Skopje: Advocate for international partnerships and EU funding opportunities.

table continues

continued

Table 1: Smart mobility findings (cont.)

Aspect	Ljubljana	Skopje	Key insights	Suggested improvements
Generational differences	Younger generations drive sustainability efforts; the elderly are less engaged.	Younger generations often migrate, reducing local potential for smart city adoption.	Retaining and educating younger generations could improve adoption of smart city practices in Skopje.	Ljubljana: Create programs that engage elderly citizens in smart initiatives. Skopje: Develop youth-focused initiatives to retain talent locally.
Lessons from past initiatives	Successful pilot projects and consistent improvements, plans for the transportation in the near future.	Pilot projects like bicycle sharing failed due to theft, damage, and cultural attitudes. The BRT project has been on hold for a very long period.	Proper planning, funding, education, and community engagement are essential for the success of smart city initiatives.	Ljubljana: Invest in scaling successful pilot projects. Expand citizen engagement through regular feedback loops. Skopje: Improve security, funding, and community ownership in future pilot projects. Use focus groups to co-create policies with citizens.

Source: Own work

5.4 Comparison of smart energy strategies in Ljubljana and Skopje

When comparing how Skopje and Ljubljana manage smart energy strategies, funding consistently emerges as a major difference. Smart use of energy requires a lot of time and money. After conducting the research, it is evident that Ljubljana, as a member of the EU, has less difficulty securing funding for smart energy initiatives. Skopje struggles, especially because it rarely has enough money to fund all its initiatives.

While both Skopje and Ljubljana promote smart energy strategies, their approaches vary in numerous ways. Skopje's strategy relies on collaborative efforts across municipal organizations, with an emphasis on environmental protection, energy efficiency, and renewable energy adoption. In contrast, Ljubljana benefits from the leadership of innovative enterprises such as Danfoss, which pioneer sustainable practices using comprehensive plans and cutting-edge technology. Ljubljana, as the capital city, also relies on municipal organizations, but a large part of the solutions comes from private enterprises. This is because those businesses have their own strategy, don't wait for government regulations or funds, and don't rely on municipal activities (Erlandsen & Svendsen, 2023). For instance, LPP and JSP necessitate the approval and alignment of all activities with municipal goals, a process that could be lengthy. In contrast, Avant2Go, Bolt, and BinBin successfully established and promoted their systems within a short timeframe and promptly upgraded them due to their autonomy and high demand. On the one hand, Skopje's approach prioritizes local governance and public sector activities, primarily due to the lack of companies specializing in the production and promotion of energy-efficient solutions. On the other hand, Ljubljana uses private sector skills and international alliances to promote sustainability. However, both cities share the same goals of increasing environmental resilience, lowering pollution, and supporting renewable energy, even though they are on slightly different paths of the journey.

The interview with employees in Grad Skopje showed that the city found success by implementing several smart-energy solutions, mostly in public schools, buildings, and green areas. The majority of the ideas included solar power stations in districts, roundabouts to reduce traffic, designs that increase afforestation, distinct energy facades, LED lights, and more, which are all part of the technical advancements listed in Pandiyan et al.’s study (Pandiyan et al., 2023).

Providing people with advantages or rewards is the most effective way to convince them to participate in a sustainable movement. This is why Grad Skopje provides various subsidies for bicycles and electric scooters, replaces chimneys with modern air conditioners, and installs pellet stoves. Adapting to changes or letting go of habits can be challenging, particularly in the rapidly changing world we live in. This approach would assist people in understanding the benefits of switching to energy-efficient solutions, ensure they receive rewards for their participation in the movement, and contribute to the reduction of

greenhouse gas emissions. However, the severely restricted budget presents a significant challenge. Most of the time, they receive funding to repair two or three streets, when in reality, they need sufficient funds to fix the whole city. Even more challenging is the possibility of starting a project and pausing it along the way, a process we have defined as the Plan-Do-Check-Act (PDCA) framework. The PDCA framework evaluates the maturity and progress of smart city projects and demonstrates that most cities are still in the early "planning" stages. As stated in previous chapters, this is due to a number of problems, including insufficient money, infrastructure constraints, and poor public participation (Nincević et al., 2021).

Companies like Danfoss are prime examples of how Slovenia stands out for its sustainable energy projects. The interview with a Danfoss employee and sustainability expert in that field revealed the company's dedication to reducing its environmental impact through a comprehensive lifecycle strategy. Danfoss aims to reduce CO2 emissions throughout the value chain while also promoting circularity through product design and material recycling. The company uses advanced technology, including lifecycle assessment tools that examine and enhance its environmental performance. The discussion provided insight into Danfoss' strategic approach to addressing sustainability concerns, which prioritizes transparency, regulatory compliance, and proactive risk management. Danfoss, despite being a Danish company, is an example of how to incorporate environmental responsibility in a smaller country like Slovenia. As stated in Prašnikar & Cirman, Danfoss Trata has adopted a hybrid management style that mixes Danish and Slovenian organizational elements (Prašnikar & Cirman, 2007). Influence from a Danish city such as Copenhagen, which ranked first in the world's digital cities index in 2022, provides valuable examples and insights that can accelerate and enhance the sustainability of smaller countries (Statista, 2023).

Overall, both countries are trying to make a difference with their available resources. They aim to encourage citizens to replace polluting, old equipment with smart energy technology to its full potential by offering and explaining the advantages it could bring. Providing certain rewards and subsidies is a good strategy to motivate the people to participate. Furthermore, public entities succeed at securing and utilizing funding to implement more sustainable practices. However, these government organizations often struggle to secure funding in a timely manner, which can hinder their ability to respond to critical changes in the environment. For that reason, having public funds available is always a good idea, but having private companies like Danfoss is also beneficial for the city itself. Smart energy technologies developed by multinational corporations with decades of experience in the field are useful for smart-evolving cities such as Skopje and Ljubljana Table 2 below contains a summary of all the findings from the smart energy interviews (Table 2).

Table 2: Smart energy findings

Aspect	Ljubljana	Skopje	Key insights	Suggested improvements
Funding	EU membership facilitates funding for smart energy projects.	Struggles with insufficient and delayed funding for initiatives.	Funding is a critical enabler; Ljubljana has a significant advantage as an EU member.	Ljubljana: Streamline funding processes for rapid project implementation. Skopje: Seek international partnerships and donor support.
Approach to smart energy	Leverages private enterprises (e.g., Danfoss) alongside public efforts.	Relies primarily on public sector initiatives and municipal collaborations.	Ljubljana benefits from innovative private sector input, while Skopje lacks such enterprise support.	Ljubljana: Foster stronger public-private partnerships. Skopje: Attract private-sector participation through incentives and support.
Citizen incentives	Citizens benefit from private sector advancements and public programs.	Offers subsidies for eco-friendly equipment such as free bus rides, discounts on electric vehicles, free installation of air conditioning chimney replacements, etc.	Citizen engagement and incentives encourage sustainable behavior in both cities. Primarily, subsidies play a bigger role in citizen behavior.	Ljubljana: Expand citizen awareness campaigns. Skopje: Increase the scope and reach of subsidies for renewable energy equipment.
Innovative solutions	Advanced technologies (e.g., lifecycle assessments, material recycling) by companies like Danfoss.	Focus on solar power, LED lighting, afforestation, and roundabouts for energy efficiency.	Both cities employ innovative methods, but Skopje needs higher investment in cutting-edge solutions.	Ljubljana: Invest in research for new technologies. Skopje: Collaborate with international firms for technological adoption.
Public awareness and engagement	Well-informed citizens, with sustainability efforts embedded in education in households.	Limited public participation and awareness of smart energy benefits.	Public engagement is a key factor for long-term success in sustainability initiatives.	Ljubljana: Engage older generations with tailored programs. Skopje: Implement widespread educational campaigns from schools onward.
Private sector involvement	Strong, proactive participation from companies like Danfoss.	Limited private sector involvement.	Private companies accelerate innovation and implementation of smart energy solutions quicker and more efficient.	Ljubljana: Expand collaborative projects with local startups. Skopje: Offer tax benefits and grants to attract green technology firms.
Shared goals	Focused on environmental resilience, reducing pollution, and promoting renewable energy.	Similar goals but slower progress due to resource limitations.	Shared ambitions highlight the importance of collaboration and sharing best practices.	Establish a regional platform for collaboration and knowledge exchange between cities.

Source: Own work

6 CONCLUSION

This thesis has explored the strategies and implementations of smart city initiatives in two mid-sized European cities, Ljubljana and Skopje, with a focus on smart energy and smart mobility. The comparative analysis reveals distinct differences in their approaches, successes, and challenges, providing valuable insights into how these two cities can strive to be better. One of the key findings of this research is the importance of tailored solutions that consider each city's unique socioeconomic context, geographical limitations, and infrastructural readiness. The thesis also underscores the critical role of stakeholder engagement, including the involvement of governments, businesses, and citizens, in driving the successful implementation of smart city technologies. Interviews with key stakeholders in both Ljubljana and Skopje revealed that private and public participation are essential for overcoming resistance to change within the citizens, securing funding for project realization, and ensuring the long-term success of smart city projects.

However, a notable limitation emerged in secondary research for both Ljubljana and Skopje: engaging with private companies such as Bolt, BinBin, and Avant2Go proved challenging. Attempts to interview a developer were unsuccessful due to confidentiality concerns. The companies have either not responded or stated that such interviews are against their policy. These limitations restricted more profound insight into the companies' business models and strategic contributions to each city's smart city goals. But the user's feedback, experience, and collaboration provided greater insights into the services these private companies provide.

On one hand, considering the interviewees responses, Skopje has a lot of potential to succeed in their smart city initiatives. Despite past failures, Skopje needs a little push from younger generations who are willing to make a difference and take risks in order to grow faster like other European cities. Choosing to examine a topic like smart cities is a highly popular and rapidly changing challenge nowadays. During the thesis writing process and research, I discovered several significant developments in Skopje, including the reintroduction of the BRT project, which has the potential to significantly impact public transportation. While there is always room for improvement, all respondents, whether users or developers, shared a common attitude of striving for better results in the near future.

On the other hand, Ljubljana also has a long way to go, and there is always room for improvement. For example, foreigners who have relocated to Ljubljana have been amazed with the services that are not available in their home city. However, these mobility services have been around for quite some time now in Ljubljana, and citizens are used to these services and consider them as standard and nothing out of the ordinary. That's why the majority of people travel throughout Europe in search of new, better services or modifications that could greatly benefit cities like Ljubljana and Skopje. This is a very natural way of doing things, primarily because we live in a fast-paced world where new

things are introduced every day, and that particular cycle often repeats itself. Citizens are often dissatisfied with their home country and feel the need to move to another country in search of better opportunities for studying, working, and living overall.

In conclusion, both Ljubljana and Skopje present distinct yet promising paths toward becoming smarter, more sustainable cities. While Skopje faces historical challenges, it holds great potential, particularly with younger generations eager to drive innovation and take risks. Significant initiatives like the BRT project highlight the city's willingness to evolve as a European smart city. Ljubljana, though more advanced in its smart city journey, continues to seek improvements, with its established services setting a strong foundation for future growth. Both cities demonstrate a commitment to progress, but their development will depend on continuous innovation, collaboration, and the pursuit of better solutions to meet the needs of their citizens and keep pace with their European counterparts.

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APPENDICES

Appendix 1: Povzetek (Summary in Slovenian language)

Zaradi hitre globalne urbanizacije in naraščajočih okoljskih izzivov, mesta se soočajo z vse večjim pritiskom za uvedbo trajnostnih strategij, ki naslavljajo učinkovitost, varstvo okolja in kakovost življenja. Ta magistrska naloga z imenom "Analiza pametne energije in pametne mobilnosti v mestih: primerjava Ljubljane in Skopja" preučuje implementacijo strategij pametnih mest, s posebnim poudarkom na pametni energiji in pametni mobilnosti, skozi primerjalno analizo dveh srednje velikih evropskih mest: Ljubljane v Sloveniji in Skopja v Severni Makedoniji. Z analizo njunih različnih pristopov, raziskava osvetljuje učinkovite strategije, obstoječe izzive ter priložnosti za nadaljnji napredek na področju urbane trajnosti.

Namen študije je analizirati učinkovitost pobud pametnih mest pri doseganju trajnosti in izboljšanju kakovosti življenja prebivalcev. Da bi to dosegla, naloga obravnava tri ključna raziskovalna vprašanja:

- Katere strategije so se izkazale za najučinkovitejše pri doseganju trajnosti na področju pametne mobilnosti in pametne energije?
- Kako sta se Ljubljana in Skopje prilagodila izzivom, povezanim z omejenimi viri, infrastrukturnimi omejitvami in odporom prebivalcev do novih tehnologij?
- Kako lahko ti mesti še izboljšata svoje dosežke na področju pametnih mest?

Za odgovore na ta vprašanja sem uporabila kombinacijo metod. Primarne podatke sem zbrala z intervjuji z razvijalci in uporabniki storitev pametnih mest v obeh mestih, ki so zagotovili dragocen vpogled v praktične izzive in uspehe pri uvajanju pametnih pobud. Sekundarni podatki iz literature, študij primerov in strokovnih člankov so dodatno umestili ugotovitve v širši kontekst pametnih mest.

Ljubljana, priznana kot Evropska zelena prestolnica, je uspešno implementirala dobro uveljavljene storitve pametne mobilnosti, kot so souporaba avtomobilov, koles in električnih skirojev ter učinkovit javni promet. Poleg tega je mesto izvedlo številne projekte za optimizacijo rabe energije, vključno z naprednimi sistemi pametnih omrežij. Čeprav so ti ukrepi prinesli pomembne izboljšave, ostaja prostor za nadaljnji napredek, saj je za ohranitev vodilne vloge v trajnostnem razvoju potrebna nenehna inovacija in uskladitev s trendi napredka evropskih držav in prijahajočimi standardi.

Skopje se po drugi strani sooča z večjimi ovirami, vključno z visoko stopnjo onesnaženosti zraka, počasnejšim uvajanjem pametnih tehnologij in omejenimi finančnimi sredstvi, kar je značilno za države zunaj Evropske unije. Kljub temu ima Skopje velik potencial za napredek. Intervjuji so razkrili naraščajoče zanimanje mlajših generacij za uvajanje inovacij, obetavni projekti, kot je ponovna uvedba sistema Bus Rapid Transit (BRT), pa nakazujejo pozitivne spremembe v infrastrukturi javnega prometa.

Primerjalna analiza poudarja pomen prilagojenih rešitev, ki upoštevajo edinstvene družbenoekonomske in infrastrukturne razmere posameznega mesta. Kritični dejavnik za uspeh v obeh primerih je vključevanje ključnih deležnikov, vključno z vladami, podjetji in prebivalci. Sodelovanje med njimi lahko prispeva k premagovanju odpora do novih tehnologij, zagotavljanju potrebnega financiranja in dolgoročni vzdržnosti projektov pametnih mest.

V zaključku Ljubljana in Skopje ponujata dve različni, a dragoceni poti proti razvoju pametnih mest. Ljubljana, kljub naprednosti, potrebuje nadaljnje inovacije za ohranjanje svojega napredka, medtem ko Skopje zahteva strateške naložbe, močnejše politike in večjo vključenost prebivalcev za premagovanje obstoječih izzivov. Obe mesti dokazujeta, da je pot do pametnejših in trajnostnih urbanih okolij odvisna od sodelovanja, prilagodljivosti ter zavezanosti k izpolnjevanju nenehno spreminjajočih se potreb prebivalcev.

Appendix 2: Interviewees

Topic	Role in project	Separately/Focus group	Background/Position	Period when interview was conducted	City	Service/Company
Smart mobility	User	Separately	Pensioner in Skopje	Dec-23	Skopje	JSP
Smart mobility	User	Separately	Employed in Skopje	Dec-23	Skopje	JSP
Smart mobility	User	Separately	Employed in Skopje	Dec-23	Skopje	JSP
Smart mobility	User	Separately	Employed//Person with disability	Dec-23	Skopje	JSP
Smart mobility	User	Focus group	Student from Skopje	Dec-23	Skopje	JSP
Smart mobility	User		Student from a rural area in Skopje	Dec-23	Skopje	JSP
Smart mobility	User		Student from Kavadarci that studies in Skopje	Dec-23	Skopje	JSP
Smart mobility	User		Student from a rural area in Skopje	Dec-23	Skopje	JSP
Smart mobility	User	Separately	Student from Skopje	Dec-23	Skopje	BinBin
Smart mobility	User	Separately	Student from Skopje	Dec-23	Skopje	BinBin

appendix continues

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Appendix 2: Interviewees (cont.)

Topic	Role in project	Separately/Focus group	Background/Position	Period when interview was conducted	City	Service/Company
Smart mobility	User	Separately	Employed in Skopje	Nov-23	Skopje	BinBin
Smart mobility	User	Separately	Employed in Skopje	Jan-24	Skopje	BinBin
Smart energy	Developer	Separately	Employed (Head of the Unit for Energy, Energy Efficiency and Renewable Energy Source, Grad Skopje)	Dec-23	Skopje	Grad Skopje
Smart energy	Developer	Separately	Employed (LCA, sustainability and management systems consultant for the Danfoss Climate Solutions segment)	Mar-24	Ljubljana	Danfoss
Smart mobility	Developer	Separately	Employed (Deputy CEO LPP)	Mar-24	Ljubljana	LPP
Smart mobility	User	Separately	Student and employee in Ljubljana	Mar-24	Ljubljana	LPP

appendix continues

continued

Appendix 2: Interviewees (cont.)

Topic	Role in project	Separately/Focus group	Background/Position	Period when interview was conducted	City	Service/Company
Smart mobility	User	Focus group	Student and employee in Ljubljana	Mar-24	Ljubljana	LPP
Smart mobility	User		Student in Ljubljana	Mar-24	Ljubljana	LPP
Smart mobility	User		Student in Ljubljana	Mar-24	Ljubljana	LPP
Smart mobility	User		Student and employee in Ljubljana	Mar-24	Ljubljana	LPP
Smart mobility	User	Separately	Student in Ljubljana	Mar-24	Ljubljana	LPP
Smart mobility	User	Separately	Employed in Ljubljana	Mar-24	Ljubljana	Bolt
Smart mobility	User	Separately	Employed in Ljubljana	Mar-24	Ljubljana	Bolt
Smart mobility	User	Separately	Employed in Ljubljana	Mar-24	Ljubljana	Bolt
Smart mobility	User	Separately	Employed in Ljubljana	Mar-24	Ljubljana	Avant2Go
Smart mobility	User	Separately	Employed in Ljubljana	Mar-24	Ljubljana	Avant2Go

appendix continues

continued

Appendix 2: Interviewees (cont.)

Topic	Role in project	Separately/Focus group	Background/Position	Period when interview was conducted	City	Service/Company
Smart mobility	User	Focus group	Student and employee in Ljubljana	Mar-24	Ljubljana	Avant2Go
Smart mobility	User		Student and employee in Ljubljana	Mar-24	Ljubljana	Avant2Go
Smart mobility	User		Student and employee in Ljubljana	Mar-24	Ljubljana	Avant2Go
Smart mobility	User		Student in Ljubljana	Mar-24	Ljubljana	Avant2Go
Smart mobility	Developer	Separately	Employed in Europlakat (operator of Bicikelj)	Mar-24	Ljubljana	Europlakat/Bicikelj
Smart mobility	User	Focus group	Student and employee in Ljubljana	Apr-24	Ljubljana	Bicikelj
Smart mobility	User		Student in Ljubljana	Apr-24	Ljubljana	Bicikelj
Smart mobility	User		Employed in Ljubljana	Apr-24	Ljubljana	Bicikelj
Smart mobility	User		Student and employee in Ljubljana	Apr-24	Ljubljana	Bicikelj
Smart mobility	User		Student in Ljubljana	Apr-24	Ljubljana	Bicikelj

Appendix 3: JSP questions

Users
1. What modes of transport do you use? 2. How long have you been using smart services? 3. How satisfied are you with the public transportation in Skopje? 4. Can you describe any specific improvements you have noticed with the public transportation in recent years? 5. Are you using JSP's applications? ЈСП-Во Движење, ЈСП Распоред or Skopska. If yes, are the timelines accurate? From your experience, is the application useful? 6. Do you pay with your mobile phone on the bus to get a ticket, if needed? 7. If there were an option to pay with a card directly on the bus, would you use that? 8. Can you describe an every-day scenario when using public transportation? Are people being polite (for example letting someone in more need sit)? Can a disabled person get into the bus? Are the buses usually crowded or is there enough space? 9. Do you think the double decker buses help within busy times? Does everyone have place to sit or at least stand? 10. In your opinion, are the buses frequent enough? 11. Are you familiar with the idea of BRT (Bus Rapid Transit)? If yes, what do you think of the idea, considering that recently the project has been reopened? Do you think that such bus lines would solve the traffic that is happening in Skopje? 12. To what extent does the idea of being sustainable play a role in your decision of using public transport? If you owned a car, would you still use public transport? 13. Can you share any ideas that could make the public transportation easier and more efficient to use? 14. Based on your experience, what do you think is the main reason why smart services in Skopje are not effective? What should people and organizations work on to make the future better and more sustainable? 15. Considering the series of problems that our city Skopje is facing, which reflect our citizens' mentalities, do you think there is hope that our city will become a successful smart city in Europe? If not, why not? 16. If there was an option to rent a bicycle or electric car would you use it instead of having your own? Would it be beneficial, just like the opportunity we have of using scooters and buses?

Appendix 4: BinBin questions

Users
1. What modes of transport do you use? 2. How long have you been using smart services? 3. How satisfied are you with renting electric scooters? 4. Can you describe the journey of renting, using and leaving the scooters? 5. There are some scooter stations around the city, but are they enough? From your experience, do you always find a scooter nearby? 6. Are the scooters well-kept or usually damaged? 7. How satisfied are you with the application? 8. Is the electric scooter a useful and faster transportation for you? 9. Where do you usually drive the scooters? On the street, on the bicycle paths, on the pedestrian paths…? 10. What are the most specific challenges you face when using these electric scooters? (Have you been experiencing issues with scanning the codes, locking and unlocking the scooters, connecting your bank card with the app…) 11. Can you share any ideas that could make the renting of electric scooters easier and more efficient to use? 12. Based on your experience, what do you think is the main reason why smart services in Skopje are not effective? What should people and organizations work on to make the future better and more sustainable? 13. Considering the series of problems that our city Skopje is facing, which reflect our citizens' mentalities, do you think there is hope that our city will become a successful smart city in Europe? If not, why not? 14. If there was an option to rent a bicycle or electric car would you use it instead of having your own? Would it be beneficial, just like the opportunity we have of using scooters and buses?

Appendix 5: Grad Skopje questions

Developers		
Smart energy	BRT (Bus Rapid Transit)	General questions
1. Could you give me an overview of Skopje's current projects that are approved and running for renewable energy? 2. Given that we are one of the world's most air polluted cities, could you please speak about what steps the city has made to reduce air pollution in regard to your responsibilities at Grad Skopje? 3. Do you provide certain training for employees that are not familiar with the modern technology that is used for smart initiatives? 4. What energy-efficient strategies has the city implemented to cut down on energy use in transportation, buildings, and other areas?	1. There are a lot of past and present news regarding this topic, I would appreciate if you could explain in short about this project and its most recent initiatives? 2. Is the project officially open again? 3. Why was this project put on pause? 4. Has sufficient funding been received for this project? 5. How long will it take to build the whole project? 6. Will there be new electric buses involved or the same JSP buses will drive?	1. Recently the service of renting electric scooters was introduced in Skopje. Do you think that implementing a service for renting bicycles or electric cars would be also useful and used? Or have you discussed implementing something similar in the near future? 2. Based on your experience, what do you think is the main reason why smart services in Skopje are not effective? What should people and organizations work on to make the future better and more sustainable? 3. Considering the series of problems that our city Skopje is facing, which reflect our citizens' mentalities, do you think there is hope that our city will become a successful smart city in Europe? If not, why not?

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Appendix 5: Grad Skopje questions (cont.)

Developers		
Smart energy	BRT (Bus Rapid Transit)	General questions
5. Are there plans to build smart grids, energy storage, or other important pieces of infrastructure in the near future? 6. What is the vision for the future of sustainable energy in Skopje, and what role does the Department envision playing in achieving that vision? Are there specific goals or targets set for the coming years? 7. Are you familiar with the company Danfoss? If yes, would you say that there is some similar company like Danfoss in Skopje? 8. Do you think that having such companies would benefit the smart-energy solutions from Grad Skopje?		

Appendix 6: Danfoss questions

Developers
1. Can you tell me more about your position, what do you work specifically? 2. Can you tell me what specific initiatives or projects you are currently involved in? 3. Can you explain to me what is Danfoss doing to be sustainable? 4. Could you give some examples of specific goals or aims that Danfoss has set for itself in terms of sustainability, especially when it comes to smart energy solutions? 5. What are some of the biggest problems you've seen companies like Danfoss face when they try to be more environmentally friendly, especially in the smart energy sector? 6. What do you use to calculate how many emissions are being used with using Danfoss products instead of other products? Or if you'd like you can also connect other experiences you had outside of Danfoss, which could help my understanding of this topic. 7. In your opinion, what part do you think smart energy solutions play in efforts to make the world more sustainable? How does Danfoss plan to be a leader in this field? 8. Do you have some material you can share with me that can support my research? 9. Lastly, are there any upcoming developments or initiatives within Danfoss's sustainability strategy that you're particularly excited about or that you believe will have an impact on the future of smart energy solutions?

Appendix 7: LPP questions

Developers	Users
1. Have you looked into how many people have used public transportation by bus in the past year or even the past few years? Is the number increasing or decreasing? 2. You recently implemented test electrical buses. Is there a plan to replace regular buses with electrical ones entirely in the near future or are there any other changes that will be made to buses to make them an easier, and quick way to get around the city? 3. Does the idea of a "smart city," or long-term ways to cut down on pollution, traffic, etc., drive every move you make, for example, making the buses more fuel-efficient? 4. Sustainability is a “buzz” word that has been used a lot in Ljubljana and other European cities over the past couple of years. Have you done or are you planning on doing campaigns to raise citizens’ awareness on this topic with the idea of using more public transport rather than having their own vehicle? 5. Do you have some issues that prevent certain changes or projects from launching? 6. Do you have issues with employment, specifically drivers of LPP buses or controllers that go around and check whether people are paying for their tickets?	1. What kinds of transportation do you use? 2. How satisfied are you with Ljubljana's public transportation? 3. How is it different from the public transportation in Skopje? (for Macedonian citizens) 4. Can you describe any specific improvements you have noticed with the public transportation in recent years? 5. Are you using LPP’s new application? If yes, are you satisfied with the new features, overall the whole app? 6. Do you pay with your mobile phone on the bus to get a ticket, if needed? Do you have a problem that you can't pay for with HOFER SIM card for example...? 7. Have you paid with the new form of payment with card? What do you think about it? Are there any problems you're having with it? Do you have any ideas for how to make it better? 8. Can you describe an every-day scenario when using public transportation? Are people being polite (for example letting someone in more need sit)? Can a disabled person get into the bus? Are the buses usually crowded or is there enough space? Are they air-conditioned, comfortable, etc.…? 9. In your opinion, are the buses frequent enough and right on schedule?

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Appendix 7: LPP questions (cont.)

Developers	Users
7. Are employees (drivers or bus controllers) trained on how to react in certain scenarios, like when someone is making a problem in the bus, someone is not feeling well, a handicapped person needs to get in the bus, someone didn't pay for their ticket, etc.? 8. I know we read and hear everything online or from traditional word-of-mouth, but have there been any certain complaints directed towards you as a company? Or are there any certain requests from citizens regarding public transportation? 9. Your new URBANA app launched a while ago, and it has been proven to be very efficient and useful. Have you received more positive or negative feedback regarding this app? Are you planning on adding certain features in the future for this app? 10. Are there any similar improvements planned for LPP that you would like to share? 11. Can you share any statistical reports that could support my research?	10. Where do you check the schedule? Is it on the LPP website, the app, or the screens at the stations? 11. To what extent does the idea of being sustainable play a role in your decision of using public transport? If you owned a car, would you still use public transport? 12. Can you share any certain issues you have been experiencing while using public transportation? 13. Can you share any ideas that could make the public transportation easier and more efficient to use?

Appendix 8: Bolt questions

Users
1. What modes of transport do you use? 2. Can you describe your personal journey of renting, using and leaving the scooters? Is the whole process of registering, using the app and scooters relatively easy? 3. There are some scooter stations around the city, but are they enough? From your experience, do you always find a scooter nearby to rent and leave? 4. Are the scooters well-kept or usually damaged? 5. In your experience, is the electric scooter a useful and faster transportation than cars or bicycles for example? 6. Where do you usually drive the scooters? On the street, on the bicycle paths, on the pedestrian paths…Are there strict rules about this? Have you experienced fines being given if these rules aren't followed? 7. What are the most specific challenges you face when using these electric scooters? (Have you been experiencing issues with scanning the codes, locking and unlocking the scooters, connecting your bank card with the app, etc.…) Do you have a specific event that happened to you which you found very challenging when using these services? 8. Can you share any ideas that could make the renting of electric scooters easier and more efficient to use? 9. Would you rather have your own scooter or rent one? And please provide a short explanation why.

Appendix 9: Bicikelj questions

Users
1. What modes of transport do you use? 2. What did you thought of this new feature of having to rent a bicycle to ride around the city? Were you excited, wanted to try it and found it useful right away? Or did you rather wanted to buy and have your own bicycle? 3. Can you describe your personal journey of renting, using and leaving the bicycles? Is the whole process of registering, using the app and bicycles relatively easy and affordable in your opinion? 4. Considering the big amount of use of these services, do you experiencing certain issues with finding a bicycle to rent or even just leave at stations? There are a lot of bicycle stations around the city, but are they enough? Do you think this should be an on-going task of implementing new stations or should the employees bring out new bicycles if stations are empty? Or just give me another idea if you have that would ease this process. 5. Are the bicycles well-kept or usually damaged? Are they easy to ride, considering that they have "kontra"? Are they heavy? 6. Recently, a new service was added- Nomago bicycles, which are electric bicycles available for rent. Would you rather ride them instead of Bicikelj? 7. In your experience, is the bicycle a useful and faster transportation than cars to get around the city? For example, is it more useful in rush hour, when there are a lot of cars and buses on the street, and you can just use this bicycle on the bicycle paths? 8. Do you use the bicycles regularly, or just in certain cases when you don't have a choice, for example you didn't catch your bus, you don't have your car, etc.…? 9. Where do you usually drive the bicycles? On the street, on the bicycle paths, on the pedestrian paths…How do you feel about this - are there strict rules about this? Have you experienced fines being given if these rules aren't followed? 10. Considering everything – renting, leaving the bicycles, stations, heaviness and everything - what are the most specific challenges you face when using these bicycles? Do you have a specific event that happened to you which you found very challenging when using these services? 11. Can you share any ideas that could make the renting of Bicikelj easier and more efficient to use? 12. Would you rather have your own bicycles or rent one? And please provide a short explanation why.

Appendix 10: Avant2Go questions

Users
1. What modes of transport do you use? Do you own a car? 2. What did you thought of this new feature of having to rent a car to ride around the city? Were you excited, wanted to try it and found it useful right away? 3. Can you describe your personal journey of renting, using and leaving the cars? Is the whole process of registering, using the app and cars relatively easy and affordable in your opinion? 4. Considering the big amount of use of these services, do you experiencing certain issues with finding a car to rent or even just leave at stations? Are there enough parking spaces? Do you think this should be an on-going task of implementing new stations or should the employees bring out new cars if stations are empty? Or just give me another idea if you have that would ease this process. 5. Are the cars well-kept or usually damaged? Are they easy to ride, considering that they are electric and automatic? Are they usually clean? 6. There is also competition in the market-Sharengo, have you used it? Would you rather ride them instead of Avant2Go? 7. In your experience, is the car a useful and more efficient transportation than having your own to get around the city? For example, is it more useful to know that you almost always have a parking space if you rent these cars? 8. Do you use the cars regularly, or just in certain cases when you don't have a choice, for example you didn't catch your bus, you don't have your car, etc.…? 9. Considering everything – renting, leaving the cars, stations, and everything - what are the most specific challenges you face when using these cars? Do you have a specific event that happened to you which you found very challenging when using these services? 10. Have you used these cars for longer journeys? Renting them for the whole day or even a few days? If yes, how where you satisfied with the overall journey – considering that you have to charge these cars every couple of hours and the price of renting? 11. Can you share any ideas that could make the renting of Avant2Go easier and more efficient to use? 12. Would you rather have your own car or rent one? And please provide a short explanation why.