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# MODERN SOLUTIONS FOR URBAN PUBLIC COLLECTIVE TRANSPORT IN POLAND

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## **Abstract**

*The implementation of intelligent transport system solutions in cities provides passengers with better comfort and safety, moreover it considers the adaptation of vehicles to the needs of people with disabilities, the distribution of tickets as well as the broader infrastructure. The progressive digitization of transport services creates the opportunity to take use of the time spent traveling. Planning a smart city offering effective solutions in the field of urban mobility is one of the main problems of urban areas. The development of electromobility should contribute to reducing greenhouse gas emissions and increasing the share of alternative fuels in public transport. Through a system of incentives for residents to cycle and walk, local governments create their mobility. The aim of the study is to present current solutions in public transport used in Polish cities. The empirical material based on the survey allows for a comprehensive look at the development of urban public transport.*

**Keywords:** *digitization of transport services, intelligent transport system solutions, urban mobility, electromobility*

## **1. INTRODUCTION**

Presenting the current solutions in public transport used in Polish cities is important in terms of sharing knowledge and experience, which can, to some extent, be transferred to other cities, not only in Poland. The purpose of the study is to present current solutions in implementing innovative options in public transport in Poland, including pro-ecological, intelligent, and electromobility implementations. It is assumed that cities are increasingly interested in modern solutions in public transport, with still significant differences in the scope of their use and preferences regarding specific technologies and procedures. Based on the research results, the article presents an analysis of practical applications of modern solutions in urban public transport, focusing on selected and important functions from both the economic and social point of view. Currently, cities offer a high quality of life, referring to the wide availability of various types of services, including public transport, which must meet the requirements related to time saving (offering increasingly shorter travel time and flexibility of movement) or the progressive digitization of transport services (e.g., free Internet access, USB ports, and information screens). The implementation of intelligent transport system solutions in cities not only provides passengers with better comfort and safety, but also improves travel efficiency for instance by offering access to

traffic data in key places which contributes to reducing transport congestion. Transport must primarily meet the requirements related to saving time, offering increasingly shorter travel times and flexibility of movement as well as the possibility of using the time spent traveling, and adapt to the expectations of various professional and age groups of the population (Long-term National Development Strategy, 2013). The transport policy should fully consider the provisions of documents such as a study of conditions and directions of spatial development, a low-emission economy plan as well as a commune/city/county development strategy. It is pointed to the necessity of full integration of the public transport system in the form of organization of multimodal transfer nodes, ensuring easy access to stops, tariff and timetable integration, construction of park and ride systems, use of bus lanes, separate bus routes, priorities for tram traffic at intersections. Referring to the author's experience (Mayor of the City of Zgierz from 2010 to 2014) in the field of organizing public collective transport, the author sees the need for the use of research results by local government units (LGUs) in Poland. It is common practice to share knowledge and experience by local governments in areas that can be used by other local governments. From the point of view of city authorities and people responsible for transport services, it is important to refer to and learn from the solutions developed so far and create opportunities for their implementation in their city. It should be emphasized that the introduction of changes in public transport is necessary and results from the ever-growing needs of residents and the changing environment. At the same time, demographic, economic, environmental, technical, and technological, social, and political as well as legal factors should be continuously monitored. The study used the results of the research (the research tool and methodology of the study were prepared by the author of the study, which was carried out under the author's supervision by NIST, the unit whose work is managed by the author of the study as Director of NIST) entitled *Modern solutions in public transport in local government units* (NIST), prepared and implemented by the National Institute of Local Government, a state budgetary unit subordinated to the Minister of the Interior and Administration. The questionnaire survey was conducted using the CATI technique (computer-assisted telephone interviews) in June-July 2021. The study covered cities with at least 50,000 inhabitants. At the beginning of 2020, there were 83 such cities in Poland. Most of them - 79 - are represented in the study (only 4 cities from this group did not participate in the study - Gdynia, Radom, Szczecin, and Zabrze). Let us add that according to the data of the Central Statistical Office (BDL), at the end of 2019, communes with a population of at least 50,000 there were 89 in Poland. Most of them are towns with powiat rights and urban communes. In addition, the following urban-rural communes meet this criterion: Piaseczno (85,226 inhabitants), Wieliczka (60,481), Nysa (56,951), Pszczyna (52,770), Wołomin (51,884), Swarzędz (51,522). Therefore, the vast majority of municipalities subject to the provisions of the Act on electromobility and alternative fuels participated in the study - they represent 95% of cities with more than 50,000 inhabitants (92.5% of the population living in them) and 89% of communes with this number of inhabitants (covering 90.1% of their population). On the basis of the obtained results, it is possible to draw conclusions about all cities and communes subject to the Act with high reliability. The article discusses issues relating to urban mobility challenges faced by Polish cities, the use of alternative fuels and intelligent solutions in public transport, and the digitization of transport services. However, further questions should be asked: how can the level of safety in public transport be further increased, what are the directions of development of transport infrastructure, how to encourage residents to use public transport? Therefore, the stages of further development and directions of evolution in building smart cities are another research challenge.

## 2. URBAN MOBILITY CHALLENGES

Planning a smart city offering effective urban mobility solutions is one of the main problems of urban areas. Many cities compete in creating the image of smart cities, because they are considered to be more attractive locations, with high intellectual potential, which is a driving force for development (Florida, 2004). It is worth noting, however, that the development goals of a smart

city may be different depending on the environment and the way the city's problems are perceived. From the point of view of urban logistics, mobility is defined as all transport behaviours associated with the movement of people and activities conditioned by movement and generating movement (Hebel, 2013). Local governments are looking for various solutions in this area, among others, by introducing a system of incentives for residents to cycle and walk, thus creating their mobility. As a result, we observe changes in the habits of people moving within cities resulting from the need to get to work, school, shops, as well as places of relaxation.



Picture 1 Bicycle parking at Sloterdijk Station, Amsterdam, Netherlands

Source: author's own.

Looking at the popularity of cycling (see Picture 1) as a means of transport in other European countries with similar weather conditions as in Poland (e.g., the Netherlands, Denmark, Germany, Great Britain), it is worth building a bicycle infrastructure (see Figure 2) and trying to look for such solutions that (especially at current fuel prices) motivate people to use this mode of transport. In the public bicycle rental system in London, there are over 11,500 of them in over 750 docking stations, set up for the first time in 2010 (Dudycz & Piątkowski, 2018). Copenhagen is a perfect example of such a city where several actions are taken to make the dominance of individual transport give way to alternative forms of people's movement. A manifestation of such solutions are the introduced multimodal systems of passenger transport (Wach-Kłoskowska & Rześny – Cieplińska, 2018). However, problems related to mobility in cities are a source of growing concern for residents. Among EU citizens, nine out of ten believe that the road situation in their cities requires action to change mobility patterns (Pawłowska, 2017). The city should strive to eliminate social, economic, and educational inequalities and try to engage its residents to take action to improve its functioning (Lehr, 2018). Therefore, it must consider the needs of its residents, including entrepreneurs, academic circles, non-profit organizations, and the role of local authorities comes down to using the potential of citizens. Creativity, innovation, democracy, a sense of happiness, the degree of acceptance by the environment, but above all, satisfaction with living in each city are gaining in importance. Therefore, the cooperation of authorities with citizens cannot be overestimated (Montgomery, 2015).



Picture 2 Underground bicycle parking in Maastricht, the Netherlands

Source: author's own.

Mobility is realized through communication behaviors (Szołtysek, 2011). As a result, we observe changes in the habits of people moving within cities resulting from the need to get to work, school, shops, places of relaxation, among others (see Figure 3). One of the ways is the Park&Ride car park (Park & Ride), which is located near stations, tram loops or bus stops. They allow drivers to leave their car in a safe place to change to public transport and continue their journey, which saves time and money and, in the long run, reduces the use of internal combustion vehicles.



Picture 3 P+R car park at the train station, Maastricht, The Netherlands

Source: author's own.

A coherent mobility network influences the shaping of new transport behaviours, allowing to reduce the traffic of cars, reducing transport congestion, and thus improving the quality of life of residents (Kauf, 2015). Faced with these challenges, mobility management is seen as (Osyra, 2016):

- Satisfying communication needs through integrated and more effective use of the existing transport infrastructure and urban layout.
- Reducing traffic in the transport system by limiting the number and length of trips to a minimum and promoting solutions limiting the demand for these trips.
- Reducing the negative impact of vehicles on the natural environment using more energy-efficient vehicles and fuels from renewable sources.
- Improvement of transport accessibility for as many inhabitants as possible by improving public transport, cycling, and walking infrastructure.
- Increasing the standard of travel by public transport and encouraging car sharing.
- Increasing the economic efficiency of the transport system while adapting it to the needs of users.

Mobility creates a new image of a European city that responds to transport problems, affects energy efficiency, and contributes to climate protection (Hahn, 2011). As the increase in the use of individual transport means may result from the lack or low attractiveness of alternative means of transport in the city, which contributes to the increase in noise and environmental pollution, lowering the quality of life in the city, which also affects the process of migration of inhabitants (Osyra 2016). The above means that sustainable urban transport will integrate various means of communication, contributing to reducing car traffic, and the development of electromobility should contribute to reducing greenhouse gas emissions and increasing the share of alternative fuels in public transport. Economic (lower travel costs), environmental, social (moving by public transport encourages social contacts) and communication benefits - reduction of congestion should be pointed out. The concept of sharing may also contribute to this, enabling better use of resources by sharing, transfer, making available, and co-sharing (Burgił, 2015). Shared micro mobility is a type of movement carried out using vehicles of small size and weight, most often for one person, e.g., bicycles, scooters, intended for independent and individual use. Most often they are rented via mobile technologies. After completing the journey, the vehicle becomes available to other users. As the results of the conducted research (NIST, Report 11/2021) it is shown that solutions of this type are in place in 2/3 of cities with a population of 50.000 and more, and half of the cities with 50-100 thousand inhabitants. Most of the surveyed local government units offer only one solution and it is usually a city bike - generally speaking, it is offered in 44 cities from the surveyed group. The most diverse offer in this regard is in Gdańsk, where you can use a city bike, an electric bike, an electric scooter, an electric scooter, and electric cars for minutes, as well as a free bicycle trailer lent to parents. Other large cities also offer great opportunities in shared mobility: Kraków, Lublin, Poznań, and Warsaw. In every third city over 50.000 residents, electric scooters are offered. On the other hand, electric scooters are used in nearly every fourth city. These three solutions are used in all the largest cities and in half of the cities with a population of 100-500 thousand. In terms of activities increasing micro mobility, the largest number of communes declared the operation of public bicycles and Park & Ride car parks in their area. Popular solutions also include electric scooters and Bike & Ride parking lots.

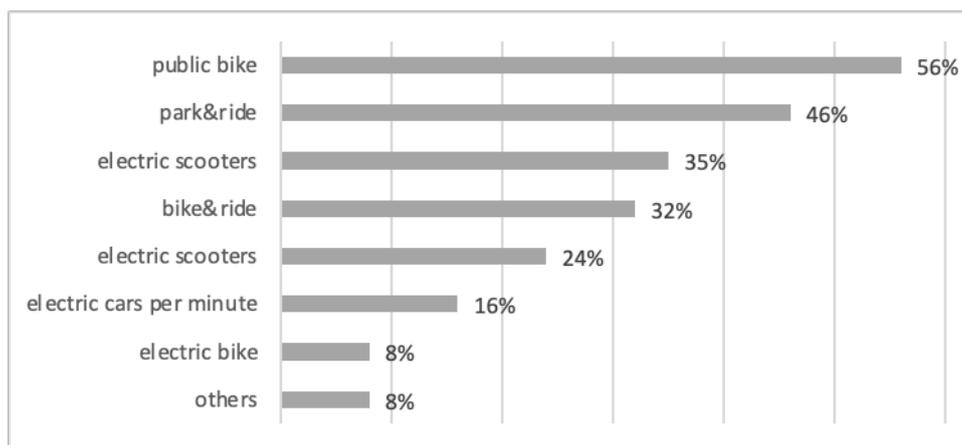


Figure 1 Selected modern solutions in public transport - micro mobility and micro mobility multimodality

Source: NIST, Report 11/2021, Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

The above-mentioned solutions in the field of micro mobility operate based on various financing models. In the case where the municipality finances the whole service (n = 33), the main service is public bicycle. In turn, for scooters and electric scooters, as well as cars for minutes, the model of 100% financing of the service by a private operator dominates.

### 3. ALTERNATIVE FUEL USED IN PUBLIC TRANSPORT IN POLISH CITIES

The goal of low-emission transport in cities is to improve the quality of life of residents by reducing the negative impact of transport on air pollution or noise (Wieczorek, 2021). In Poland, the key document in medium and long-term economic policy of the state considering activities in the field of electromobility is the Strategy for Responsible Development until 2020 (with a perspective until 2030). The basic legal act that regulates issues related to the development of electromobility in Poland is the Act of 11 January 2018 on electromobility and alternative fuels (Journal of Laws 2018, item 317), which is a response to the Directive of the European Parliament and of the Council 2014 /94/EU of 22 October 2014 on the development of alternative fuels infrastructure (OJ L 307 of 28.10.2014, p. 1). Pursuant to the Act, alternative fuels are fuels or electricity used to propel engines of motor vehicles or vessels constituting a substitute for fuels derived from crude oil or obtained in its processing, in particular: electricity, hydrogen, liquid biofuels, synthetic and paraffin fuels, compressed natural gas (CNG), including from biomethane, liquefied natural gas (LNG), including from biomethane, or liquefied petroleum gas (LPG). Municipality or county with at least 50,000 inhabitants is to provide or outsource public transport services to an entity whose share of zero-emission buses in the fleet of vehicles used in each local government unit is at least 30% (implementation deadline is January 1, 2028). Local government units should ensure that the share of electric vehicles in fleet was 10% from January 1, 2020, and the share of zero-emission buses was 5% from January 1, 2021, 10% from January 1, 2023, and 20% from January 2025. Therefore, municipalities are particularly interested in issues related to the development of public transport using alternative energy sources. Many cities, wanting to reduce exhaust emissions, decide to modernize their rolling stock (Wieczorek, 2018). Electric trolleybuses and buses have several advantages, including they do not emit exhaust fumes, they are characterized by the lowest possible emission of noise and vibrations from all means of public transport (Maleszczyk & Sagan, 2018). Skalski is of a similar opinion (Skalski, 2017). It is therefore important that local governments take care of the promotion of low-emission solutions. There are several ways to alternatively "refuel" public transport. Among them, the most common are electricity, liquefied or compressed natural gas as well as hydrogen (Ziembicki & Pyza, 2018).

Out of the 79 cities surveyed, solutions in the field of powering bus engines with alternative fuels were used in 46 of them, i.e., in nearly 2/3. Relatively more often these solutions are used in cities with county rights than in urban communes. In the smallest cities, they are used in 56%, and in cities inhabited by 100-500 thousand inhabitants – in nearly 2/3 (64%). Geographically, there are also differences in this respect. In terms of the number of cities equipped with buses with alternative fuel – Śląskie is a leader, while buses equipped with alternative fuel were not declared in three voivodeships – Opolskie, Podlaskie and Zachodniopomorskie. Among buses using alternative fuels, hybrid vehicles are most often used, although many municipalities use electric buses and/or CNG buses. Only one city uses LNG as fuel for buses. Other types of vehicles using alternative fuels included trolleybuses (Lublin and Tychy) and biodiesel (Warsaw). One type of alternative fuel is used by 2/3 of the examined cities, while 1/4 of them - two types, only three cities use three different types of alternative fuels. Cities using only one solution in this aspect usually opted for hybrid buses (14 out of 30). The study shows that the diversification of the bus fleet is greater in larger communes. Out of 46 of them (50.000-100.000 inhabitants), nearly half (21) use only one solution, while half of the large cities (100.000-500.000 inhabitants) and all the largest cities use at least two types of fuel. Hybrid, electric and LNG buses are available in 3 out of 5 Polish largest cities surveyed. CNG buses are relatively most often used in cities with a population of 100-500 thousand, and least often in cities with a population of 50-100 thousand. The smallest of the surveyed cities have the most hybrid buses, followed by electric ones. In the 25 surveyed cities with a population of 50-100 thousand, a total of 245 alternative fuel buses are in use. A total of 480 buses using alternative fuels are in use in the three largest cities. Within the next 3 years, 51 of the respondents declared the purchase of buses powered by fuel other than diesel oil (n = 51; 65%). When analysing the results of the study, it should be emphasized that by 2023 all cities inhabited by over 500.000 people will use buses using alternative fuels in public transport. In the ecological bus segment, almost every second vehicle sold in Poland in 2020 was powered by CNG fuel. In 2020, 165 gas buses entered the streets of Polish cities ([www.transport-publiczny.pl/mobile](http://www.transport-publiczny.pl/mobile)). For comparison, in 2019 in Sweden there were over 45%, and in Spain about 40%, while in Poland and Italy about 20% of GNG buses. From the perspective of implementing innovative solutions in the field of propulsion of bus fleet vehicles by engines other than those powered by diesel oil, most respondents indicated hybrid engines (n = 29; 59%), electric engines (n = 21; 46%) and natural gas-powered CNG engines (n = 16; 35%). None of the respondents pointed to hydrogen-powered engines. Therefore, the Polish Government is working on adopting the Polish Hydrogen Strategy so that the first hydrogen-powered buses will appear by 2025 (Project of the Polish Hydrogen Strategy until 2030 with a perspective until 2040).

Regarding the issue of charging technology for electric buses, plug-in methods (n = 18, 86%) and pantograph charging (n = 13; 62%) dominate. The planned activities of municipalities in this area focus on the construction of charging stations (n = 36; 46%).

#### **4. SMART SOLUTIONS FOR URBAN PUBLIC TRANSPORT**

The implementation of modern solutions in public transport in Poland makes carriers propose several new solutions. The concept of smart city has gained popularity all over the world. In 2012, 143 projects in the field of the smart growth concept were implemented, and three years later there were about 300-400 of them (Masik & Studzińska, 2018). According to the report on nationwide research on smart cities, the implementation of smart city solutions was mainly interested in large cities and those units whose economic situation is good or very good. In Krakow, local authorities involve residents in designing a smart city, which is a role model (Zysińska, Krysiuk & Zakrzewski, 2014). Recently, more and more attention has been paid to the safety and comfort of passengers, especially the elderly, the disabled, and pregnant women. The solution is the so-called low floors, which makes it much easier and faster to get in and out of the vehicle. This leads to a reduction in the time expected for passenger rotation at stops, as well as travel time. Research

shows that for more than half of the respondents, the criterion for choosing public transport is also safety and communication equipment with monitoring, and vehicles with photocells, and the continuation of the "Safe Return" campaign (Bielińska-Dusza, Żak & Pluta 2021). This is also confirmed by the results of research on safety (Zielińska, 2018) and the report by P. Budziły, D. Socały (2019).

Another solution, commonly used in public transport, is air-conditioning, which by maintaining the right temperature provides travellers with adequate comfort. New generation vehicles also have modern heating systems that are activated automatically when the interior temperature drops below a certain value. The system of so-called *warm button*, where the doors at stops are opened by passengers, not the driver. Thanks to this solution, when there are no people getting on or off at the stop, the door of the bus, tram or train remains closed, preventing unnecessary air exchange both on hot and frosty days. An example in terms of maintaining the optimum temperature in buses are the electrically opening front or rear roof hatches, thanks to which the driver can dynamically adjust the ventilation of the vehicle. Another solution is to use the tinted and double-glazed side and rear windows that act as insulation: keep it warmer in winter and cooler in summer. They also improve visibility in the autumn and winter and ensure the safety of passengers, in the event of breakage, the second pane protects them against shards. There are many ITS (Intelligent Transport System) systems in Polish cities. These systems are assumed to use the latest technologies to improve the safety, efficiency, and convenience of using urban transport. The effect of this is to shorten the travel time for people traveling by public transport, which increases its attractiveness in relation to individual car transport. ITS systems increase the capacity for the entire controlled area, contributing to environmental protection, reducing congestion and carbon dioxide emissions into the atmosphere (Kozłowski, 2021). According to the report on nationwide research on smart cities carried out by the Silesian University of Technology, in the case of intelligent road traffic control systems, only 26 out of 280 Polish cities declared using it. Modern information technologies will enable access to e.g., for the mobile timetable and the sale of services. The most important functions, the task of which is to improve the management of passenger transport, include the location of vehicles, collecting fees using electronic cards, payments via the Internet or using mobile telephony. Currently, customers expect current information about the actual arrival and departure times of public transport. The tables of the Dynamic Passenger Information System (SDIP) become a standard, which show the current time remaining until the vehicle's departure, and display other messages, e.g., information about traffic difficulties. You can also listen to voice messages informing about departures. Increasingly, public transport vehicles are equipped with information and direction boards that make it easier for passengers to orientate themselves where they are, inform about the route, the number of the selected line, the starting and destination stops. In addition, they provide other information that is relevant now. Monitoring creates a sense of security for traveling passengers, increasing the comfort of their journey. The use of monitoring in public transport gives a chance to quickly detect the perpetrators of vandalism or other offences. The modern monitoring system consists of cameras installed inside the vehicle and cameras recording events taking place outside, as well as microphones, a digital recorder and an LCD monitor placed in the driver's cabin, enabling continuous control of the interior of the vehicle. Cameras placed at the front and rear of the vehicle help in conflict situations and when there has been a traffic accident. Microphones ensure communication between vehicle staff and passengers. New vehicles also use the latest types of digital recorders, which are often integrated with many other devices: cash registers, printers, POS systems (cash computer, on-board computer), access control and alarm systems. Currently, thanks to special applications available on mobile phones, constant access to timetables is possible. Popular mobile applications used in Polish cities include:

- 1) myBus online application, in addition to the traditional timetable, the application can display the nearest departures in the form of the so-called Table of nearest departures, based on data obtained thanks to the GPS system,

- 2) plates with 2D codes, thanks to which passengers have easier access to websites with current timetables from a given stop,
- 3) the system: "When will it arrive?", which operates based on location data obtained from mobile telephony; thanks to it, passengers can check when their bus will arrive.

For travellers, the waiting area for transport is also important, in many cities there are already modern shelters with lighting and electronic boards of dynamic passenger information, and there are ticket machines nearby. In the quoted study on innovative solutions used in public transport, thirteen categories of activities were indicated, consisting in equipping bus fleet vehicles and tram rolling stock. In the case of buses, the most frequently indicated innovations were the low-floor structure of the body (n = 76; 96%), the installation of a GPS module (n = 74; 94%) and the provision of direction and information boards (n = 73; 92% and n = 72, respectively); 91%). On the other hand, in the tram fleet, the most popular solutions are the installation of a GPS module (n = 20; 91%) and equipping the vehicle with direction boards (n = 19; 86%), as well as voice information about the next stops (n = 19; 86%), information, door opening and closing sensors and the hot button system (in each case n = 18; 86%).

An important element of introducing modern solutions to public transport is the advance and development of an intelligent transport system (ITS). Only 32 respondents declared the implementation of this type of system, and 14 - carrying out work on its launch. 35 local government units indicated that they do not have and do not implement such solutions in their communes. In terms of building an intelligent transport system, the most popular actions were the provision of information on travel routes (n = 56; 71%) and the implementation of an electronic timetable (n = 43; 54%). Less frequently used were the creation of an integrated city card (n = 34; 43%), the transport management system and the construction of a city bike station as a component of the public transport network (both measures: n = 29; 37%). The construction of smart car parks (equipped with cameras, sensors, Smart Parking Solutions; n = 8; 10%) and the introduction of on-demand communication (n = 7; 9%) was sporadic. None of the surveyed communes have implemented autonomous vehicle communication (see the table below).

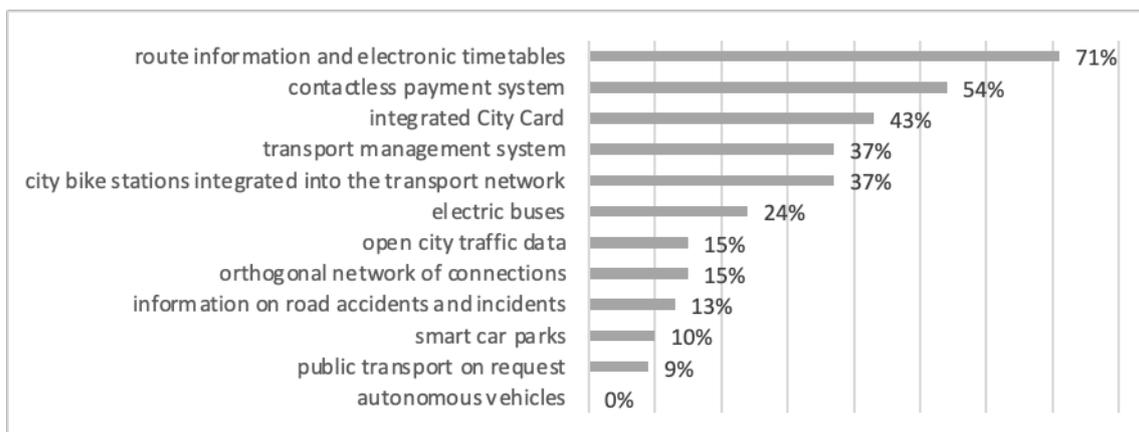


Figure 2 Selected modern solutions in public transport - components of an intelligent transport system (ITS)

Source: NIST, Report 11/2021. Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

Actions aimed at meeting the needs of people with disabilities and people with special needs were very often indicated by the respondents. Almost all the respondents declared that they would provide places for people using wheelchairs in public transport, as well as places for people

with disabilities, and the use of low-floor vehicles (in each case n = 78; 99%). Adaptation of vehicles in public transport to the needs of people with disabilities.

Table 1 Selected modern solutions in public transport - a response to the needs of people with disabilities

	Number of communes (n = 79)
places for transporting people using wheelchairs	78
low floor	78
specially marked places for the disabled	78
availability of seats for passengers with a low floor	74
movable platform for wheelchair access	73
kneeling system	72
sound information	70
places for transporting prams	70
places for women with children marked with a pictogram	67
adapting the infrastructure to the needs of disabled people and people with reduced mobility	58
descriptions of buttons in Braille	47
version of timetables for the visually impaired	21
blind man's individual pilot	15
other	13

Source: NIST, Report 11/2021. Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

Solutions often indicated were implementations related to facilitating the use of public transport for people with disabilities (accessibility of seats for passengers from a low floor, a movable platform enabling wheelchair access, kneeling system, sound information) and dedicated to people traveling with small children (places for transporting prams, places for women with children marked with a pictogram). By far the least popular activities were the provision of timetables for the visually impaired (n = 21; 27%) and an individual blind pilot (n = 15; 19%).

Among other activities improving the quality of public transport services, modern methods of ticket distribution and solutions increasing the quality of services were included in the study. Regarding the first of them, by far the largest group of respondents indicated the possibility of purchasing public transport tickets in applications (n = 69; 91%). Almost 3/4 of the communes make it possible to purchase a ticket via the Internet (n = 55; 72%) and have made ticket vending machines available to passengers (n = 54; 71%).

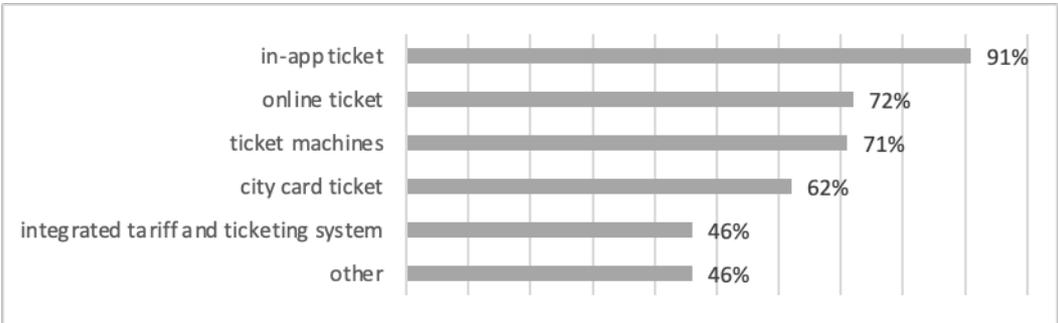


Figure 3 Selected modern solutions in public transport - modern methods of ticket distribution

Source: NIST, Report 11/2021. Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

Among the activities increasing the comfort of using public collective transport, the use of Dynamic Passenger Information boards dominates (n = 66; 84%). Slightly less than half of the respondents declared the implementation of a voice communication system and cameras at stops (n = 37; 47% and n = 34; 43%, respectively).

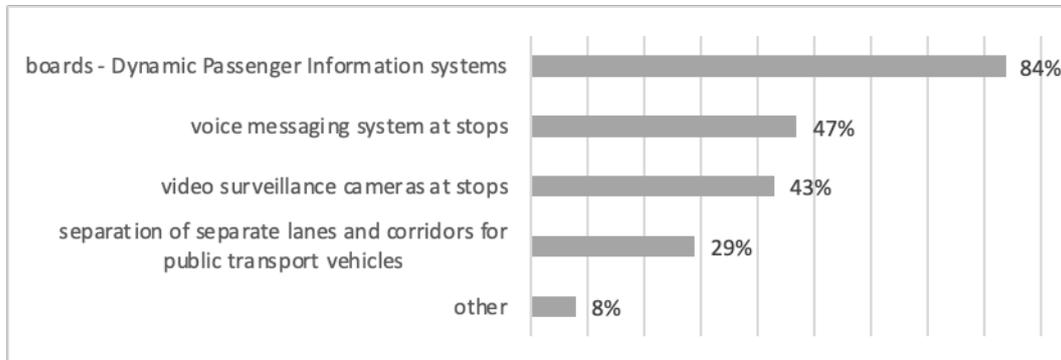


Figure 4 Selected modern solutions in public transport - infrastructure that increases the comfort of using public transport

Source: NIST, Report 11/2021. Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

## 5. DIGITALIZATION OF TRANSPORT SERVICES

An important convenience for those traveling by public transport is free access to the Internet, enabling the use of published timetables, checking transport connections, and buying a ticket online. As the fleet is modernized, USB chargers are becoming the standard. In recent years, the way of selling tickets has been revolutionized. In Poland, there are several modern solutions in the field of ticket distribution, including:

- 1) tickets in the application,
- 2) online tickets,
- 3) ticket machines,
- 4) tickets in the city card.

In the study in digitization, three categories of activities introduced as part of the implementation of modern solutions in public transport were distinguished: equipping vehicles with USB ports, free Internet in public transport, and mobile ticket machines in vehicles.

The answers given by the units covered by the study indicate that the most popular measure was to equip vehicles with USB ports. Out of 79 communes organizing bus transport, 52 communes (66%) declared its implementation. Among the 22 communes that provide transport with tram rolling stock, such modules were used in 9 cases (41%). Open, free access to the Internet in the bus fleet was provided by less than half of the respondents (46%), while in the tram fleet this indicator was 27%. Ticket machines were available primarily in the tram fleet (11 communes, 50%). In the case of bus transport, 29 respondents (37%) declared their installation.

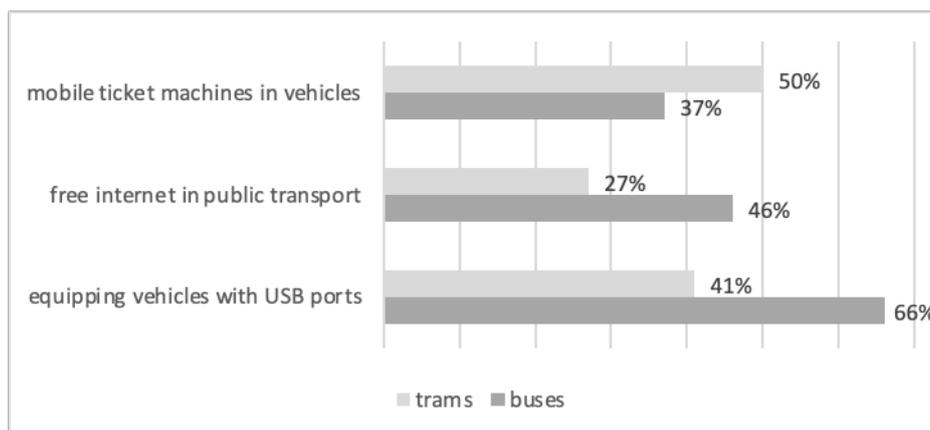


Figure 5 Selected modern solutions in public transport – digitization

Source: NIST, Report 11/2021. Modern solutions in public transport in local government units. [https://www.nist.gov.pl/files/texts/1623744752\\_BADANIA%20I%20RAPORTY%20nr%2011.pdf](https://www.nist.gov.pl/files/texts/1623744752_BADANIA%20I%20RAPORTY%20nr%2011.pdf) (date of access: 12.04.2023).

## 6. CONCLUSIONS

The dynamic development of all types of public transport in Poland is observed. Not only new infrastructural solutions are created, but also the transport fleet is being modernized, which affects the communication behaviour of the inhabitants. Considering the recommendations (Human smart city, Guide for local governments, Ministry of Investment and Development), city users decide how they move around. It is the responsibility of local authorities to treat all modes of travel equally. Therefore, when defining the urban mobility strategy, standards should be created for designing, building, and maintaining mobility infrastructure, including standards for parking infrastructure, pedestrian and bicycle infrastructure, and standards for stops. Moving is becoming faster, more comfortable, and in many cases cheaper. Efficiency and comfort of traveling by public transport can be a significant stimulus to change the transport behaviour of residents. Summing up, the presented results of the study allow us to conclude that the key challenge for cities is to strive for the development of public transport. In this context, specific decisions of city authorities and consistent action are needed. It is important to provide LGUs with the possibility of cooperation in various forms in order to effectively meet the needs between units of different levels of territorial division (Ziemski & Misiejko, 2016). Transforming cities into a smart and sustainable environment is one of the most important challenges facing the EU, as indicated by Wolański in his study (Wolański, 2020). Regarding Polish cities, however, there is a lack of research on the possibility of qualifying cities to the group of smart cities, as well as the scope of using the smart city concept in the context of supporting decision-making processes regarding the functioning and development of the city (Stawasz & Sikora – Fernandez, 2012). This study does not exhaust the discussed topics, but it is a point of reference for reflection on improving the quality of operation of local government units in the field of public collective transport.

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