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Digital public transport in New Economy – contemporary mobility trends

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Abstract

Public transport is very often treated as a nerve of all city systems. Changing cities need proper organisation of transport. In particular, the development of public transport is associated these days with such concepts as IT systems, big data, alternative energy sources, autonomous mobility, transport effectiveness, sharing economy and personal mobility (micromobility). In this work, the author presents contemporary trends that affect city mobility. The author also takes into account the macroeconomic context – the COVID-19 pandemic, inflation, migration trends, because changes in the demand and supply of transport services have become one of the challenges for cities. The main purpose of this article is to review current trends in public transport development and mobility changes in the new, digital, post-pandemic perspective. The research gap found by the author is connected with the interrelationship between technology and the development of public transport systems. The article is an attempt to answer two main research questions: 1) What is the influence of digitisation and technology development on the development of public transport? 2) How are contemporary social, economic and political problems changing public transport? The article is based on critical analysis of literature and selected case studies. The result of the research work is the indication of the most important directions for the development of public transport and related risks and opportunities.

Keywords

- public transport
- alternative energy sources
- digitalisation
- autonomous driving
- sharing economy

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Introduction

Public transport is full of stereotypes. One of them assumes that public transport should be a worse alternative to individual motorisation. Meanwhile, as in many western cities, public transport can be a daily, fully functional alternative to individual transport. Public transport in Central and East European countries is undergoing intense transformation – and the New Economy brings many new challenges but also many new opportunities for both local governments and inhabitants, who are final users of public transport and urban space.

1. Methodology

Public transport remains an interesting field of research. It is an area of many changes – technological, organisational as well as economical. This study takes into consideration cities and their trends in public transport development, with the purpose being the analysis of selected case studies – in different areas of technology implementation (drives, IT, etc.). The review of the case studies is preceded by a literature review, including both domestic and foreign literature, the purpose of which is identifying directions of development of public transport and current trends related to it. The aim of the author is to create a list of trends and applied technical solutions. The subject of the study is Polish cities, and the object is public transport solutions. The whole study includes an analysis of literature sources and selected case studies.

2. Public transport as the basis of the functioning of cities in the New Economy

Transport is widely regarded as the nerve of the urban system. It plays an important, often underestimated role in shaping the mobility of urban areas (Komsta et al., 2019). Consistent development of a city's transport system is an effective tool for creating a specific functional and spatial structure of the city (Suchorzewski, 2010). What is more, the efficiency of urban transport systems affects the efficiency of the country's transport system (Krysiuk & Nowacki, 2016). Making cities more sustainable is also a part of the United Nations Sustainable Goals. On this

list of 17 goals, we can find Goal 11 – sustainable cities and communities (United Nations, n.d. a). The main aim of this goal is to "make cities and human settlements inclusive, safe, resilient and sustainable" (United Nations, n.d. b).

Modern cities are areas of many contemporary challenges – cities struggle with a global environmental crisis, climate change concerns as well as unsustainable urbanisation habits (Rode, 2013). Development of sustainable urban mobility is seen as critical to ensuring sustainable development of the whole city (Rezende Amaral et al., 2018). Especially since in the last decade digital innovations have radically changed traditional concepts of urban transport and introduced new opportunities (Dia et al., 2020). Additionally, we must remember that public transport has been affected by the COVID-19 pandemic (Abu-Rayash & Dincer, 2020).

The functioning of cities in the new economic reality remains an additional issue. The concept of the New Economy is understood as a fast-moving technological revolution, a global revolution related to the networking of the economy, information management, relationships and security (Kelly, 1999). The New Economy stands for a wide use of information and communication technologies (ICT), which has had a major impact on economic development, among others in the US economy (Pohjola, 2002). It has also had a strong impact in Europe since the 1990s; strong development connected with a wide use of ICT technologies has been observed in many countries, especially the UK, Denmark, Finland, Sweden, Ireland and Greece (Daveri, 2002). In smart cities, public must provide real-time response services, convenience and high quality (Kuo et al., 2023). Another idea of developing public transport is connected with the concept of smart mobility (Paiva et al., 2021).

Organisation of public transport is also a challenge in the perspective of the new institutional economy, which strongly changes the perception of economic aspects of transport, introducing new concepts and theories such as transaction cost economics, agency theory, contract theory and property rights economics (Canitez, 2019).

The New Economy raises many questions, e.g. how far will service sectors develop instead of traditional production-based systems? Is it possible to continuously increase productivity and efficiency? How will the network economy also change entire organisations? (Herzenberg et al., 2018). The New Economy is an economy based on knowledge and learning (Lundvall, 2004). Practically from the very beginning of the New Economy concept, researchers have wondered to what extent the idea changes the perception of reality, and to what extent the "old economy" still allows us to explain economic events (Stiroh, 1999). Digitalisation in many sectors of the economy is an undeniable trend, visible today more than ever.

A separate area of interest for researchers is connected with the factors determining the choice of public transport instead of private cars. The final decision is made by the consumer, who makes the decision based on his or her individual

preferences. The use of public transport in Poland is motivated primarily by economic factors such as rising fuel prices – indicated by 57% of respondents, time savings and the ability to move around the city faster –54% of respondents, and environmental aspects – 52% of respondents (Nationale Nederlanden, 2022).

3. Contemporary trends in public transport development

In a rapidly changing world, mobility and accessibility play an increasingly important role, especially in cities and urban areas. The problem of mobility is solved, among others, through the use of modern technologies or improving public transport management (Gakenheimer, 1999). This means, among others, technologies in the field of autonomous and electric vehicles or the integration of shared mobility services (Schuckmann et al., 2012, Burns, 2013; Nijkamp & Kourtit, 2013; Dia, 2019, as cited in: Miskolczi et al., 2021).

The above trends seem to be complemented by the development of micromobility – a response to the last mile problem, different transport needs and spatial conditions (McKenzie, 2020). Researchers discuss, among other things, the possibility of a wider use of technology and information management for urban mobility (Guirao & Orellana, 2021). This means, at the technological level, e.g. access to open data or the use of Bluetooth technology – in order to minimise a waste of time and energy as well as to improve user satisfaction (Soriano et al., 2018).

The above-mentioned examples from the literature do not end the list of trends observed in the development of technology-based public transport and the digitisation of processes. The following subsections discuss a few key trends in this field as well as some case studies.

3.1. Development of IT systems

Traffic management systems remain one of the widely used groups of IT tools in public transport. This means all the tools that can ensure the efficient movement of public transport vehicles – both in terms of traffic management and the management of the vehicles themselves (for example, their activities).

An intelligent transportation system (ITS) may consist of four basic components: Advanced Traveler Information System (ATIS), Advanced Traffic Management System (ATMS), Advanced Public Transportation System (APTS) and Emergency Management System (EMS) (Singh & Gupta, 2015). Many trends in the develop-

ment of this type of IT tools can be seen today. They include, for example, short-term real-time forecasting, dynamic routing and traffic modelling, as well as real-time demand and supply support – using big data and bidirectional data transmission (Nuzzolo & Comi, 2016).

Today, every Polish city has an ITS system or its selected components. A lot of such projects were implemented between 2010 and 2012, when the EURO 2012 football tournament was organised in Poland. It was one of initiation factors for cities to invest in such technical solutions (EURO 2012 provided some opportunities for financing such investments).

Among the biggest systems implemented during that period we shall mention the Tristar system – traffic management in Gdańsk, Gdynia and Sopot (together with an intelligent transport management system in the whole agglomeration), the project of the Integrated Public Transport System implemented in Poznań (which has dedicated subsystems for public transport, parking lots, information exchange for drivers and passengers) or the project of modernisation of infrastructure and construction of passenger information system in Lublin (with vehicle monitoring, transfer hubs, dynamic passenger information system) (Zysińska, 2013, pp. 869–870). Dynamic information systems are also very popular – an example of a display with data from such a system is shown in Figure 1.

Figure 1. Information display from a dynamic passenger information system in Łódź

Source: author's own archive.

Of course, these are not the only IT tools used in public transport. Transport operators use enterprise resource planning (ERP) systems and dedicated business-class systems for managing resources and infrastructure, planning systems (for timetables, job scheduling), systems for managing passenger information and communication with passengers (web tools, mobile applications). Furthermore,

a separate group consists of IT solutions widely used in simple vehicles, e.g. related to the vehicle, its passenger information or more and more often – management of refuelling and charging infrastructure.

3.2. Alternative energy sources

The global search for alternative sources of energy to drive vehicles has become one of the fundamental trends in the development of the automotive industry. The first group of the solutions used today are electric vehicles – usually battery-powered vehicles. Such a vehicle is equipped with a set of batteries storing the electrical energy necessary to power both the engine and auxiliary, external systems (like heating, air conditioning, etc.). The batteries are charged periodically from external sources, usually via a wired connection and less frequently, as in the case of some buses, using a dedicated pantograph or an inductive charger.

The environmental performance of electric vehicles depends largely on the source of the energy they generate. In Poland, coal-fired power plants dominate, so the development of renewable energy sources becomes even more important (Koch-Kopyszko, 2018). In addition, it increases the discussion in Poland about other possible sources of energy to ensure a real reduced impact on the environment.

Several leading trends related to alternative vehicle drive solutions can be identified these days, including internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), electric vehicles (EVs) and fuel cell vehicles (FCVs). Several types of fuel can be used in alternative-fuel modes, i.e. EVs, HEVs, fuel cell (hydrogen), methanol and natural gas (Morita, 2003; McNicol et al., 2001; Sperling, 1995, as cited in: Tzeng, 2005). It is pointed out that buses based on batteries (electric, especially with overnight charging) and fuel cells (e.g. hydrogen) are those directions that at the current level of technological development allow us to meet operational requirements (Mahmoud et al., 2016). Unfortunately, in Polish reality, a poorly planned revolution related to electromobility leads to numerous problems and a partial loss of profits (Połom & Wiśniewski, 2021). Regardless, it is worth pointing out that sales of Solaris buses with alternative drives on the Polish market in 2022 were, for the first time in history, higher than sales of conventional vehicles (Solaris Bus & Coach, 2023). The Polish bus market has so far gathered a lot of experience related to the operation of alternative vehicles. There are hybrid buses, powered by natural gas (both CNG and LNG), as well as numerous electric buses. Additionally, intensive efforts have been underway to bring hydrogen buses into service. An example of such buses (hybrid and electric) is shown in Figure 2.

In October 2022, a contract for the delivery for 25 hydrogen buses for MPK Poznań Sp. z o.o. (public transport municipal company) was signed. The 12-meter

Figure 2. Hybrid bus and electric bus on the streets of Kraków

Source: author's own archive.

low-floor buses are supplied by Solaris Bus & Coach. They are electric vehicles powered by electricity from hydrogen, converted into electricity in the vehicle's fuel cell. Advantages of this type of buses over battery buses are their long range and short charging time. The range is expected to be around 350 km, and the refuelling time is about 10 minutes. After the delivery of these buses, zero-emission buses will make up 25% of the company's fleet, which will bring MPK closer to meeting the statutory requirements (by 2028, 30% of the fleet should consist of zero-emission buses) (Urząd Miasta Poznania, 2022). First hydrogen buses in Poznań started operating in September 2023. Further deliveries of hydrogen buses are currently underway[2].

The purchase of vehicles is complemented by the choice of fuel supplier. The tender organised by MPK has been the largest tender of its kind on the Polish market so far. As the number of vehicles ordered is lower than originally planned (25 instead of 84), MPK decided to outsource fuel supplies instead of building its own refuelling infrastructure. The only bid in the tender was submitted by PKN Orlen, a national company. Unfortunately more than twice the estimated budget of MPK for this purpose (101.6 million PLN compared to 48.7 million PLN in the budget). Due to the limited offer of suppliers in this market, MPK decided to increase the budget and choose the offer. This means that in the tender for the supply of 1 800 000 kg of hydrogen over a period of 15 years, instead of the estimated price of 27.06 PLN/kg gross, the final price will be 56.46 PLN gross per kg of hydrogen (Transinfo, 2022).

[2] Based on the industry portal of transport enthusiasts www.phototrans.eu, a total number of 15 (out of 25) of these vehicles were delivered to the company (up to 29 November 2023).

In 2019, buses with alternative drives (zero- and low-emission) accounted for 12.42% of the structure of the bus fleet in Poland, including: buses powered by CNG – 6.12%, hybrid – 3.67%, electric – 2.01%, LNG and LPG – 0.40% and biofuels – 0.22% (Izba Gospodarcza Komunikacji Miejskiej, n.d.). The number of electric buses increased rapidly. At the end of the first half of 2022, the number of electric buses in Poland reached 734 units, with the majority operated at MZA Warszawa (162 units, 11% of the whole MZA fleet), MPK Kraków (78 units, 13.7% of the fleet), MPK Poznań (59 units, 18.3% of the fleet), PKM Jaworzno (44 units, 62.9% of the fleet) and MZK Zielona Góra (43 units, 48.3% of the fleet). Taking into account the ongoing contracts for the supply of new vehicles and planned deliveries, this number will increase by 654 vehicles between 2022 and 2024, bringing the number of electric buses operating in cities to 1388 (Stowarzyszenie Polska Izba Rozwoju Elektromobiności, 2022). At the end of 2022, the number of electric buses in Poland reached the level of 821 units (Polish Automotive Industry Association, 2023), and at the end of June 2023 – 856 units (Polska Izba Rozwoju Elektromobilności, 2023). In 2023, it is clear (analysing new vehicle registrations) that vehicles with alternative powertrains are predominant. In the first 10 months of this year, 232 diesel buses, 253 electric buses, 85 hybrid buses, 57 gas buses and 17 hydrogen buses were registered (Transinfo, 2023). The sharp increase in the number of new zero-emission vehicles is, among other things, the effect of new financial support government programmes, such as "Green Public Transport".

The number of other alternative drive vehicles registered in Poland is also growing. According to the statistics of the Polish Alternative Fuels Association, in 2021 there were about 17 000 electric cars (battery-powered – BEV) and 21 000 hybrid cars (plug-in hybrids – PHEV) in Poland. These numbers are forecast to increase to 34 000 / 33 000 in 2022, 75 000 / 75 000 in 2023, 150 000 / 120 000 in 2024 and 246 900 / 183 700 vehicles in 2025. This means that in 2025 more than 430 000 BEV and PHEV electric cars should be present on Polish roads (Polskie Stowarzyszenie Paliw Alternatywnych, 2022). The number is growing quite quickly, with the latest Polskie Stowarzyszenie Paliw Alternatywnych data indicating more than 29 000 new registrations of electric passenger cars in 2023, as well as 2300 vans and trucks, 263 buses, 3200 motorcycles and scooters, 229 microvehicles and 86 hydrogen-powered cars. A total of 90.9 thousand electric cars and 1083 buses were registered in Poland at the end of October 2023 (Polskie Stowarzyszenie Paliw Alternatywnych, 2023). On the other hand, data from the whole European market show that the number of PHEV registrations in the period from Q4 2020 to Q2 2022 remains at a nearly similar level, around 200–220 thousand vehicles per quarter (ACEA, 2022). It should also be noted that the number of hydrogen-powered passenger cars on the Polish market is increasing – the first 74 vehicles of this type were registered in 2021, followed by 115 units in 2022 (EAFO, 2023).

3.3. Autonomous mobility

Autonomous mobility is now being analysed primarily in the context of the possibility of providing a new type of service to customers and social change (Fayyaz et al., 2022; Zardini et al., 2022). They are also widely recognised as one of the most important areas for the introduction of AI in public transport (Zhang et al., 2017).

In practice, more and more cities are now looking for ways to introduce autonomous vehicles both in areas deprived of typical public transport (fairgrounds, cemeteries, harbour areas) and as an extension. In addition, small autonomous vehicles have great potential for use also in areas of dispersed or low-density buildings (especially residential), for example, wherever typical public transport vehicles are economically inefficient or impossible to implement due to their size. Autonomous vehicles can be used here, for example, as "tele-buses", running on routes and courses offered "on demand". Today, technology provides more and more opportunities for vehicles to move independently on the road, and with each generation of vehicles these opportunities are increasing.

In Poland, such vehicles have not been permanently implemented to date. Gdańsk has some experience with pilot operations of autonomous vehicles. The experiment for the commissioning of a line operated by an autonomous vehicle was carried out here for the first time in 2019, as part of the "Sohjoa Baltic" project. The vehicle was scheduled twice an hour, bringing passengers to the zoo (free of charge), seven days a week. The line was marked with number 322, and the bus carried a maximum of 12 passengers. The trips were carried out with the hu-

Figure 3. Autonomous vehicle tested in Gdańsk

Source: (Urząd Miejski w Gdańsku, 2021).

man operator, who was a supervisor in case of a crisis situation. The project was carried out by Easymile using EZ10 vehicles on behalf of the City Hall in Gdańsk (Urząd Miejski w Gdańsku, 2019).

As part of the next pilot programme, an autonomous vehicle appeared on the streets of Gdańsk in autumn 2021. The vehicle running without an operator on board completed 450 courses within 30 days and carried 2017 passengers – completing the courses on the planned route at the Łostowice Cemetery. The eight-seater Iseauto vehicle (4th autonomy level according to SAE) was supplied by Roboride, and the project was carried out in cooperation with Auve Tech (bus delivery and programming) and Trapeze (IT solutions). There were four stops on the 2,2 km long route (Urząd Miejski w Gdańsku, 2022). The autonomous vehicle from Gdańsk project is shown in Figure 3.

It is worth mentioning that in November 2023 the first tests of an autonomous vehicle started in Gliwice – the Blees BB-1 vehicle started tests at the Silesian University of Technology (Gliwice.eu, 2023).

3.4. Sharing economy

The use of shared vehicles remains an important trend in modern mobility. Several basic groups of this type of vehicles have developed in Polish cities, with the first being passenger cars. According to the data from the association Stowarzyszenie Mobilne Miasto, the largest fleets of shared cars in 2022 were in Warsaw (1656 cars), Gdańsk (738 cars) and Kraków (673 cars) (Stowarzyszenie Mobilne Miasto, 2022). Of course, these data are constantly changing – most of the fleets are operated by a few major car-sharing operators, who, because of their operations in many cities, relocate the fleets (they also allow journeys between cities). The second group of powered vehicles that appeared in large numbers on the streets of cities are scooters – first diesel and then electric ones.

A separate group of solutions, usually in the form of organised systems managed at the city level, are urban bicycle systems. Practically in every city there are (or used to be) such systems. In a typical model, an operator selected in a tender by the local government installs bicycle docking/receiving stations and supplies appropriate vehicles, and the tariff of charges operates independently or in conjunction with, for example, public transport charges. In the new systems, there are also dockless bicycles (which do not need to be pinned to the docking station) and electric bicycles. Such systems have played a very important role in building cycling culture in Polish cities and even if they are terminated for cost-related reasons (e.g. Poznań City Bike stopped functioning at the end of the 2022 season), their role in the development of bicycle transport shall not be underestimated.

Figure 4. Public city bike station in Warsaw

Source: author's own archive.

The number of users of vehicle-sharing systems in Poland is currently about 3.5 million. This level was reached in 2019 and now, after a slight correction due to the COVID-19 pandemic (and a drop below 3 million), the market has actually rebuilt the number of users. Forecasts indicate that the number of users of vehicle-sharing systems in Poland will reach around 4 million between 2025 and 2026 (Statista, 2021). Statistics show that Poland is the leader in terms of the number of users of shared transport in the countries of Central and Eastern Europe (Kuźma et al., 2022). An example of a typical bike-sharing station (the whole Warsaw system is called Veturilo) is shown in Figure 4.

3.5. Personal mobility (micromobility)

Shared vehicles allowed us to rediscover the role of the bicycle, among others, as a means of getting around the city. They are increasingly complemented by individual vehicles for the so-called "personal mobility" (or micromobility). Technological developments (especially in the field of batteries and electric drives) have resulted in the creation of a relatively small group of light electric vehicles used to transport one person. These are scooters and skateboards used for moving over short distances with limited speeds. Some researchers also place the above-

mentioned bikes in this group. And although scooters and skateboards were of course already present in the past, it was only with the widespread use of electric drives that their role in meeting the needs of urban mobility increased. These vehicles may also be shared (for example, electric scooters are available from private operators in Polish cities).

4. Changes in urban mobility

All the concepts and trends mentioned above also strongly emphasise transport effectiveness. Economic efficiency is often the basis for decision-making in the sector of public services. Many of the above-mentioned groups of solutions have been developed on the basis of modern technologies – for example, through widely used information tools. However, these are not the only factors that change urban mobility.

Transport has to face challenges in many fields. What are contemporary social, economic and political problems and are they strongly changing public transport? Key to the current changes in urban mobility is the concept of "sustainable mobility", which is understood today, among others (Banister, 2008, pp. 73–80, as cited in: Wyszomirski, 2017, p. 29) as:

- choosing rationally minimum travel time,
- journey as an independent activity,
- reducing travel needs, e.g. by reducing the travel distance, choosing remote computer connections for work,
- increasing the amount of time for walking, cycling and using public transport in relation to travelling by a passenger car,
- reducing air pollution and traffic noise and at the same time improving the energy efficiency of transport,
- increasing the capacity utilisation by making better use of vehicles,
- increasing the infrastructure capacity by introducing the rules on remuneration for use,
- improving the quality of urban space, e.g. by the introduction of Tempo30 traffic zones.

In general, technology today has a major impact on changes in public transport. We can use technology in order to:

- improve the quality of services,
- make public transport more available (better accessible),

- make public transport more sustainable,
- make public transport more effective.

Changes in urban mobility are also influenced by the current macroeconomic situation. Such factors as the COVID-19 pandemic, high inflation and migrations are all changing the demand for transport services. Cities are forced to react dynamically by adjusting supply, based on current social, economic or political factors. On the other hand, the involvement of certain groups of resources (vehicles, qualified staff) in public transport services results in relatively high fixed costs for public transport services. A strong change in supply over a short period of time may therefore be difficult to carry out.

Financial perspectives for local governments also remain an important factor influencing public transport. Changes to the law related primarily to personal income tax (PIT) generate large losses in local government budgets. Experts from the Union of Polish Cities have calculated that the biggest Polish cities will lose the most from these changes, and this loss will amount to 5.9 billion PLN for Warsaw, 1.6 billion PLN for Krakow, 1.4 billion PLN for Wrocław, 1.1 billion PLN for Poznań and over 1 billion PLN for Łódź (Związek Miast Polskich, 2022). This analysis takes into account both losses associated with lower tax revenues and additional equalisation funds, which are, however, significantly lower than the revenue foregone.

The high level of inflation is a separate problem, which also poses a threat to public transport services. Exceeding the inflation target (2.5%) in March 2021 ushered in many months of almost continuous inflation growth, reaching 17.9% on an annual basis in October 2022 (GUS, 2022). High inflation naturally forces upward pressure on wages, rising labour costs as well as external service costs and rolling stock maintenance costs. And in the longer term, there is a real risk that adequate funding will not be provided for the whole service sector.

5. Directions of transport development – opportunities and threats

Research made by Autopay shows that the longer the travel distance is, the more willingly public transport is used. For trips up to 2 km – 7% of the trips are made with the use of public transport, for 3–5 km – 19%, for 6–10 km – 24% and for 11–20 km – 25%. It is noteworthy that in all four distance ranges the number of journeys made by public transport (the survey concerned the Polish market) is lower than the number of journeys made by car (Autopay, 2023). A large share of road transport means great prospects for the development of public transport. On the other hand, for traveling to work, commuters most often use public

transport (42%), own transportation (car/motorcycle – 22%) and a bicycle (13%) (Colliers International, 2023).

Financial constraints remain one of the most serious threats to sustainable mobility in public transport. Investing in alternative fuels means high costs. The cost of operating a diesel-engine bus (from the perspective of purchase and fuel consumption for a period of 10 years) is about 2.65 PLN/km. This is at least more than for an analogous bus powered by gas (2.60 PLN/km) and at the same time more than the operating cost of an electric bus (2.38 PLN). The latter, however, takes into account an 80% stake in the purchase of the vehicle. For a hydrogen bus, the cost (even if 90% of the vehicle purchase is financed from external sources) is 3.10 PLN/km (Izba Gospodarcza Komunikacji Miejskiej, 2021, p. 6).

The operation of hydrogen vehicles will therefore be noticeably more expensive than vehicles with other propulsion sources. It shall be noted that the analysis is contained in a document from 2021, i.e. before the sharp rise in the prices of certain fuels (e.g. electricity). At the beginning of 2021, a barrel of crude oil cost approximately $50, surpassed $120 in the first half of 2022 and reached $80 by the end of November 2023 (Oil Price, n.d.). The average quarterly price of electricity sold on the competitive market in Poland increased from 256 PLN/MWh in the second quarter of 2021, reaching 890 PLN/MWh in the first quarter of 2023, and the following quarter (Q2/2023) brought the first decrease in two years – to 751 PLN/MWh (Urząd Rozwoju Energetyki, 2023).

With such an unstable fuel situation, both an electric bus and a hydrogen bus can only be considered economically meaningful if the vast majority of its purchase is financed externally. Even then, the operating costs remain higher compared to a conventional vehicle. The development and deployment of hydrogen vehicles is therefore primarily a matter of operating costs and not of technology itself.

The COVID-19 pandemic turned out to be a threat to the development of public transport. The sharp drop in the number of passengers using public transport has resulted in a decrease in revenue (through a significant decrease in revenue from tickets). Cities paid compensation, giving passengers money back for unused season tickets. In addition, changes in mobility trends were visible for months, so a relatively long period of time. In this period, public transport services were of course still in operation, which means a high level of costs. In addition, changes in urban mobility are permanent – after the pandemic, some workers and employees (in various industries) returned to work in a hybrid work model, i.e. partly remotely. This has affected, for example, preferences in terms of purchasing public transport tickets. Passengers today expect the flexibility of fare systems, adapted to different forms and working systems. On the other hand, public transport can act as a stimulus, and attractive fares can encourage other activities and drive the development of transport. This was the case, for example, with the 9-EURO-Ticket introduced on the German market, a ticket that reached very high popularity.

Conclusions

What is the role of digitisation and technology development on the development of public transport? Public transport is currently struggling with many challenges – the need to meet new technological challenges (e.g. implementing new propulsion sources), economic difficulties (due to changes in fuel prices) and fluctuations in the demand for services (as a result of the COVID-19 pandemic or the war in Ukraine). Technology can help overcome some of the challenges – for example, by improving the quality of services and reducing the environmental impact of transport. In general, the impact of technology will be positive as technology offers many opportunities to develop transport and adapt it to the current needs. The use of modern technologies also allows for increasing efficiency (e.g. vehicle use), which is also a key issue in sustainable mobility.

Current trends in public transport development and mobility changes have a strong connection with digitisation and technology development of public transport. Contemporary social, economic and political trends are changing public transport – technology and customer needs. A factor in assessing this change may be passenger statistics or mobility trends in a wider context. On the other hand, urban transport has always accompanied cities and followed their transformations – adapting to their development or following their degradation. It still remains (and will remain) an important element contributing to an adequate quality of life in all cities.

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