

Development of Urban Biking Infrastructure in Conditions of Ecologization of Transport and Overcoming The Consequences of Covid-19

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ABSTRACT

In the article, the authors draw attention to the priority of city cycling infrastructure development to improve the quality of life, safer movement, preservation of the environment. The need for measures in the development of cycling infrastructure in cities helps in solving a number of problems related to improving the environmental situation, has a positive economic effect, and is aimed at attracting additional cyclists from other regions. The authors study the development problem of municipal bicycle infrastructure on the example of Ukrainian cities and offer an adaptive approach to the development of a network of bicycle paths, which encourages residents to increasingly use bicycles for short trips. The study presents the authors' views on plausible scenarios for the implementation of municipal programs for the development of cycling, environmental quality and closely related to the concept of sustainable development and overcoming the effects of the COVID-19 pandemic. Using the survey method, a portrait of a potential user of local bicycle transport was formed, the economic and ecological expediency of creation and development of bicycle infrastructure in the cities of Ukraine was determined. The scenario plan of development of the municipal bicycle infrastructure of the city of Odessa is offered and substantiated.

Keywords: environmental quality; local transport infrastructure; bicycle traffic; survey method; script plan.

Journal of Economic Literature (JEL) Classification: C42, L62, Q25, R41

1. INTRODUCTION

The global pandemic COVID-19 has significantly affected urban mobility and the transport sector of municipalities. Residents of large cities and travelers have reduced travel due to local and regional quarantine restrictions, some of them prefer to abandon public transport, return to the use of personal transport or use hiking, cycling short distances.

Local communities and municipalities are implementing measures to build pedestrian and bicycle infrastructure to reduce car use and achieve the real goal of zero emissions and clean mobility. The urban tourism business sector has also felt the effects of the pandemic and the need to comply with quarantine restrictions, social distancing on quotas in hospitality and public transport, and developing new routes and locations to attract cyclists (Hassan and Soliman, 2021).

In most EU countries, local authorities are considering post-quarantine mobility measures aimed at creating cycle paths along the sidewalks on the streets, where the speed of cars will be limited to 30 km / h (instead of the usual 50 km / h); moving parking spaces so that the new pedestrian or bicycle area is protected from traffic by parked cars; construction of bicycle lanes separated from vehicle lanes by means of temporary road signs and limiters; creation of two-way bicycle routes on some streets with traffic restrictions for other vehicles, etc. According to Worldometers, more than a billion bicycles are used in the world, and the pace of their production far exceeds the pace of car production. In highly developed countries, the bicycle has long been part of the culture - it is used daily by both the youngest and oldest residents. The European Cycling Federation (ECF) has even estimated that the economic benefits of using a bicycle as a vehicle for the European Union are € 513.19 billion, which is 25% more than Belgium's annual GDP. The calculation was conducted as part of the study "The cycling economy of the European Union". According to its authors, they have a positive impact, in particular, in the field of ecology, health care, society, as well as in business and urban planning (Neun, Haubold, 2016).

Developed countries of the world are actively involved in the implementation of sustainable development policy, which indicates the need for the introduction of environmentally friendly modes of transport. Sustainable urban mobility is a priority for the development of urban infrastructure to improve the lives of people: improving pedestrian and bicycle infrastructure, regulating public transport, improving public health, reducing various risks, safer movement, and preserving the environment. The development of cycling in cities helps to solve a number of problems related to improving the socio-environmental situation, as well as having a positive economic effect. Increasing the share of bicycle traffic is one of the tactical means of achieving the strategic goal - to make the city's transport system sustainable and the city's public space accessible to all its users. The relevance of bicycle transport is confirmed by the fact that bicycles are cheap to use and maintain human health and urban development, and the development of cycling infrastructure - inexpensive to create and quick to implement, compared to others.

The purpose of the article is to substantiate the feasibility of creating a bicycle infrastructure of a large city based on a scenario approach and identify prospects for further development in the post-crisis conditions of overcoming the effects of the pandemic, forming proposals for management decisions and measures for sustainable development of transport in Odessa.

2. THE ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The issue of infrastructure development as a multifunctional and multifaceted system that ensures the development of the economy has been widely considered by foreign and domestic scientists. In the

economic literature, the term "infrastructure" was used in Rosenstein-Rodan, R. (1961), which defines infrastructure as the environmental conditions necessary for private industry to be able to make the first leap. Modern researchers, specifying the economic nature of infrastructure cities, conclude that its most significant feature in a market economy is the role in creating the general preconditions for the reproduction process and the general conditions for the growth of social production and, consequently, its progress (Yaskovets, 2013; Redin, Suptelo, Baynazarov, & Nyemets, 2018; Salvati, Chelli, & Zambon, 2018).

Cycling infrastructure is considered to be a set of road elements, facilities and services necessary for the functioning of cycling. Bicycle infrastructure facilities include an automated bicycle rental system, parking lots, bike paths, "pockets" and railings for cyclists at intersections, bicycle traffic lights and other elements of the urban environment, etc. (Neun and Haubold, 2016; Song, Preston, Ogilvie, 2017; Zhao, Carstensen, Nielsen, & Olafsson, 2018). That is, cycling infrastructure includes a set of facilities and activities necessary for the safe and convenient movement of cyclists in the village. Researchers suggest that cycling infrastructure may lead to an increase in cycling among the general population through recreational use (Goodman, Sahlqvist, Ogilvie, 2013). Specialist publications identify the benefits of cycling and public transport in large cities (Buehler, Pucher, 2012; Gehl, 2014). Iseki and Tingstrom (2014) considered the problems of planning regional bicycle routes between districts and rental sites using methods of spatial analysis. Fraser and Lock (2011) pay attention to the development of transport strategy of the city, which provides development of active transport and cycling routes, which can be one of the solutions to improve public health and environmental protection. Their research is supported by the fact that the construction of bicycle and pedestrian routes can also benefit public health. Researchers draw attention to the need of reducing negative externalities in cities, emphasizing that between mortality and air pollution there is a direct link with the use of cars, therefore, limiting the traffic load may be beneficial to society as a whole (Hidalgo and Huizenga, 2013). Evaluating the development of cycling infrastructure and its spatial arrangement, user behaviour, cost sensitivity and the impact of special cycling infrastructure in Budapest have been studied by Mátrai, T., Tóth, J., Cruz, J. (2020). An effective strategy to promote cycling as an urban transport is to develop and implement bicycle infrastructure development programs such as bicycle paths, bicycle parking and bicycle exchange schemes, considers Orellana, Martínez-Pesántez, Pulla-Tenemaza, Tapia-Sisalima (2019). Rachel Aldred, Bridget Elliott, James Woodcock & Anna Goodman (2017) conducted a study of gender and age similarities and differences in preferences for different types of cycling environments of urban dwellers (Winters, Brauer, Setton, and Teschke, 2010).

3. METHODOLOGY AND EMPIRICAL ANALYSIS

The main methods used in the study were: economic and statistical analysis - for grouping and visual presentation of digital information, the dynamic indicators, etc.; sociological research (surveys, questionnaires, interviews) - in order to analyze the current state of cycling infrastructure in cities and determine the feasibility of its development. The study used data from surveys of Poltava residents, which were collected by the public organization "CityLab". Survey data were analyzed by structural equations in the sample of 260 respondents.

To substantiate the scenarios of bicycle infrastructure development, based on the quantitative indicators of bicycle traffic, arrangement of bicycle paths and the results of the survey of urban residents, forecasting methods were used to develop models of urban transport infrastructure (Maldonado-Hinarejos, Sivakumar, Polak, 2014).

The formula for calculating the technical speed while driving was used to calculate the traffic. Technical speed (V_t) is the average speed of road transport for a certain time of movement, which is determined by the ratio of the distance travelled (L) to the time of movement (T):

$$V_t = L / T.$$

The application of this technique will allow to make a scenario forecast of the development of bicycle infrastructure in order to achieve the goal of zero emissions and environmentally friendly mobility and safe urban development.

4. RESULTS AND DISCUSSION

In the 21st century, the bicycle has become one of the most priority vehicles in Europe and the world's leading countries. The cycling infrastructure is improved annually; decisions are made to increase bicycle and pedestrian zones; bills on comprehensive support for cycling are being lobbied at the state level. In modern conditions, restrictions on the mobility of travelers and locals, social distance in public transport in the regions, local authorities stimulate cycling. Thus, there is an expansion of bike lanes in Berlin, where during quarantine traffic decreased by 40%. To maintain a safe distance, bicycle routes were widened by one meter with the help of markings. The Brussels City Council plans to build 40 kilometers of bike lanes by the end of the quarantine. In the Colombian capital, Bogota, the city hall during the lockdown has built about 320 kilometers of temporary bike lanes for use as an alternative to public transport. The New York City Hall has announced plans to close 65 kilometers of highway in the city and has already arranged 11 kilometers for walking and cycling. Local governments in Birmingham, Manchester and Liverpool are funding measures to separate cycling routes from road traffic. More than 100 kilometers of new walking and cycling routes will be built in Manchester by 2023 (Petroschuk, 2020). Thus, in the context of overcoming the consequences of the COVID-19 pandemic, the world experience of municipal administration shows that the development of cycling infrastructure is a modern trend of greening the city environment and one of the priority strategies for sustainable development of public transport.

Municipal authorities in the cities of Ukraine, on the basis of world experience together with public organizations: "Kyiv - Bicycle City", "Lviv Cyclists Association", "Kyiv Cyclists Association", "City Reforms" (Kharkiv), "CityLab" and "VeloPoltava" (Poltava), Ukrainian Bike Family (Kharkiv), Urban Movement "Zaporizhzhya Bicycle", "VeloVector" (Odessa), "Velo-Frankivsk" are developing concepts for the development of cycling infrastructure. As of early 2018, Ukrainian cities have built a number of bicycle paths, namely: in Lviv - more than 100 km, in Vinnytsia - 39 km, in Kyiv - 58 km, in Kharkiv - 8 km, in Ivano-Frankivsk - 7 km, in Odessa - 6 km (How cycling infrastructure can change a city, 2017). In the meantime, let's pay attention to bicycle safety, for 11 months of 2020 in Ukraine, the patrol police officially registered 2097 collisions with cyclists, which killed 210 people and injured 1546. The police believe that speeding and drunk driving is the cause, on the other hand, the experts- lack of

quality urban cycling infrastructure. To determine the feasibility of further development of cycling infrastructure in the city of Poltava, NGO «CityLab» within the project "Comfortable City" conducted a survey of the city population, through interviews and online questionnaires on social networks, which allowed to form a portrait of potential cycling infrastructure users, identify key issues its development and justify the feasibility of creating and developing cycling infrastructure in the city of Poltava. The results of the survey were obtained by processing electronic (201 pcs.) and paper (59 pcs.) of questionnaires. A total of 260 people took part in the survey. Time of the survey: 1.12.2014-01.10.2015. The portrait of the respondent shows that 61% of respondents are men and 39% - women. By age, the respondents were distributed as follows: 3.8% - up to 15 years; 51.9% - from 16 to 25 years; 31.9% - from 26 to 33 years; 11.2% - from 34 to 49 years; 1.2% - from 50 years old. The results of the survey show that 84.2% of respondents have a bicycle and 7.3% do not, but express a desire to buy it. 0.4% of respondents rent a bicycle, and 0.8% of respondents said they do not have a bicycle and do not plan to buy one (Survey results "What prevents Poltava residents from using a bicycle", 2015). After analyzing the results of the survey, it was determined that for most respondents the purpose of cycling is leisure (68%). 32% of respondents use bicycles for work trips, 30% for trips to the store, and 30% for sports trips. According to the survey, 35% of respondents use a bicycle several times a week, 25% - every day, 22% - once a month and less often. Only 10% of respondents use a bicycle once a week, and 9% - several times a month. Only 0.1% of respondents get to work by bicycle. The majority of respondents go to work by public transport (37.6%) and on foot (34.7%); by car - 27.5%. More than a third of trips to the place of work are made at a distance of 5 - 8 km. Also, a significant proportion (32%) of respondents said that the distance from home to their place of work is 2 - 5 km. The distance from home to the place of work is less than 2 km, 22% of respondents cover, and the distance is more than 8 km - only 10% of respondents (Survey results "What prevents Poltava residents from using a bicycle", 2015). The results of the survey of Poltava residents on the factors that hinder the use of bicycle transport are shown in Table 1.

Table 1: Factors that prevent residents from using bicycles

Important factors	Very important	Important, but not critical	Not important
Poor quality of roads and sidewalks	75.3%	20.4%	4.3%
Disrespect on the drivers part and pedestrians, violation of traffic regulations	48.1%	41.3%	10.6%
Lack of bicycle parking	44.7%	41.3%	14.0%
Lack of bicycle storage at work	38.7%	29.4%	31.9%
No bike paths	45.1%	46.8%	8.1%
Unimportant factors	Very important	Important, but not critical	Not important
Inconvenience to carry things	8.1%	31.9%	59.6%
Expensive bicycle maintenance	11.5%	36.2%	56.3%
Lack of bicycle storage at home	9.4%	35.3%	55.3%
Lack of shower after at destination point	14.0%	37.0%	48.9%
Curbs	19.6%	35.3%	44.7%

Source: Adapted from <https://es.slideshare.net/jalyna/ss-45143976>

According to the results of the survey, the main factors that prevent cycling: lack of bicycles, lack of bike paths, insecurity, fear and inability to ride a bike (Fig. 1).

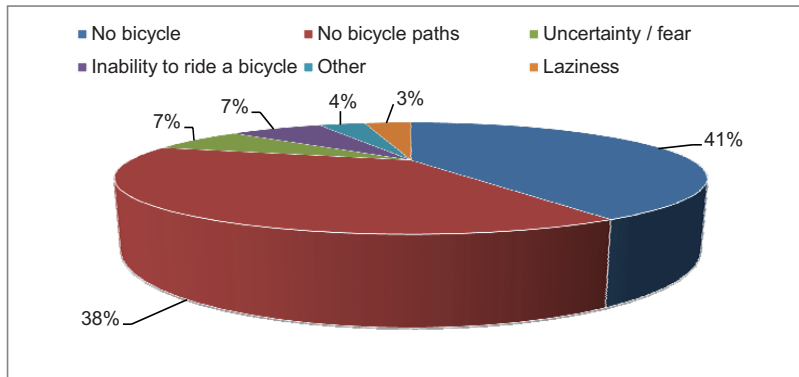


Figure 1. Factors that prevent residents of Poltava from cycling
Source: Adapted from <https://es.slideshare.net/jalyna/ss-45143976>

As a result of the description, measures were also identified that could encourage the population to start membership or increase the number of bicycles (Fig. 2).

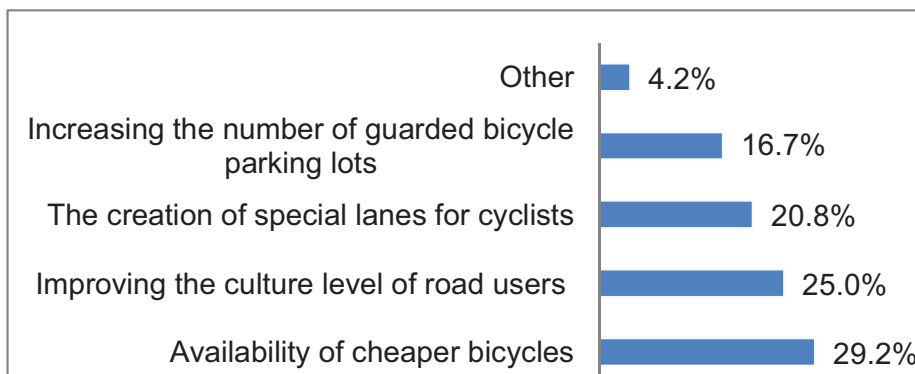


Figure 2. Local activities for the development of cycling infrastructure in the city of Poltava, who want the population to start using or increase cycling
Source: Adapted from <https://es.slideshare.net/jalyna/ss-45143976>

Thus, the results of a poll among the residents of Poltava indicate the benefits of developing quality cycling infrastructure. The survey is the basis for the development of the Bicycle Concept of Poltava. The length of bicycle routes according to the scheme proposed in the project is 133.07 km. The total mileage of trunk routes (i.e. routes of citywide importance, connecting areas of the city and the largest locations of cycling) - 28.77 km, secondary routes - 53.1 km, recreational routes (i.e. routes through parks, forests, embankments, etc., away from streets with heavy traffic) - 28.7 km, suburban routes - 22.5 km ("Poltava bicycle": results of the project, 2015).

Unlike Poltava, Odesa already has 6 km of bike paths in the city center, which is not enough for a city with population of a million; there is no single network of bike paths that are connected to each other

and residential area. There are a number of negative factors that affect the attractiveness of cycling in Odesa, but the main thing is the lack of modern municipal cycling infrastructure as such. It is necessary to equip radial-ring cycling infrastructure with markings and signs. To develop the cycling infrastructure of Odesa, the authors propose to create 8 main routes, which are shown in Table 2. Given the average market price for the design and construction of bicycle paths, as well as the length of planned bicycle routes, it is advisable to calculate the cost of creating bicycle routes. The calculations are based on information from the Odesa Cyclists' Association and the Department of Transport and Communications of the Odesa City Council, where the recommended cost of 1 running meter of a one-way bike path on both sides of the street at a width of 1.6-2 m - 1230 UAH. The results of calculations of the proposed cycling routes are given in table. 2.

Table 2: The bicycle routes in the city of Odesa are offered for arrangement

№	Bike route	Length, km	Cost, thousand UAH
1	"Ring" (Marazlievskaya, Troitskaya, Novoselskogo, Dvoryanskaya, Pastera, Olgievskaya, Zhvanetsky Boulevard, Primorsky Boulevard, Pushkinskaya, Gretska, Kanatnaya, Nakhimova Lane)	9.2	11316
2	"Suvorovsky" (Paustovsky, Dnepropetrovsk road, Nikolaev road, Black Sea Cossacks street, monument to Marinesco)	14	17220
3	"Primorsky" (Marinesco descent, Zhvanetsky Boulevard, Primorsky Boulevard, Pushkinskaya Street, Gretska, Yuri Olesha, Suvorov Avenue of Shevchenko Park, Health Route, Arcadia, "Gold Coast" beach)	16.5	20295
4	"Fountain" (Walk of Fame of Shevchenko Park, Belinsky, French Boulevard, April 10 Square, 5th station of the Great Fountain, Admiral Avenue, Lustdorfskaya Road, Gorky Park, Cosmonaut Komarov Street, Marshal Zhukov Avenue, Academician Williamskaya Street, Archi, Memorial of the 411th battery)	18.5	22755
5	"Airport" (Peresypsky Bridge, Balkivska Street, Melnytska Street, Ovidiopska Road, Odesa International Airport, Borys Derevyanka Square, Yitzhak Rabin Street, 25th Chapayev Division Street, Lustdorfska Road, Dovha Plyazhva Street, Davskoho Street "Gold Coast")	19.5	23985
6	"Historical" or "tourist" (Primorsky Boulevard, Ekaterininskaya Street, Deribasovskaya Street, Gretska Street, Starobazarny Square, Troitskaya Street, Novoselskogo, Soborna Square)	3	3690
7	"Student" (Olgievskaya, Pastera, Novoselsky, Staroportofrankovskaya, Didrichson)	2.5	3075
8	"Srednefontansky" (5th station of the Great Fountain, Srednefontanskaya Square, Gagarin Avenue, French Boulevard)	3.2	3936
	Total	86.4	106272

Source: compiled by the authors

Thus, the cost of development of 86.4 km of bicycle routes in Odesa within the development of bicycle infrastructure will cost 106272 thousand UAH. Also the budget of the program can be supplemented by the cost of accompanying and informational measures:

- development and installation of a bicycle signpost system;

- development and installation of bicycle parking lots and other small infrastructure;
- public bike rental;
- integration with public transport;
- development and printing of bicycle maps, related content filling on city's website;
- design, printing and promotion of social advertising, etc.

To forecast the prospects for the development of bicycle transport in Odesa, it is proposed to consider three scenarios for the development of cycling infrastructure and compare them with the current situation. The first development scenario envisages an increase in the share of cycling among city residents to 1.5%, the second to 3%, and the third to 5%. A comparison of the distribution of trips by mode of transport according to the current state and possible development scenarios is shown in Figure 3.

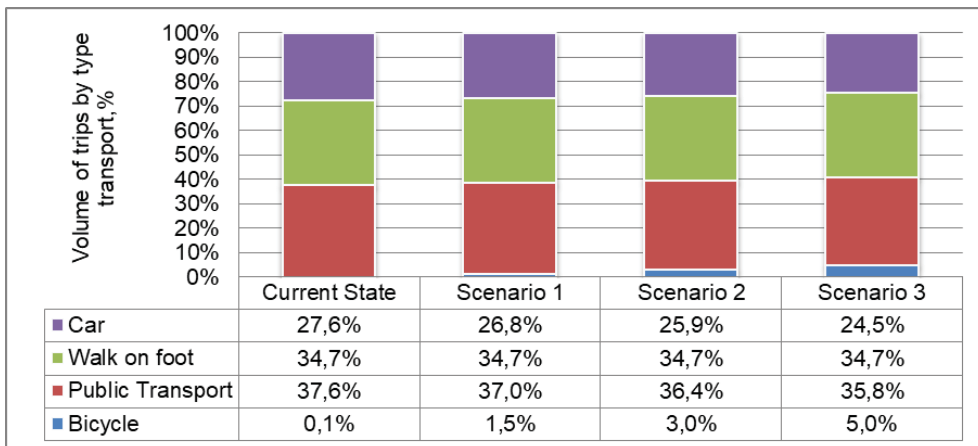


Figure 3. Distribution of trips by types of transport according to the forecast

Source: compiled by the authors.

According to the first development scenario, the share of bicycle travel will increase to 1.5% by reducing the share of car travel by 0.8% and public transport by 0.6%. According to the second development scenario, the share of bicycle travel will increase to 3% due to a decrease in the share of car travel by 1.7% and public transport - by 1.2%. The third scenario of bicycle infrastructure development envisages an increase in the share of cycling to 5% by reducing the share of car use by 3.1 % and public transport by 1.8%. The lion's share in the structure of travel by mode of transport is public transport. Public transport routes of Odesa are served by 10 carriers. One of them is the «Odesmiskelektrotrans» utility company, the others are private. According to the Odesa Department of Transport, Communications and Traffic Organization, the daily mileage of public transport in Odesa is 36090 km per day (Report of the Department of Transport, Communications and Traffic Management, 2019). This figure per year is $36090 \text{ km} \times 365 \text{ days} = 13172850 \text{ km}$. We calculate the daily mileage of public transport in accordance with the scenarios for the development of bicycle infrastructure in Odesa. Under the first scenario of development of a bicycle infrastructure in Odesa the share of use of public transport will decrease by 0.6%, according to the second - by 1.2%, under

the third - by 1.8%, and under modern conditions, the daily mileage of public transport is 36090 km, then:

- according to the first development scenario, the daily mileage of public transport is $36090 \times 0.37 / 0.376 = 35514.1$ km;

- according to the second scenario - $36090 \times 0.364 / 0.376 = 34938.2$ km;

- according to the third scenario - $36090 \times 0.358 / 0.376 = 34362.3$ km.

Thus, in the implementation of the first scenario of development of bicycle infrastructure in Odesa, the total daily mileage of public transport will decrease by 575.9 km, in the implementation of the second scenario - 1151.8 km, and in the implementation of the third - by 1727.7 km. This will have a positive impact on the environment by reducing CO₂ emissions and saving fuel, installing bicycle parking to encourage people to use alternative types of transport (Bezerra, Manzato, DeMello, Peixoto & Batistao, 2019).

The average annual mileage of a car in a big city like Odesa is 15.000 km (AUTO. RIA. What real mileage should you expect when buying a used car, 2019). We calculate the daily mileage of cars in accordance with the scenarios of development of bicycle infrastructure in Odesa and compare with the current situation. As under the first scenario of development of a bicycle infrastructure in Odesa, the share of trips by the car will decrease by 0.8%, according to the second - by 1.7%, according to the third - by 3.1%, and under modern conditions daily mileage of one car averages 40 km, then:

- according to the current situation, the total daily mileage of private cars is $72576 \text{ cars} \times 40 \text{ km} = 2903040$ km;

- under the first development scenario, the total daily mileage of private cars will be $2903040 \times 0.268 / 0.276 = 2818893.9$ km;

- according to the second development scenario, the total daily mileage of private cars will be $2903040 \times 0.259 / 0.276 = 2724229.6$ km;

- according to the third development scenario, the total daily mileage of private cars will be $2903040 \times 0.245 / 0.276 = 2576973.9$ km.

In the implementation of the first scenario of development of bicycle infrastructure in Odesa, the total daily mileage of private cars will decrease by 84146.1 km, in the implementation of the second scenario - 178810.4 km, and in the implementation of the third - 326066.1 km. This will have a positive impact on the environment by reducing CO₂ emissions and saving fuel, as well as relieving traffic and reducing congestion, as indicated by recent research (Zayed, 2016).

To predict the development of cycling infrastructure in Odesa, it is advisable to determine the amount of time that city residents spend in traffic jams and analyze how the travel time of city residents will change according to the scenarios of bicycle infrastructure development. According to a survey, most trips from home to work are made at a distance of 5-8 km. At the maximum permissible city speed of 50 km / h, this distance can be covered in (8 km: 50 km / h = 0.2 hours or 12 minutes). The online service Google maps real-time estimates the density of traffic as a percentage of additional time on the road, compared to the situation of free traffic flow (Online service Google maps). The data is based on changes in traffic speeds on certain sections of the road, which are collected by drivers. With the help of this service, it was analyzed that during rush hour, the delay on the road for residents

of Odesa increases by 94%. Thus, a trip lasting 12 minutes increases to 23 minutes (12 minutes + 94% = 12 + 12 × 0.94). Morning rush hour is at 8: 00-9: 00, evening - at 18: 00- 19:00. Based on these data, we calculate the total amount of time spent by residents of Odesa due to congestion and changes in this indicator as a result of increasing the share of cycling.

As a basis for calculating the total daily amount of time spent in traffic jams, it is proposed to choose the number of employed people who travel daily from home to work. As of January 1, 2019, the number of employed population in Odesa was 460 thousand people. According to the results of the social survey, the share of people who use a bicycle as a daily transport is 0.1%, then the number of people who get to work by car and transport is - 459.54 thousand people. Then, the average total daily time spent on the road by residents of Odesa who travel by car and public transport is 352314 hours (459.54 thousand people × 23 minutes × 2 = 21138840 minutes, or 352314 hours).

We calculate the average daily travel time in accordance with the scenarios of development of cycling infrastructure in Odesa and compare with the current situation. Under the first scenario of development of a bicycle infrastructure in Odesa the share of trips by bicycle will increase to 1.5%, under the second - to 3%, under the third - to 5%, and under modern conditions the share of people who use a bicycle as daily transport. is only 0.1%, then:

- according to the first scenario of bicycle infrastructure development, the amount of time spent on the road of the employed population of the city will be - 347376.7 hours (460 thousand people-460 thousand people × 0.015) × 23 minutes × 2 = 20842600 minutes, or 347376.7 hours ;

- according to the second scenario - will be (460 thousand people-460 thousand people × 0.03) × 23 minutes × 2 = 20525200 minutes, or 342086.7 hours;

- under the third development scenario - will be (460 thousand people-460 thousand people × 0.05) × 23 minutes × 2 = 20102000 minutes, or 335033.3 hours.

In the implementation of the first scenario of bicycle infrastructure development in Odesa, the total daily loss of time on the road will be reduced by 4937.3 hours, in the implementation of the second scenario - by 10227.3 hours, and in the implementation of the third - 17280.7 hours. This will help reduce unproductive time. Thus, the development of cycling infrastructure and an increase in the share of urban cycling in the third scenario will have a positive impact on the following indicators:

- reduction of the total daily mileage of public transport by 1727.7 km;
- reduction of the total daily mileage of passenger private transport by 326066.1 km;
- reduction of time losses of the population in traffic jams by 17280.7 hours.

This trend indicates a positive impact on the environment by reducing CO2 emissions, saving fuel, and reducing unproductive time, as evidenced by studies by other scientists (Krenn, Oja, & Titze, 2015). In general, with the development of cycling infrastructure and reducing the share of public transport can be achieved by reducing the average daily mileage by:

1 scenario = 36090-35514.1 = 575.9 km;

2 scenario = 36090-34938.2 = 1151.8 km;

3 scenario = 36090-34362.3 = 1727.7 km.

Due to the reduction of the share of individual passenger transport, it is possible to achieve a reduction in the average daily mileage by:

1 scenario = $2903040 - 2818893.9 = 84146.1$ km;

2-nd scenario = $2903040 - 2724229.6 = 178810.4$ km;

3 scenario = $2903040 - 2576973.9 = 326066.1$ km.

Today in the city of Odesa there are no data on emissions of harmful substances from motorized vehicles in open sources of information, so for the calculation we will take data from EU countries on CO₂ emissions. On average, a modern passenger car emits approximately 130 grams of CO₂ per 1 km (Road transport: Reducing CO₂ emissions from passenger cars, 2020). Based on this, for each scenario, the probable share of CO₂ emissions is calculated:

1 scenario - $(575.9 + 84146.1) \times 0.13 = 11013.86$ kg, or 11.04 t;

2 scenario - $(1151.8 + 178810.4) \times 0.13 = 23395.086$ kg, or 23.4 t;

3 scenario - $(1727.7 + 326066.1) \times 0.13 = 42613.19$ kg, or 42.6 t.

That is, the environmental effect of the implementation of bicycle infrastructure development can be estimated by not getting from 11.04 tons to 42.6 tons, depending on the scenario, of harmful substances per day in the city air. Given that in Ukraine the requirements for engines are much lower than in the EU, this figure may increase significantly. Overruns also cause irrational use of limited fuel resources. Assuming that, on average, a conventional car uses about 10 liters of fuel per 100 km (0.1 l / km), the energy efficiency of the measures will save:

1 scenario - $(575.9 + 84146.1) \times 0.1 = 8472.2$ l;

2 scenario - $(1151.8 + 178810.4) \times 0.1 = 17996.22$ l;

3 scenario - $(1727.7 + 326066.1) \times 0.1 = 32779.38$ l;

That is, the savings of fuel resources from the implementation of the development of bicycle infrastructure can be estimated from 8472.2 liters to 32779.38 liters of fuel per day, depending on the scenario. Thus, the development of bicycle infrastructure in Odesa has significant prospects. The study identified the prerequisites for the creation and development of municipal cycling infrastructure, which is confirmed by the positive expected socio-economic effect. In our opinion, the municipal authorities of Odesa need to learn from the experience of bicycle development in Lviv, where since 2015 the public bicycle rental company Next bike has been introduced. As of 2020, there are 24 stations. Bicycle rental allows you to ride a bike without worrying about its repair or possible theft. From 2018, season ticket buyers and Next bike customers will receive an additional season ticket for electric vehicles. Trends in recent years show the growing popularity of individual electric vehicles, such as electric scooters, gyro scooters, electric unicycles and others. The cycling infrastructure is the most acceptable for their movement. The city of Odesa must be ready to enter the market of services that rent electric scooters. Such services have already flooded many cities around the world. In particular, charging stations will be in demand. Observations indicate that the corresponding trend is inherent in other cities of Ukraine. The Government of Ukraine considers that the development of the National Cycling Strategy is one of the important steps in the implementation of the National Transport Strategy until 2030 and is in line with the EU 2020 sustainable mobility strategy, which aims to improve mobility of citizens in COVID-19 and transition to zero-emission transport. (Ukraine begins development of National Cycling Strategy, 2020).

4. CONCLUSION

The COVID-19 pandemic has clearly shown that the economies of individual countries and cities, and of the European community as a whole, are highly dependent on public transport and population mobility. One of the tools of the strategy is to stimulate the development of low-emission vehicles by spreading active cycling and the development of cycling infrastructure to reduce congestion and environmental pollution. This study analyzes the role of cycling infrastructure in socio-economic development and identifies the benefits of cycling and according to the results of a sociological survey of residents of Ukrainian cities, the preconditions and prospects for the development of bicycle traffic and bicycle infrastructure have been identified. In addition, a bicycle can be a convenient way to reach the main transport hubs of the city, if you arrange bicycle storage and parking. The authors proposed and substantiated measures for the arrangement of bicycle infrastructure in Odesa, which consist of 8 bicycle routes, with a total length of 86.4 km and a total cost of 106.272 thousand UAH. This will have a positive impact on the environment by reducing CO₂ emissions and saving fuel, as well as relieving traffic and reducing congestion (Orellana, Martínez-Pesántez, Pulla-Tenemaza, Tapia-Sisalima, 2019). The environmental effect of the development of cycling infrastructure can be estimated by reducing emissions of harmful substances from 11.04 tons to 42.6 tons per day in the city air, depending on the scenario proposed by the authors. The development of a network of bicycle routes will increase the level of safety for pedestrians and cyclists, increase investment in the construction of bicycle infrastructure and the development of cycling and tourism potential of the city of Odesa.

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