

ANALYSIS OF THE UKRAINIAN CITIES' SUSTAINABLE MOBILITY
ON THE EXAMPLE OF LVIV

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Abstracts. The world tendencies of popularization of ecological elements of sustainable mobility and the results of their introduction in Lviv on the way to sustainable development are considered in the article. Examples of implementation of the Sustainable Mobility Plan in the city in accordance with the set priorities are given: residents, public transport, ecological means of transportation, private transport. The development of infrastructure for individual environmental means of mobility and public transport is analyzed.

Keywords: Sustainable development, sustainable mobility, sustainable development goals, Sustainable Urban Mobility Plan, public transport, public space, pedestrians in priority, ecological transport.

1. Introduction

The issue of sustainable development of countries is one of the most important nowadays, as environmental problems and the issues of environmental damage are approaching critical limits. Since transport is one of the biggest pests for the environment, the issue of sustainable urban mobility is relevant for administrations, institutions, research and educational organizations dealing with it. This concept is studied in various fields of science and practice. "Many people in many small towns and villages are changing the world by doing many small things" is the motto of sustainable development supporters. Modern youth in interaction with nature must be "sustainable" in

their development, caring for the ecological heritage for future generations. One of the important steps in this direction is "sustainable urban mobility". The Sustainable Development Goals describe the main tasks for humanity related to development, production, consumption with a maximum saving of the environment. By joining the global process of providing the Sustainable Development, Ukraine has begun an inclusive process of adapting the Goals to the problems and national peculiarities of Ukraine [1]. The eleventh goal of the Sustainable Development is to ensure the openness, security, vitality and environmental sustainability of cities and towns, and tasks 11.2, 11.3, 11.7 are related to bringing urban transport systems, living space for the citizens to a level that will meet the needs without causing harm, or reduce it significantly [2].

The cities of Ukraine have taken moving in the right direction. The leader among them is the city of Lviv. The level of motorization in Lviv is still relatively low, but if we don't start taking steps to regulate the movement of private transport, then soon we can get a city of continuous congestion. One of the principles of sustainable mobility is the choice for citizens: to travel by bicycle, public transport, on foot, or to stay in traffic jams most of the time. If all private cars were removed from the city, walking, cycling or public transport would be ideal, but because it is unrealistic, it is necessary to find other solutions for comfortable, safe and, at the same time, sustainable traffic moving in the right direction.

2. Research statement

The analysis of world experience has shown that the sustainable mobility of cities is a necessary step towards their sustainable development. How many cities in Ukraine are ready to implement the Sustainable Development Goals? What has been done and what still needs to be done? One of the steps on the way to sustainable mobility is to develop a Sustainable Urban Mobility Plan, support it at the administrative level and implement in the cities. Therefore, there is a necessity to use Lviv as an example to show at what stage the implementation of this plan in the life of Ukrainian cities is.

3. Implementation of the elements of sustainable mobility in the city of Lviv in accordance with the priority developed in the sustainable urban mobility plan of the city

On February 13, 2020, at the Plenary Session of the Lviv City Council, the deputies supported the Sustainable Urban Mobility Plan, which determines the direction of the development of the city's transport for the next ten years [3]. The main idea of this project is a "City for People", in which the movement of residents should be efficient in terms of time, comfort, cost, as well as the promotion of health and the elimination of the least negative impact on the environment.

Such issues as the development of public transport, the benefits of environmentally friendly urban movement, road safety, traffic and parking of road transport, urban logistics, mobility management, intelligent transport systems are addressed in the Plan. Without such a Plan, the measures developed by the various institutions were chaotic and ill-considered. Until recently, Lviv didn't have a strategic vision for the development of transport and mobility of the population. Similar Mobility Plans have been developed in other cities of Ukraine: Kyiv, Vinnytsia, Chernihiv, Poltava, etc.

In [4] the advantage of urban mobility planning from the standpoint of its sustainability is shown. Planning sustainable urban mobility allows increasing the efficiency of management and coordination of logistics processes within the city.

It is possible to use the Index of Sustainable Urban Mobility I_SUM as an auxiliary tool for urban mobility management, [5]. This index includes the main factors and indicators needed to monitor urban mobility. The viability of this Index has been tested for the use

in medium-sized cities, but with an improved data collection procedure.

In [6] the Index of urban mobility of key cities of the world is analyzed. It is shown that out of 100 possible points, Hong Kong has the highest index of 58.2. Despite, practically, the highest population density in the city, it has the best system of urban mobility, in which the main emphasis is, of course, on public transport for 64 % of trips.

In [7] indicators that can be used for sustainable transportation evaluation are identified. The paper discusses sustainable transportation definitions and concepts, describes factors to consider when selecting indicators, exemplifies specific sustainable transportation indicators, discusses issues of the data quality, and provides recommendation on further research and development in the field.

The Todd Litman Index is characterized by its flexibility and usability for cities with different characteristics and includes three main principles of sustainability: social, economic and environmental [8].

In accordance with the tasks of the Sustainable Development Goals and the ideas of the Sustainable Urban Mobility Plan to solve the problem of emissions into the atmosphere by mobile sources, the priorities of development of the city of Lviv are formed:

- ✓ pedestrians;
- ✓ public transport;
- ✓ alternative personal modes of transport;
- ✓ logistics and delivery;
- ✓ private vehicles;
- ✓ car parking.

The first and main priority is pedestrian. Pedestrian movement is one of the most economical, environmentally friendly, healthiest, and, with short distances, the fastest types of movement. Due to the priority and the need to organize public space, many Lviv streets, especially in the central part of the city, are being reequipped with maximum comfort for socialization: these are promenades, illuminated in the dark with benches and landscaping. The movement of private transport there is limited, but there is a possibility of emergency services. Parking areas and recreation areas should be located in a balanced way to satisfy the needs of the citizens as much as possible. Two such streets have already been created in the city of Lviv (Fig. 1), but it is planned to arrange several more sections in the Central part of the city.

Small streets, which are used inefficiently and connect roads with more traffic, are best suited for organizing public space. Such pedestrian areas are found in other large and small cities of Ukraine. The longest

pedestrian street is in the city of Mykolaiv, its length makes up thousands of meters.

Scientists around the world try to identify challenges for science and innovations that will help improve public health and sustainable development in the world's cities [9], [10]. The need for comprehensive studies of the effectiveness, benefits and unpredictable consequences of a sustainable approach is shown. Cities are often centers of political and technological

innovation and economic development. In many cases, they develop and implement solutions to current health and environmental problems related to climate change, pollution and unsustainable use of natural resources. One of the necessary elements to improve the ecology of cities is the landscaping of roads and streets [11]. Noise reduction, local cooling, improved physical activity and mental health are important components of the proper development of human settlements.



Fig. 1. The view of Rudanskogo str. and K. Kurbasa str. after reconstruction

Public transport is among the priorities in the Sustainable Urban Mobility Plan. Separate lanes for public transport allow you to reduce the duration of movement for one unit by 3–4 minutes. The length of separate lanes for such a type of transportation in Lviv is about 15 km per 600 km of the transport network. If we take into account the separate tram tracks, this distance will increase to 30 km, which is a very low quantity, the length of separate lanes for public transport in Kyiv is 35 km per 2000 km of the length of highways. For example, in European cities, which are close to Lviv, in terms of population, the length of the lanes for PT is 3–4 times longer.

Of course, the arrangement of lanes for public transport causes an increase in the density of lanes for private transport and compaction in many areas of mixed flows, which causes sharp dissatisfaction among the owners of private cars. The presence of such lanes caused particular dissatisfaction during the quarantine announced in the cities in mid-March 2020 because of COVID-19 virus pandemic. Public transport was transferred to a special mode of working with a limited number of passengers. Due to the unprofitability of transportation, carriers have reduced the number of transport units on the routes. After the quarantine was partially eased, when the population needed to get to work, the number of private vehicles increased. At this time, the lanes for this transport were used inefficiently.

It is advisable in such cases to introduce a “temporary priority” for the use of lanes by public transport at certain peak hours, and at other time allow traffic for private transport.

Separate lanes for public transport have been introduced in many major cities around the world. This didn't happen without compromising the capabilities of car users, but city authorities managed to increase the number of public transport users to 25 % [12]. The establishment of a unified system of transport communication and ensuring its operation on market conditions in Vilnius is discussed in [13]. The new transport system in the city was launched in July 2013 and included the arrangement of priority lanes, a combination of main, fast and additional routes, the integration of taxis and private buses into a single urban passenger transport system.

An important step towards promoting the use of public transport is to improve its quality, reduce the duration of travel and introduce a long-awaited e-ticket. “Smart” traffic lights can positively affect the duration of public transport traffic. These adaptive traffic lights give preference to citizen's transport and help to create a reliable and safe transport system of the city. Besides, the transport stations, which platforms are raised, increase the comfort of public transport users, which makes them suitable for the use by low-mobile segments of the citizens (Fig. 2).



Fig. 2. Station of public transport with raised platforms

Problems with practical use in Lviv arose because of the mismatch of the height of the platforms to the height of the first step of some types of trams, because of which the doors could not open. While in Kyiv, Dnipro, Odesa, this problem is not encountered.

If a few years ago bicyclists fought for their status as “road users”, now, thanks to public attention, there has been an increase in research on the role of cycling in urban transport systems and its promotion as one of the elements of sustainable mobility [14]. And not only the use of bicycles for private purposes is growing but also the use of cargo bicycles for transportation of a certain type of cargo, or family trips [15]. One of the problems they face when arranging bicycle lanes is the inability to make them continuous [16], which increases the level of danger, reduces comfort and speed. Hereupon, the third priority of the Sustainable City in Lviv is to organize the movement of alternative personal modes of transport. These are bicycles, electric scooters, gyroborders, unicycles, etc. So, as mentioned above, the movement of such types of transportation turned from a means of walking and a kind of sports into a means of transportation in the city, business, advertising, patrolling. And, it is not only ecological but also much faster means than classical private transport at a high density of cars on the roads. Therefore, there is a demand for documented legalization and promotion of such transport units. The bicycle was and for a long time remains the most widespread ecological mode of transport. Intensive development of cycling infrastructure began in 2011 and for the first few years Lviv came out on top in terms of its development, leaving behind Vinnitsia and Kyiv.

For the first time in Lviv, the city's bicycle concept was developed, approved and implemented. The bicycle concept of Lviv should solve many difficult problems, but this requires changes to the Rules of the Road, approval of common standards for the construction of bicycle paths, the establishment of those responsible for both construction and arrangement of bicycle paths, cleaning the area, establishing cooperation with other modes of transport.

The first bicycle lane in Ukraine which separates the private lane from the public transport lane was built in Lviv in 2013, (Fig. 3); also in Lviv, for the first time, bicycle countersinks were installed, despite certain risky moments associated with traffic in the opposite direction with other vehicles (Fig. 4). One of the elements of cycling infrastructure is bicycle supports, which allow cyclists to rest while waiting for the allowed signal of a traffic light (Fig. 5), installed for the first time in Lviv at several intersections.

A bicycle rental system was introduced in Lviv for the first time, which is currently being supplemented by the rental of gyroborders, electric scooters, and unicycles, which is very popular among a great number of tourists in the city (Fig. 6).

Lviv novelty was the introduction of additional elements such as marking arrows indicating the direction of bicycle movement; arrows to indicate turns; lines showing the delimitation of flows on two-way bicycle paths; as well as zebras marking the intersection with the footpath. Bicycle traffic lights have also been installed at five intersections in Lviv.

In total, as of 2020, more than a hundred kilometres of bicycle paths have been built in Lviv, connecting the northern and southern parts of the city through the centre, forming the so-called “bicycle highway”.



Fig. 3. A separate bike path in S. Striltsiv street



Fig. 4. Counterband for cyclists in Copernica street



Fig. 5. Bicycle support in front of the intersection in Svobody Avenue



Fig. 6. Bicycle and electric scooter rental stations in the central part of the city

Three types of signs and road marking are used to mark bicycle paths in Lviv (Fig. 7):



Sign 4.12: "Cycling path"



Sign 4.14: "Pedestrian and cycling path"



Sign 4.22: "Adjacent lane for pedestrians and cyclists"



Marking 1.29: "Path for cyclists"

Fig. 7. Types of road signs and marking used in Lviv to mark bicycle paths

Private transport is the next priority on the way to sustainable mobility. Cars have been and remain expensive, but also the most comfortable way to travel. According to statistics, the level of motorization in Lviv is not as high as in European cities, and moving in traffic flows becomes very difficult because of high traffic, constant traffic jams. In addition to an increase in the duration of traffic in the city, an increase in the density of cars has a negative impact on the economic, environmental and social components of

sustainable development of the city. According to the global database Numbeo, Lviv ranks 154th among the 288 most polluted cities in the world, leaving behind the Dnipro, Kyiv and Kharkiv. Due to the fact that there is practically no harmful production in Lviv, vehicles are the main source of emissions into the atmosphere. You can improve the situation:

replacing old cars with more modern models that meet Euro-5.6 standards;

- ✚ reducing the longitudinal dimensions of cars;
- ✚ encouraging the population to use electric cars;
- ✚ intensifying control over fuel quality;
- ✚ having introduced state programs of crediting or partial compensation of cost of low-quality old cars at replacement by the electric car;
- ✚ improving the transport system of the city.

Cars with foreign registration have been imported into Ukraine for several years. Most of them did not come across Euro-5.6 standards. Emissions from fuel combustion in such cars, especially in dense streams, on densely built-up streets and poor ventilation, are a serious blow to the environment and public health.

It is difficult to find so many "large" private cars in most European cities as in Ukraine; this aggravates the already difficult situation on the roads. The increase in the number of smaller private cars will increase road capacity, reduce harmful emissions and help to avoid parking problems.

The positive aspect of motorization is the popularization of electric cars and hybrid cars every year. In 2019, the number of electric cars registered in

Ukraine increased by 39 % compared to 2018 and is about 7.500 cars. Lviv is the city that first signed the Concept for the Development of Electric Mobility in January 2018, which provides for the improvement of electro-mobile infrastructure and an increase in the number of electric public transport by 2025 by 40 %.

The most popular models are Nissan, Renault, Tesla, Volkswagen, BMW. In general, most brands try to develop and offer their proposals in the electric car market.

Government support is an important step towards increasing the popularity of electric transport. Electric cars imported to the territory of Ukraine are exempt from VAT and the amount of excise duty is reduced depending on the capacity of the car battery.

As the number of mobile power units increased, so did the need for more power stations. Since 2015, when the first charging stations appeared in Lviv, their number has been constantly increasing. They are installed in all new infrastructure facilities and existing ones. PlugShare service has developed an electronic map of gas stations (Fig. 8), which will allow drivers to better plan their route.



Fig. 8. Online map of gas stations in Lviv and the region

The last point of priority on the way to sustainable mobility is parking, or rather its standardization. Chaotically parked cars in unauthorized places often cause congestion, traffic complications, and reduced road capacity. The biggest problem with car parking, of course, is in the central part of the city. Most drivers trying to park comfortably near their destination often spend more time and fuel looking for a free space, as demand exceeds supply. To solve this problem, the Sustainable Urban Mobility Plan [17] proposes to zone the city and change the pricing policy of parking lots

according to the zone, form a tariff so that there are always 15 % of vacancies in the central part of the city, and reduce the number of free and unpaved parking lots to zero.

Conclusion

Thus, Lviv is a city that, unequivocally, works, develops and moves on the way to implementing the Sustainable Development Goals. Developed and implemented measures to improve the movement of

citizens have a positive result: efforts to organize the safe movement of micro-mobility and conditions created for uninterrupted movement of public transport encourage the population to use it more often for their needs. This will save time and money and improve the environmental situation. The disadvantage of this type of movement is the low quality of many transport vehicles. But in order to upgrade the rolling stock and to make it cost-effective, it is necessary to raise the number of its users. For this purpose, social, agitation work is important in persuading the population to replace private transport with alternative modes of transportation.

The connection of suburban areas with the city centre is still unfinished. The cars arriving at the central part of the city create an additional load on an insufficient number of parking lots and the density of cars on the roads increases. Therefore, the creation of regular, high-quality routes will solve such problems.

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