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MODERN SUCCESSFUL GLOBAL SOLUTIONS IN ENVIRONMENTALLY FRIENDLY URBAN DELIVERY AND THEIR APPLICATION IN UKRAINE

Lidiia Savchenko, Myroslava Semeryagina. "Modern successful global solutions in environmentally friendly urban delivery and their application in Ukraine". Nowadays the issue of reducing environmental pollution is on the agenda of all countries. Among the areas that have huge negative consequences for nature, logistics and supply chains take their place. Today, there are many concepts and scientific currents that recognize the need to account for the environmental component in urban logistics. Environmental aspects are used when evaluating the efficiency of investment projects, developing new models of vehicles, calculating taxes and insurance payments, and when searching for the best delivery schemes.

The goal of the work. Taking into account the world experience in research on the chosen topic, the purpose of this study is to consolidate the world's successful experience in environmentally friendly urban delivery and assess their applicability in Ukraine.

Technologies and methods that allow reducing the negative impact of motor vehicles on the environment include:

The technology of off-peak delivery, which allows you to improve the speed mode of the car. With off-peak delivery, the probability of traffic jams is minimized, which makes the speed of movement the maximum permissible in the city (and, accordingly, the most environmentally friendly). Although night delivery is currently not possible in Ukraine due to the curfew, late and early delivery is still available, allowing you to successfully bypass traffic jams.

Use of consolidation centers. The economic idea of consolidation of freight transportation is to use the effect of scale - the greater the carrying capacity of the vehicle, the lower the specific costs for transportation of a unit of production. Currently, the construction of the consolidation center is being evaluated from the point of view of the impact of the supply chain on the environment. At the same time, the existence of a consolidation center near or within the city allows to organize delivery by vehicles with zero or low level of environmental pollution.

Use of Parcel Delivery Lockers. Delivery lockers are usually installed in places where the maximum flow of residents is concentrated, which makes it possible to create additional comfort for users due to the possibility of choosing the point closest to their own home or place of work. This method eliminates up to two thirds of harmful emissions into the air. The number of post machines and the area covered by them increases year by year, which allows us to talk about the success of this technology. According to the results of 2022, such major players of express delivery as "Nova Poshta" (now "Nova"), "Ukrposhta" and "Meest" will continue to work with post delivery lockers in Ukraine.

Use of more environmentally friendly types of transport. The use of hybrid, electric or non-motorized vehicles is increasingly used in last-mile logistics. Electric vehicles, mopeds, two- or three-wheeled bicycles with a large trunk or cargo body can be considered environmentally friendly types of urban logistics. Such vehicles have practically zero emissions of harmful substances, they are much more maneuverable and do not require a lot of space for unloading, loading and parking.

Implementation of zones with low (zero) air pollution. Zones with zero or low emissions have long been used in developed countries. There are no generally accepted technologies for calculating the territory that requires restrictions on the movement of transport, as well as for calculating the cost of such movement. Usually it depends on the will of the local authorities, the wishes of the residents and the well-being of the region.

Prohibition on the use of motor vehicles. Some local authorities introduce a complete ban on the use of motor vehicles within certain parts of the city. Usually these are historical centers with dense buildings and a large number of tourists. Sometimes such drastic measures are combined with night delivery technology. If this is not possible, the only alternative is delivery by small, usually two- or three-wheeled, zero-emission vehicles.

Improvement of traffic management. Competently designed organization of road traffic can reduce the pressure on the environment. The use of an intelligent transport system in smart cities allows you to perform important tasks like detection of transport accidents; automated control of the ramp, traffic lights and parking, etc. Improvement of road conditions. This refers to the quality of the road surface, markings, cleanliness of the road surface, etc. Improvement of road conditions indirectly affects the improvement of environment of the region.

Summing up the results of the research, successful global practices in environmental friendly urban logistics are highlighted, which are applied and have prospects for application in Ukraine. It was concluded that there is a huge potential of using world experience in urban logistics of Ukraine. This will bring Ukrainian logistics and urban supply chains to a new level, increasing the level of health and general satisfaction of the citizens.

Keywords: last-mile logistics, urban (city) delivery, urban (city) logistics, environmental friendly delivery, parcel delivery lockers, low-emission (zero-emission) zones, environmental friendly vehicles, off-peak delivery, freight consolidation

Лідія Савченко, Мирослава Семерягіна. "Сучасні успішні світові рішення в екологічній міській доставці та їх застосування в Україні". Зараз питання зниження забруднення навколишнього середовища стоїть на порядку денному всіх країн. Серед сфер, що мають величезні негативні наслідки для природи, займають своє місце логістика і ланцюги постачань. На сьогодні існує безліч концепцій та наукових течій, які визнають необхідність обліку екологічної складової у міській логістиці. Екологічні аспекти використовують і при оцінці ефективності інвестиційних проєктів, і при розробці нових моделей транспортних засобів, і при розрахунках податків і страхових платежів, і при пошуку найкращих схем доставки.

Мета роботи. Ураховуючи світовий досвід у дослідженнях з обраної тематики, метою цього дослідження є консолідація світового успішного досвіду в екологічній міській доставці та оцінка їхньої застосовності в Україні.

До технологій та методів, що дозволяють знизити негативний вплив автотранспорту на навколишнє середовище, належать:

Технологія позапікової доставки, що дозволяє поліпшити швидкісний режим автомобіля. За позапікової доставки мінімізується ймовірність дорожніх заторів, що робить швидкість переміщення максимально допустимою у місті (і, відповідно, максимально екологічною). Хоча нічна доставка в даний момент в Україні неможлива через комендантську годину, пізня і рання доставка все ще доступна, що дозволяє вдало обійти транспортні затори.

Використання консолідаційних центрів. Економічна ідея консолідації вантажних перевезень полягає у використанні ефекту масштабу - чим більша вантажопідйомність транспортного засобу, тим менші питомі витрати на перевезення одиниці продукції. Наразі будівництво консолідаційного центру оцінюється і з погляду впливу ланцюга постачання на довкілля. При цьому існування консолідаційного центру біля або в межах міста дозволяє організувати доставку транспортними засобами з нульовим або низьким рівнем забруднення навколишнього середовища.

Використання поштоматів. Поштомати зазвичай устанавлюються в місцях зосередження максимального потоку мешканців, що дозволяє створити додатковий комфорт користувачам завдяки можливості вибору найближчого до власного будинку чи місця роботи пункту. Цей спосіб виключає до двох третин шкідливих викидів у повітря. Кількість поштоматів та зона покриття ними збільшується рік у рік, що дозволяє говорити про успішність цієї технології. За підсумками 2022 року, в Україні продовжують працювати з поштоматами такі великі гравці експрес-доставки як "Нова Пошта", "Укрпошта" та "Meest".

Використання більш екологічних видів транспорту. Використання гібридних, електричних чи безмоторних засобів пересування знаходить дедалі більшого застосування у логістиці останньої милі. Екологічними засобами міської логістики можна вважати електромобіль, мопед, дво- чи триколісні велосипеди з великим багажником або кузовом для вантажів. Такі транспортні засоби мають практично нульові викиди шкідливих речовин, вони набагато маневреніші і не вимагають великого місця при розвантаженні, навантаженні та паркуванні.

Впровадження зон із низьким (нульовим) забрудненням повітря. Зони з нульовими чи низькими викидами вже давно використовуються у розвинених країнах. Загальноприйнятих технологій розрахунку території, яка потребує обмежень на переміщення транспорту, а також розрахунку вартості такого переміщення не існують. Зазвичай це залежить від волі місцевої влади, бажань мешканців та добробуту регіону.

Заборона використання автотранспорту. Деякі місцеві влади запроваджують повну заборону використання автотранспорту в межах певних частин міста. Зазвичай це історичні центри із щільною забудовою та великою кількістю туристів. Іноді такі кардинальні заходи поєднуються із технологією нічної доставки. Якщо це неможливо, єдиною альтернативою залишається доставка малогабаритними, зазвичай двох-трьохколісними транспортними засобами з нульовими викидами.

Удосконалення організації дорожнього руху. Грамотно спроектована організація дорожнього руху здатна знизити навантаження на довкілля. Застосування інтелектуальної транспортної системи у розумних містах дозволяє виконувати важливі завдання: виявлення транспортних пригод; автоматизоване керування рампою, світлофорами та паркуванням тощо.

Поліпшення дорожніх умов. Мається на увазі якість дорожнього покриття, розмітки, ступінь чистоти дорожнього полотна і т.ін. Поліпшення дорожніх умов опосередковано впливає і на поліпшення екологічної чистоти регіону.

Підбиваючи підсумки дослідження, виділено успішні світові практики в екологічній міській логістиці, які застосовуються та мають перспективи застосування в Україні. Зроблено висновок, що існує величезний потенціал використання світового досвіду в екологічній міській логістиці

України. Це дозволить вивести українську логістику та міські ланцюги постачання на новий рівень, підвищуючи рівень здоров'я та загальної задоволеності населення.

Ключові слова: логістика останньої милі, міська доставка, міська логістика, екологічна доставка, поштомати, зони з низьким вмістом викидів, екологічні транспортні засоби, доставка у позапіковий час, консолідація вантажів

Introduction. Currently, the issue of reducing environmental pollution is on the agenda of all countries. Developed countries, which have significant funds on their balance sheets to prevent or combat pollution, have long invested money in scientific research and real projects that allow them to cause less harm to the environment, thereby increasing the standard of living of their citizens.

Literature review. Since environmental issues are now occupying many scientists around the world, a lot of research is being carried out in the field of environmentally friendly urban delivery. We can highlight the works of such authors as Taniguchi E., R.G. Thompson, T. Yamada, F. Russo, A. Comi, L. Persia, M. Holotová Holienčinová, L. Nagyová, G. Ambrosino, A. Liberato, I. Pettinelli, E. Cascetta, R. Filippova, N. Buchou, Boichuk N., Kauf S., Margita N.O., O. Lobashov, O. Kunitska, S. Gritsenko and others.

However, in most cases, foreign authors pay attention to solutions for their countries or cities, and research by Ukrainian authors concerns the adaptation of existing or the development of new concepts and technologies only for individual solutions in urban logistics.

Purpose of the study. Taking into account global experience in research on the chosen topic, the purpose of this study is to consolidate global successful experience in environmentally friendly urban delivery and assess their applicability in Ukraine.

Main part. Among the areas that have huge negative impacts on the environment are logistics and supply chains. Since the Industrial Revolution, when economic profit was the only measure of business efficiency, a huge number of concepts and scientific movements have appeared that recognize the need to take into account the

environmental component in human activity [1]. As for transport, which is the largest polluting component in logistics, the situation is changing dramatically and quickly. If 50 years ago no one thought about calculating emissions from a vehicle, now this indicator is necessary [2, 3]. It is used when assessing the effectiveness of investment projects, developing new vehicle models, calculating taxes and insurance payments, and when searching for the best delivery schemes [4, 5, 6].

Technologies and methods that can reduce the negative impact of vehicles on the environment include:

- delivery during off-peak times (at night or on weekends);
- the use of consolidation centers at different levels (in the region, at the entrance to the city, in the city) [8];
- use of parcel delivery lockers;
- inclusion of more environmentally friendly types of transport (for example, electric transport, cycling) in last-mile delivery [9, 10];
- introduction of low (zero) emission zones in parts of the city [11];
- ban on the use of vehicles;
- improvement of traffic management;
- improvement of road conditions.

Below, the above-mentioned technologies are analyzed in more detail.

1. Off-peak delivery. Off-peak times in this case are usually considered to be either overnight delivery or delivery in the middle of the working day, which avoids morning and evening congestion in the city. The time used for this term may vary and basically depends on the business traditions of the region.

First, let's look at how off-peak delivery can have a positive impact on the environment relative to traditional delivery

during business hours. Under general equal conditions, delivery is considered more environmentally friendly if:

- fewer vehicles are used;
- the most environmentally friendly speed mode is used;
- more environmentally friendly vehicles are used.

Off-peak delivery technology makes it possible to improve the speed limit of the vehicle. This is achieved due to the fact that during delivery the probability of traffic congestion is minimized, which means that the speed of movement will be the highest possible in the city (the most environmentally beneficial). This should also include the number of accelerations, decelerations, stops and starts of the engine.

The denser the traffic flow, the slower the movement speed will be. At the same time, the driver has to constantly slow down and pick up speed, following the speed of traffic in a traffic jam. Such movement significantly increases fuel consumption and, accordingly, the amount of emissions.

In addition, congestion significantly increases the likelihood of an accident with minor damage to vehicles, which, however, block one or even several lanes, worsening the already difficult situation on the road [12].

Night delivery in Ukraine is currently not possible due to the strict time frame of the curfew. They are different in different cities, but actually make it impossible to use the night hours from 00:00 to 5 am. At the same time, late delivery and early delivery are still possible, which allows you to avoid traffic jams.

It should be added that night delivery is usually accompanied by increased noise levels, which negatively affects city residents at night. Using electric or two-wheels vehicles for last-mile logistics can significantly reduce noise pollution.

2. Use of consolidation centers

The idea of freight consolidation has been around for a long time. At that time, the main factor indicating its effectiveness was purely economic. It was based on economies

of scale - the greater the carrying capacity of the vehicle, the lower the costs for transporting a unit of product. Unfortunately, often the economic effect was impossible due to the significant costs of the consolidation center itself, its maintenance and additional personnel in the supply chain.

Now the construction of the consolidation center is also being assessed from an environmental point of view [13]. If, in the process of consolidating deliveries, it is possible to reduce the number of vehicles involved in transportation, then this will also have a positive effect on the environment in the transportation area [14]. At the same time, the existence of a consolidation center near or within the city makes it possible to organize delivery to residents by vehicles with zero or low levels of pollution - bicycles, mopeds, electric cars, etc. [15].

3. Use of parcel delivery lockers

A popular alternative to home delivery is parcel lockers, known by several other terms such as parcel kiosks, locker boxes, automated lockers, self-service delivery lockers, and intelligent lockers [16]. Lockers are usually installed in places of concentration of the maximum flow of residents, which allows to create additional comfort for users due to the possibility of choosing the locker closest to the home or work area. It was established that this method saves up to two thirds of emissions [17]. The "last mile" problem using post machines is discussed in [18], modeling the use of storage cells for vehicle routing, taking into account CO₂ emissions, customer time window, and congestion.

The number of parcel lockers and the area covered by them increases from year to year, which speaks of the success of the technology. The idea is that part of the road in urban delivery falls on the client himself. In contrast to home delivery, the product is delivered to the locker by means of a postal or logistics operator, from where the customer picks it up.

At the same time, two types of post technologies should be distinguished: Pick-

Up and Drop-Off location (PUDO) and Automated Parcel Machine (APM). PUDOS are drop-off points where parcels can be picked up (for example, a small 24-hour shop, a

parcel point or a depot/micro-depot). APM is a locker in its modern form. The statistics for 2022 differ significantly across European countries (Table 1).

Table 1 - Number of post offices and drop-off points in Europe in 2022

PUDO	APM
Germany 51090	Poland 28880
France 49200	Ukraine 14000
Italy 47740	UK 15460
UK 45340	Germany 13450
Poland 29520	France 8750
Ukraine - ?	Czech Republic 7480

Express parcels delivery overlap with other segments such as mail, pallet distribution, LTL, freight forwarding, same-day courier and contract logistics, so some of the lines are blurred. At the end of 2022, Nova Poshta (now Nova), Ukrposhta and Meest continued to operate [19].

4. Use more environmentally friendly types of transport

The use of electric or non-motorized vehicles is increasingly used in last mile logistics. Typically, such vehicles are compact and economical when transporting small amounts of cargo over short distances. These distances are usually calculated from the consolidation center to the store/company, from the distribution center to the client, from stores or food outlets to city residents, etc. The types of such environmentally friendly delivery vehicles are quite diverse. The most traditional types can be considered electric cars and mopeds. However, there are also more exotic means - two- or three-wheeled bicycles with a large trunk or body for cargo, as well as the use of animals (horses, donkeys, camels, etc.).

The benefits from an environmental point of view are undeniable. Such vehicles have virtually zero emissions of harmful substances. Among other things, they are much more maneuverable and do not require much space when unloading, loading and parking [20]. If we talk about two-wheeled vehicles, they can move between traffic lanes, which does not increase the congestion on

the traffic flow and does not reduce the speed of movement. Moreover, when movement is prohibited in certain areas of the city, delivery by two-wheels types of transport usually remains the only alternative to delivery on foot. This makes it a choice for delivery in the center of some cities.

5. Introduction of low (zero) emission zones. Zero- or low-emission zones have long been used in developed countries. However, the details of this technology may vary. From a complete ban on the movement of cars with a traditional fuel system to charging a fee when driving through the zone or moving within its boundaries. Moreover, both the ban and the fee may depend on the time of movement (for example, at night or off-peak time - cheaper or free of charge).

There are no generally accepted technologies for calculating the territory that requires restrictions on the movement of vehicles, as well as calculating the cost of such movement. This usually depends on the will of local authorities, the wishes of residents and the well-being of the region.

If it is necessary to move to an area with low (zero) emission, the postal operator must assess the cost (and general possibility) of delivery by automobile. If motor transport is not allowed in the zone, you should look for alternative delivery schemes (for example, those discussed in paragraphs 2-4). If moving by road carries additional costs (in the form of tax or fee), then the logistics operator must evaluate various alternatives, for example,

road transport and delivery by tricycle, or through a distribution or consolidation center. Thus, the environmental component of transportation has already been directly transformed into an economic one, which usually facilitates the assessment of options.

Unfortunately, looking at the congestion rates in Kyiv since 2018, we can clearly see that

the situation is getting worse every year. If in 2018 Kyiv was in 13th place in the world in terms of traffic congestion, then by 2021 the situation has worsened to a critical third place. At the same time, the time in congestion increased from 42% in 2018 to 56% in 2021 (Fig. 1).

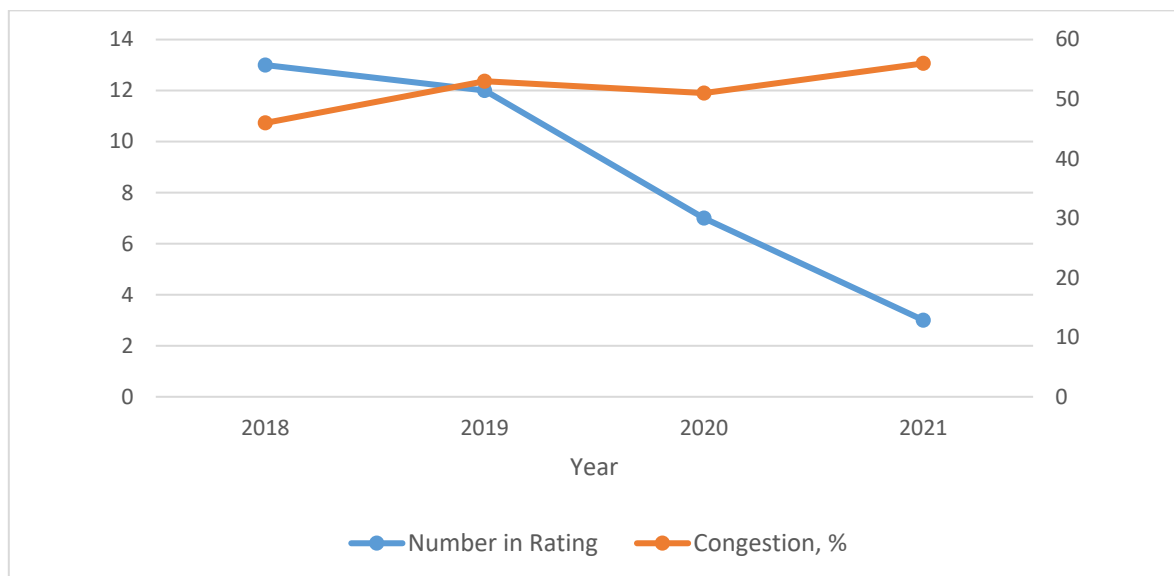


Figure 1 - Congestion indicators of Kyiv 2018-2021 [1]

Perhaps the congestion of traffic flows has decreased somewhat due to the war, however, sooner or later the war will end and the situation will return to its pre-war state, if it does not get worse.

Despite that, introducing the cost of entry to the central part of the city of Kyiv or other big Ukrainian cities is not currently on the agenda. The war, which is in its third year, does not allow investing in expensive long-term projects, even if they bring money at the stage of their implementation. The establishment of a fee for entering the zone involves the installation of a significant number of cameras, an information system capable of recognizing license plates, taking photos and videos, tracking violators, issuing invoices, etc. Given that the majority of budget funds currently go to the support of the Ukrainian Armed Forces, there will obviously not be any activities regarding the

introduction of paid entry zones in the near future.

6. Prohibition on the use of motor vehicles

Some authorities have introduced a complete ban on the use of motor vehicles within certain parts of the city. Usually these are historical centers with dense buildings and a large number of tourists. Wanting to maintain the attractiveness of the area, the authorities are completely converting these zones into pedestrian zones. Exceptions are usually granted to police and emergency vehicles. As an alternative to motor transport, bicycle transport can be left, and sometimes even horse-drawn transport with strollers for tourists. Business restrictions associated with the ban are compensated by increasing the profitability of the tourism and entertainment business, while simultaneously improving the environmental situation in the city.

Sometimes such drastic measures are combined with night delivery technology, when the area is free of visitors. If this is not possible, the only alternative is delivery by small, usually two- or three-wheeled, zero-emission vehicles. For natural reasons, the technology of a complete ban on vehicle traffic is the most environmentally friendly, however, and the most challenging for business in this location.

Pedestrian zones are distinguished by a huge variety of attitudes and rules regarding vehicles using energy generated by human efforts: bicycles, roller skates, skateboards, scooters, etc. Main advantages:

- low amount of emissions into the atmosphere;
- low percentage of road accidents;
- better environmental conditions;
- encouraging people to an active lifestyle.

There are several pedestrian streets in Kyiv: Petro Sahaidachny Street (260 m), Andriyivsky Uzviz (650 m), Heroes of the Heavenly Hundred Alley (195 m), Bessarabsky Projyzd (130 m). Khreshchatyk Street (600 m) becomes a pedestrian street on weekends and holidays.

7. Improving traffic management

A well-designed traffic management can not only make life easier for the driver, but also reduce the burden on the environment. It is known that when accelerating and moving away, vehicle emissions are at their maximum. Stopping at traffic lights, allowing pedestrians to pass, frequent turns with a small radius - all this can significantly increase the pollution of both air, soil and groundwater in this region. Therefore, properly designed multi-level interchanges, underground passages, and

tunnels can increase the speed for passing through a location, and also reduce the negative impact on the environment.

The use of an intelligent transport system in smart cities makes it possible to perform important tasks, which also lead to a reduction in environmental pollution:

1. Detection of traffic accidents.
2. Automated ramp control system.
3. Traffic light control.
4. Effective parking management tools.

The differentiated cost of parking encourages vehicle owners to travel through the central districts of Kyiv by transit, and if necessary, to park in more distant places (usually, near metro stations, etc.).

8. Improvement of road conditions

Under road conditions in this case, we mean the quality of the road surface, markings, cleanliness of the road surface, etc. If there are pits and potholes, the driver is forced to slow down and then pick up speed, which, as already mentioned, is associated with additional emissions of harmful substances into the atmosphere. In the case of poor-quality markings, a muddy or slippery road surface, the driver is forced to switch to a lower speed mode, which usually leads to large emissions as well.

As can be seen, the improvement of road conditions in this case indirectly affects the improvement of ecological cleanliness of the region.

Conclusions. Summing up the results of the study, it is necessary to highlight successful international practices in environmentally friendly urban logistics that are applied and have prospects for application in Ukraine (Table 1).

Table 1 - Modern successful solutions in environmentally friendly urban delivery and their applicability in Ukraine

Global solutions in sustainable urban delivery	Current situation in cities of Ukraine	Prospects, recommendations for Ukrainian cities
Off-peak delivery	Limited use due to night curfew	Possible development after the war in combination with low-noise technologies and means of transportation

Consolidation centers	Poorly developed. Mostly distribution centers or logistics centers are used. However, there is no emphasis on cargo consolidation.	The authors consider it effective to build a network of consolidation centers (or use existing facilities) near large regional or industrial centers. For megacities - assessment of a micro-consolidation project within the city
Parcel lockers	Developed to a significant level. The Nova Poshta company brought Ukraine to 2nd place in terms of the number of parcel lockers in Europe.	Considering the good response from the citizens to the use of parcel lockers and their proven economic efficiency, it is recommended to stimulate the express delivery market to expand the parcel lockers network
Inclusion of environmentally friendly modes of transport in delivery	Poorly developed, mainly due to unfavorable weather conditions in winter. There is also a lack of interest from local authorities and motivation for business.	It is recommended to initiate a national program that clearly and significantly motivates businesses to switch to environmentally friendly types of transport within the city.
Low (zero) emission zones	Not used	It is recommended to conduct a feasibility assessment in the historical centers of large cities and with a clear economic justification for the amount of fees charged
Prohibition on the use of motor vehicles	Used in almost all regional cities and other tourist locations	A balanced approach is recommended, allowing not just a ban on cars, but a new concept for the functioning and development of the territory
Improving traffic management	Projects to improve traffic management are periodically created and implemented.	It is worth accelerating the processes of borrowing successful world practices in traffic management to reduce environmental pollution in places where cars accumulate
Improved road conditions	Overall, it is at an unsatisfactory level	Road conditions should be given constant and close attention, since the accident rate, the speed of delivery, and the amount of harmful emissions depend on them

As we can see, there is huge potential in using global experience in environmentally friendly urban logistics. Of course, the prevailing challenge that does not allow us to begin its implementation in Ukraine is war. However, even in the pre-war period, little attention was paid to environmental problems, including urban ones, in comparison with developed countries.

We would like the good will of Ukrainian politicians and big business to turn towards perceiving our world not from a purely economic, but also from a social and environmental perspective. This will take Ukrainian logistics and urban supply chains to a new level, increasing the level of health and overall satisfaction of the population. The Ukrainian scientific community is ready to contribute to this task.

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