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TRANSPORT ECONOMICS AND SUSTAINABLE DEVELOPMENT IN UKRAINE

Abstract. *The contemporary development of transport systems is characterized by an ecological, technical, social and economic contradictions. An acceptable global solution can be obtained by matching relevant criteria. This paper provides a synthesis of economic and organizational peculiarities on sustainable development to transport internationally, it reviews recent trends in this respect and applies international trends to Ukraine. Authors concluded that environmental pollution effects connected with transport system's development providing additional costs in different spheres of society that gives the opportunity to assert on necessity of integration the research outcomes on green mobility in applied activity. This article summarizes the implemented transport project examples and analyzed their role in realizing sustainable development principles. The authors proved that all creating programs and projects in transport should be based on such interconnected principles: transport planning and localization of production and consumption; transition to more environmentally efficient transport; improving the technology and fuel. In addition it was suggested to include the transport greening principles in criteria's of economic efficiency in transport. The strategies to reorient the Ukrainian transport industry towards resource-saving approaches are formulated. Substantiated that applying energy-efficient approaches in transport will result in socio-ecological and economic benefits, including ecological, social, public health, transport and urban components. The authors analyzed advantages and disadvantages of different kind of modern transport vehicles in the context of sustainable development principles realization that allows understanding which economic sectors and entrepreneurs should be involved in the process of transport greening creating the basis for public, private and foreign investment attraction.*

Keywords: transport system, sustainable development, transport greening promotion, effectiveness, benefits.

Introduction. The World Health Organization (World, 2013) in 2013 identified transport as the main impact on the urban environment both in developed and in developing countries. The incidence of broncho-pulmonary diseases is 40-60% higher in highly polluted urban areas. Cars consume about a third of the world's oil which makes them the single most important consumer of oil.

In Ukraine, air pollution from stationary sources decreased significantly during recent years while the emission from transport) vehicles increase. In part, «green» transport is a reply to this situation. Contemporary society is aware of the need to intensify these efforts. The international trends affect Ukraine in one way or another. Technology will reduce environmental risks, while increasing energy and economic security, and human capital as a whole. Particular attention should be given to the transition towards environmentally advanced technologies. This paper reviews recent trends in this respect and applies international trends to Ukraine.

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Literature review. The theory of green transport system developed by foreign and domestic scientists. So, the Dalkhmann (Dalkhmann, 2011) investigates the main features of the transport greening, the approaches of funding in resource *efficiency* in transport sector.

Sakamoto and Palmer (Sakamoto, 2010) emphasize that the speedy development of urbanization and, as a result, well provided transport activity will generate social, environmental and economic externalities. They investigated that if modern trends in environment pollution continue, CO2 emissions are increased more than 50% by 2030.

Beevers and Carslaw (Beevers, 2005) are considered that the specific environment friendly schemes in transport could assist in attaining both the economic and environment targets in cities.

Ukrainian contributions interpreting «green» transport in a local context were provided by, among others, Melnyk (Melnyk, 2013, 2017), Vovk (Vovk, 2000), Burkynskyi (Burkynskyi, 1999) and Hranovska (Hranovska, 2007). They propose to use different economic, organizational instruments to boost greening processes in all spheres of economy and human activity.

Despite these contributions the economic and environmental aspects of «green» transport technologies need further research both in their conceptual and technical dimensions. Also issues of scale should be addressed E.g. the integration of the local sustainable transport in the national priorities, a subject which until know attracted insufficient attention.

Problem formulation. The scientific background of transport technology progresses very fast (European Environmental Agency, 2015). Transport in the EU accounts for 25% of the greenhouse gas emissions (71% – road transport, 13% – aviation, 13% – sea transport, 1.8% – internal navigation, and only 0.7% – railways). Fuel accounted for about 96% of the energy consumption. Business spends each year 210 billion euros to import 84% of crude oil. Transport significantly affects noise and air pollution. Of all cars in the world (750 million), one third is concentrated in EU. This worldwide figure is expected to triple to 2.2 billion by 2050 mainly due to the increasing number of cars in China, India and Brazil. Cars account for 72% of the passenger-kilometers. However, 60-85% of the rides in the UK are made by only one passenger and 50% of the car trips cover a distance of less than 5 km, which can be covered by bicycle (European Environmental Agency, 2015).

These trends translate directly in costs for the environment, society and economy: energy consumption and greenhouse gas emissions; congestion (and associated loss in productivity of urban areas); resource depletion and land use; degradation of human health (Kubatko 2017; 2019); impaired in human safety (traffic accidents); reduced accessibility of communities; and loss of biodiversity, just mentioning these aspects.

Research results on green mobility should be integrated and the scientific experience on specific areas of national transport should adopt the principles of «green» economy.

The aim of the paper is to analyze and systematize the economic characteristics of foreign experiences on «green» transport with estimating the probably opportunities of the domestic transport sector in the context of sustainable development in Ukraine.

Methodology and Research Methods. Transport is one of the most important components of the economy of any country. However, it functions with significant energy consumption and negative environmental impacts. Passenger transport, its capacity and speed should be limited, while preserving the social access to mobility. This may reduce the fuel consumption and environmental pollution (Bongardt, 2012; Lyulyov, 2015; Sineviciene, 2017; 2018). Currently, the average vehicle speed shows an optimum at about 80 km/h. At this speed, fuel consumption is most efficient while the emissions are minimal.

Developing transport systems entails environmental and economic contradictions. According to the general economic efficiency theory from a socio-economic point of view – the maximum capacity of transport systems P_f (performance) and a high level of social needs P_p for vehicles shows a marked

contradiction especially in large cities. From another point of view the methodology of transport economic damage assessment shows that social and ecological institutions assist in limiting air pollution reduction. This contradiction can be presented by meeting the criteria:

$$P_f = \frac{F}{t} \rightarrow \max, \quad (1)$$

$$P_p = \frac{N}{t} \rightarrow \max, \quad (2)$$

$$E_c = \frac{V_t}{P} \rightarrow \min, \quad (3)$$

In which P_f is the productivity of freight transport, tkm/year; F = V • S is the freightage, tkm; V is the total volume of freight per year, tons; S – the average route length of freight per year, km; t – the time for the freight transportation to be carried, year; P_p is the productivity of passenger transport, persons/year; N – Number of transported passengers, people; E_c – ecological capacity (of freight or passenger transport), t/tkm or t/person; V_t – volume of transport emissions, t/year; P – is the productivity of freight or passenger transportation, tkm/year or persons/year.

The freight transport capacity (1), (2) can be represented as an inverted form (t/F) or (t/N). From an economic point of view, the transport time is important. This parameter affects both the turnover of the goods, and their quality, especially for food. In Ukraine a high average value of this parameter is the result of the limited transport infrastructure.

According to formulas (1-3) and on the basis of statistics (Derzhavna, 2019) we will present the dynamics of the indicators of the productivity of freight transport, the productivity of passenger transport and ecological capacity in table 1.

Table 1. Dynamics of transport performance indicators, Ukraine, 2007-2018

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
The productivity of freight transport, million tkm/year	496400,0	491746,0	380003,5	404572,9	426427,7	394648,1	379045,0	335151,7	315341,8	323473,9	343057,1	331856,2
The productivity of passenger transport, million persons km/year	144400,0	147265,2	130106,8	129815,3	134254	132479,7	128508,2	106147,8	97280,7	102239,4	99277,7	104446,0
Emissions of pollutants and carbon dioxide into the atmosphere, million t/year	2,6	2,7	2,5	2,5	2,5	2,5	2,4	2,0	1,7	n/d	n/d	n/d

Sources: developed by the authors.

Given the dramatic change in population in Ukraine in 2014 due to the occupation of Crimea and the Donbass, in Figures 1 and 2 we give the dynamics of specific values of transport productivity (per 1 person).

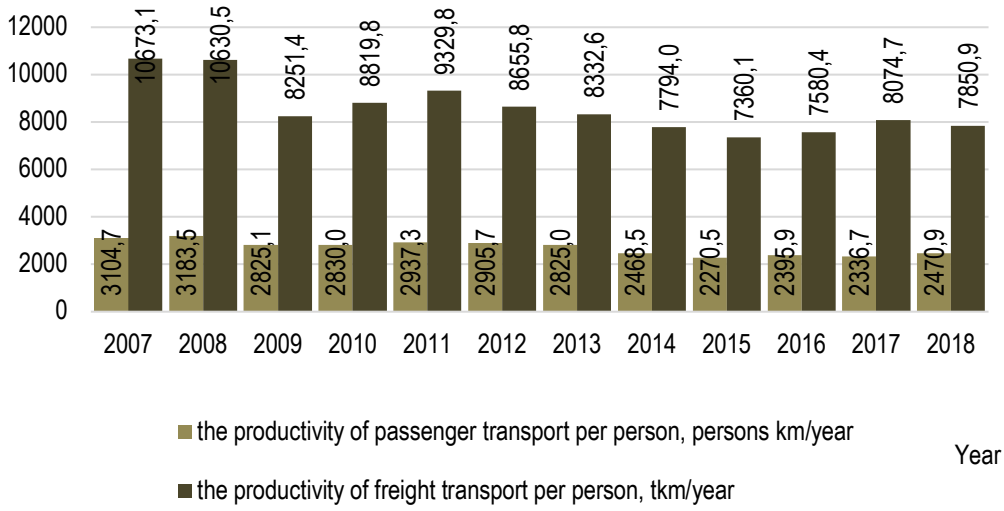

Figure 1. Dynamics of the productivity of freight transport and the productivity of passenger transport per person, Ukraine, 2007-2018

Sources: developed by the authors.

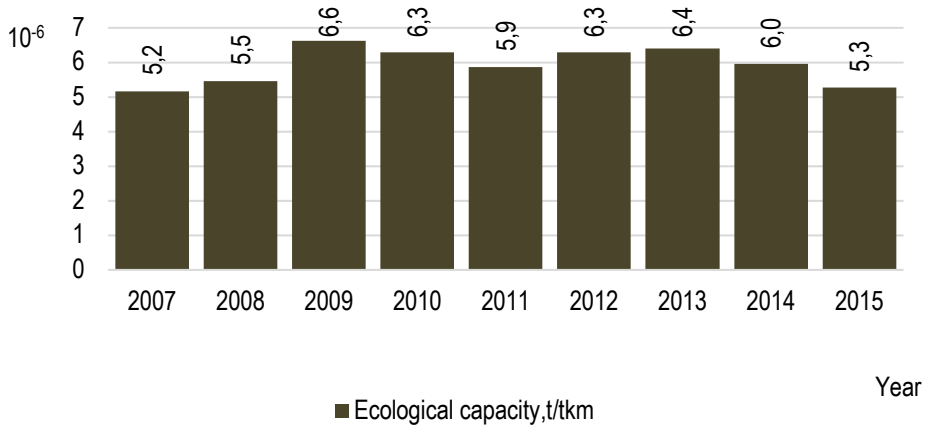

Figure 2. Dynamics of ecological capacity, Ukraine, 2007-2015

Sources: developed by the authors.

From Figures 1 and 2 until 2013, the inverse relationship between the productivity of freight transport and Ecological capacity was traced: the higher the productivity of freight transport, the lower the Ecological capacity and vice versa. Since 2014, the environmental burden has begun to decline along with productivity of freight transport. Obviously, there is an optimum at which conditions (1-3) will be respected, the finding of which our further works will be devoted.

Results. A critical issue in developing countries is combining green transport with economic growth. A series of examples exist showing the implementation of sustainable development of transport systems for countries with a range of economic development levels (table 2).

Table 2. Transport project examples and their role in realizing sustainable development principles

Example	Project aim	Economic and organizational tools that were used	Result
Rapid Bus Transit (South Africa)	Develop smart public transport system which assists the city in planning and designing a new Bus Rapid Transit	– Consulting and contracting buses and stations – Providing a clean development mechanism, financial support – Implementation of the informal taxi industry on a new public transport system	New transport system implemented in Johannesburg Providing green jobs, infrastructure construction, on bus drivers and on station personnel. Reduction of congestion and air pollution
Ports in the ASEAN region	Improving quality and efficiency of the safety, health and environmental management systems	– Assisting in developing, implementing and improving management systems and operational programs – Providing staff training – Establishing port-related emission inventories – Ship-generated waste management	Emission Reduction, improve the overall performance of the port and the local economy
Sustainable Urban Transport, (Indonesia)	Implementing measures for comprehensive mobility in cities, public transport network	– Consulting on policies, regulations and strategies for institutions and cities. – Funding on transformation costs – Designing and planning processes for prototype projects	Decreasing traffic jams, reduce air pollution and GHG emissions, establishing the green jobs
Clean Air for Smaller Cities in the ASEAN region	Implementing in small and medium-sized cities measures for improving the air quality with the participation of the civil society and the private sector	– Developing and implementing Clean Air Plans – Elaboration of Roadmaps with the required steps for each city – Providing the modular training system on air quality – Supporting the national workshops and international conferences to increase awareness on clean air issues	Business opportunities and jobs in the cleaner production sector. Promotion of public transport and the reduction of private motorized transport. Positive effects in the health care system

Sources: adapted from (Dalkhmann, 2011).

The policy of transport «greening» is based on three interrelated principles: 1) elimination or reduction of unnecessary trips by combining the land use and transport planning and localization of production and consumption; 2) transition to more environmentally efficient transport (public and non-automobile transport and for passengers and shipping – for cargoes); and 3) improving the technology and the fuel to reduce their environmental impact and social costs (Towards, 2011). These principles meet the before-mentioned criteria (1) and (2). They necessitate however details on transport «greening» in the context of the Ukrainian economy.

1) Combining land use and transport planning involves redeveloping land plots compacting main transport corridors towards and around the cities. In a first move, the transport roads should be relieved by administrative action. For example, incentives for employers to stimulate their workers to use public transport. London developed a «traffic jams tax» which charges driving in the city center. As a result, the

number of car trips decreased by 70 000 a day (Congrestion, 2004) and the CO_2 emissions by 20% (Beevers, 2004). In China, Beijing showed interest in the London experience.

2) More optimal location of production and consumption can be achieved by clustering interrelated producers and consumers. This synergism is the basis for sustainable mobility development.

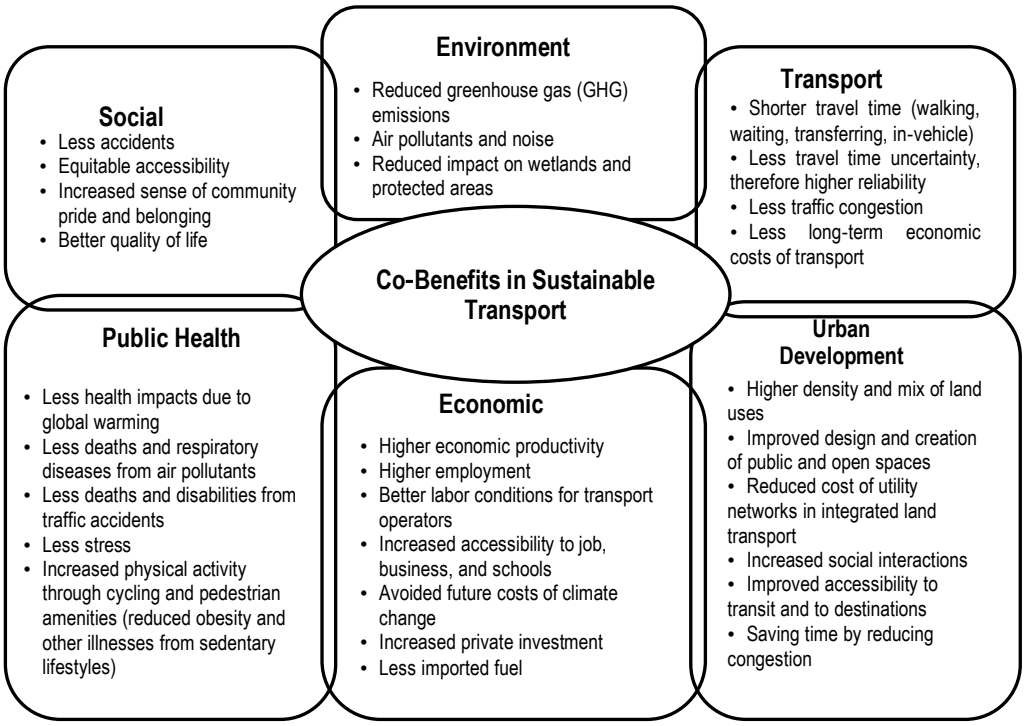

Figure 3. Co-Benefits from Sustainable Transport Projects

Sources: adapted from (Sakamoto, 2016).

3) The transition from private to public, non-automobile transport also allows increasing the environmental and social efficiency of the transport costs.

In Ukraine transport is a major polluter (emissions in the atmosphere during recent years totalized about 2.3 million ton annually or nearly 35% of the total air pollution emissions (State, 2017). Moreover, in cities and industrial centres, vehicles account for over 80% of the total emissions. This causes significant environmental and social problem (Analytical, 2015). Vehicles contribute most to air pollution. Still, the number of vehicles in Ukraine increases every year, despite the economic crisis and the population decline. This results in problems for settlements overloads the road network and raises sanitary, health, human capital and technical issues.

The transition from individual vehicles to trams, trolleys, buses, trains, bicycles etc. is voluntary. This will contribute to reducing local air pollution, saving travel cost, increasing safety, and reducing traffic jams.

Today some cities in the USA and Europe fine a driver for travelling alone in a vehicle with four or more seats. Motorists are driven in this wayfinding (a) passenger(s) or (b) to shift to fuel-efficient cars, for one or two passengers.

Individual vehicles. Today bicycles, electric bicycles, electric motorbikes, scooters, segways, and skates are popular. In the EU an extended network of safe alternative bicycle paths is under development. This will contribute to easing traffic and shows advantages in comparison with the traditional transport models. In Ukraine these safety conditions should be implemented as an incentive to motivate people optioning for car alternatives. They include bicycle paths, bicycle parking lots and bicycle rent; their development and construction require considerable investments.

Unmanned transport. Google already practices for some years futuristic self-driving cars. The French robot company «Induct» announced that its intelligent, electric «without-a-driver» vehicle is available in the USA. At the International Consumer Electronics Show – CES 2014, in Las Vegas, the first commercial self-driving car which is designed to carry eight passengers was presented. «Navia» is designed in a context of safe and environmentally friendly transport. «Navia» should rather be used in public places such as airports, major industrial sites, parks, university campuses or hospital complexes. It proceeds at 20 km / h using onboard lasers and sensors for its navigation. The electro car also uses different «angles of vision» for its cameras to provide a depth view and 3D perception. «Navia» costs about 250,000 $, which is 40% less than a similar shuttle with a driver. The electro car is charged without special assistance at the dock station and does not require special infrastructure, like rails. The vehicle can be used as a bus with stops and a defined schedule. It can also be called for, for example, from a terminal with a mobile device (Experiments, 2015).

Improving technology and fuel. The development of eco-innovations in car transport affects the market in a significant way. Two prominent areas of alternative automobile technologies include electro cars and hydrogen-fuelled vehicles.

Electro cars. The efficiency factor of the electric engine is 70-95%, while the modern combustion engine reaches only 50% at most. Therefore, the electro car allows converting almost all the energy of its batteries into effective ”miles” (What, 2015). This transport is developed most intensively and appeals to the Ukrainian reality. Experts foresee, by the end of 2019, more than 600,000 electric vehicles in Europe. Together with Norway (which is not a part of the EU), Europe is the second-largest market for electric vehicles in the world only preceded by China (Electric, 2014). The main competition here is less between the car manufacturers but among the battery producers. Modern lithium-ion batteries are heavy and quite expensive. The main competitors today are LG Chem, Panasonic, Tesla American Company and the Chinese BYD company. Ukraine could also enter this relatively young market, taking into consideration its high capacity in chemical technology and its considerable number of professionals in the sector. Today, electro cars with powerful batteries have an action radius of over 500 km for a single charge.

To popularize alternative fuel vehicles, governments use fiscal incentives and direct subsidies (Investing, 2015).

Hydrogen-fueled cars. Variations exist on the engine of electro cars and vehicles. Hydrogen can be used in combination with a fuel cell that promotes the chemical reaction between hydrogen and oxygen which generates the energy, driving the car. The «secondary» product of this process is water next to NOx. Ultramodern carbon fibre hydrogen tanks are filled up is about ten minutes. There are however serious obstacles to introducing this alternative for petrol engines:

1. Currently, hydrogen-fuelled cars are more expensive than traditional ones. Toyota Mirai is sold for 50,000 Euro; a car with a gasoline engine of the same class costs about 30,000 dollars.

2. Currently, there is no appropriate infrastructure for the fuel network in Ukraine. Generalized introduction of this fuel necessitates a sufficient number of service stations. Moreover, producing one cubic meter of hydrogen consumes four times more electricity than the combustion of the same volume

of gas generates. Also the storage of hydrogen offers problems. Hydrogen penetrates any material and should be stored as a liquid. This results in additional costs that should be added to those of the generation stage. Gas leaks might cause explosions.

3. Filling up the tank of a Toyota Mirai costs about 100$ for 482 km, which is near twice as expensive as to fill the gasoline engine car of the same class. Today, electro cars in Ukraine are 30-35% more expensive than petrol cars, though they have strong advantages. For the time being, in Ukraine, electro cars are charged for free at the electric charging stations. On average, to cover 200 kilometres, the vehicle can even be charged at home at a cost of 15 UAH (1UAN ≈ 0,04 $), while the cost of gasoline for the same distance is approximately about 300 UAH.

The main advantage of electro cars is the opportunity to be charged at the household electric network (table 2). Although it takes rather a long time (6-8 hours for modern batteries to be charged). Industrialized countries develop fast-charging networks producing direct current serving cars like CHAdeMO and Tesla. No such stations exist in Ukraine fuels far. Charging a battery according to the latest standards takes 15-30 minutes. The most popular electric filling levels in the USA are Mode 2 and Mode 3 (table 3).

Table 3. The most common types of electro car charging

Indicator	Charging mode			
	Mode 1	Mode 2	Mode 3	Mode 4
Type of current	Commuted	Commuted	Commuted overvoltage	Direct
Voltage, (V)	110–120	220–230	240	unknown
Amperage, (A)	15	16	16	unknown
Power, kW·hour	1,6	3,3–6,6	7,2–43	50–135
Charging time*	About a day	6–8 hours	0,5–4 hours	20–30 min.
Charging cost	3 $/100 km	0,5-0,8 $/100 km	free	According to the car brand
Availability in Ukraine	No (household network in the USA)	household network	State electric charging stations	no
Representatives	–	–	Ukrainian company E-Line and others	CHAdeMO, CCS, Tesla Supercharger

*given for the electro car with the battery of 20–25 kW·hour.

Sources: developed by the authors.

Fuel quality. One way of transport greening is to improve the environmental performance of the fuel. In Europe legal norms of ecological fuel safety «Euro-x» have been established since 1988. In Ukraine, there were no mandatory requirements for «Euro» emission standards for a long time. Only since 2006, the cars below «Euro-2» standard is not registered anymore, although Europe developed while meaning its index «4» and «G» standards (Forced, 2008). Since 2013 a mandatory compliance scheme «Euro-3» for new cars, has been introduced in Ukraine for the standard not lower than «Euro 3», in 2014 – «Euro-4». In 2016 this shifted to «Euro 5». In Europe the currently valid standard which applies is «Euro 6».

Multimodal transport. Recently, transport technologies that combine several modes of transport became widespread. These technologies include among others piggy-back freighting, intermodal, multimodal and bimodal transport services. Inter- and multimodal transport is characterized by the presence of an operator that provides transport from the starting point to the point of destination; a single transport rate; one bill shared responsibility for the goods and the transport agreement performance.

From an environmental point of view, multimodal transport differentiates between the load on the various means of transport and thus reduces emissions of motor vehicles – the largest polluters of all types of transport.

In view of these developments, hydrocarbon energy has little time left. Countries producing oil and gas often used these resources as economic weapons. The «greening» of transport is an effective countermeasure in his respect (Lyulyov, 2018). Taking into consideration the household electric network in Ukraine and the available electricity the electrification of transport has most potential. By November 2016 Ukraine registered 1,630 electro cars of which 1,062 electro cars were registered for the first time; Ukrainians bought 65% of new electro cars and 35% of second-hand ones (Ukraine, 2016). In 2018 the electro cars represented 0.7% of the Ukrainian market of new cars. Compared with the EU countries this is a significant indicator as the share of purchased electro cars in Ukraine is comparable with Norway, Switzerland, Austria, France, the Netherlands and Sweden. In the first half of 2016, the share of new electro cars in the EU was 0.4%, which is less than in Ukraine (Association, 2019).

Many revenue-generating opportunities for the private sector support or complement sustainable transportation systems and operations: public-private partnerships, concession contracts between a public agency and private entity, or a for-profit business providing a service or product directly to users (Chygryn, 2016; Lyulyov, 2018). Table 4 lists such businesses in the context of the «Avoid-Shift and Improve» strategy for sustainable transport. Avoid – means to avoid unnecessary movements or trips. Shift – to more sustainable and shared modes. Improve – improve the environmental performance of transport modes (includes technological improvements to reduce GHG emissions and air pollution).

Table 4. Green transport businesses in the avoid, shift and improve groups

Avoid – Shift – Improve	Sustainable business	Proposition	Examples and references
1	2	3	4
Avoid	Telecommunication technology and services	Alternatives to physical travel	Teleconferences and tv-work by major companies in, among others, Europe and the US (Report, 2018)
Avoid and Shift	Parking providers	Formal parking space and avoids informal parking	Private parking operators in Tokyo (Parking, 2015)
	Shared vehicle systems	Encouraging less car using	Car sharing integrated with rail and public transport in Switzerland. Bicycle sharing such as JCDecaux/Cyclocity, Paris, Clear Channel/ Smart Bike, Barcelona (Midgley, 2011)
Shift	Public transport operations	Increasing the quality of service, making transit systems more attractive	Bus Rapid Transit systems in Bogotá, Pereira, Curitiba, Ahmedabad, Guayaquil, Mexico, Leon, Guadalajara, Guatemala. Bus systems in Santiago, Sao Paulo (and most Brazilian cities) Metro rail systems in Singapore (Midgley, 2007)

Continued Table 4.

1	2	3	4
	Taxis and transit operations	Providing door-to-door alternative to private cars (depends on fuel type and operational efficiency)	Auto-rickshaws in India, Pakistan (Pettinga, 2009)
	Non-motorized transport services	Implementation land use patterns that support shorter journeys	Bicycle rickshaws in India, New York City, San Francisco. Bike stations in Germany. Bike rentals in Amsterdam and other European main cities. Walking tours in Boston (Pettinga, 2009)
	Intelligent Transportation Systems	Optimizing transportation system performance	Technology providers in Santiago, Guayaquil
	Commercial enterprises in public spaces, advertising and street furniture	Improves the user experience of transit/non-motorized transport	Barcelona, Buenos Aires, Guayaquil
Improve	Low carbon vehicles	Improving energy efficiency	Small, light-weight vehicles, ultra-low emission engines, hybrid vehicles, plug-in hybrids linked with sustainable generation of electricity (Khan, 2009)
	Alternative fuels	Reduction CO_2 per unit of energy	Second-generation biofuels, conforming international sustainability criteria (Khan, 2009)
	Vehicle Maintenance	smart vehicle maintenance can reduce emissions and GHG	Annual vehicle checks in e.g. Indonesia (Khan, 2009)

Sources: developed by the authors.

Thus, the Avoid-Shift-Improve system could be the overarching, integral approach in the mechanism of transport greening. Table 4 shows different sustainable business activities with their effect on the environment and examples of their implementation. The information allows understanding which economic sectors and entrepreneurs should be involved in the process of transport greening.

Investments in green transport will only reach their full potential following changes in the current financing framework. These should be introduced on par with market conditions to enhance the economic feasibility of green transport. More specifically this includes transport as a major attraction for public and private investment. This is characterized by (Ang, 2013):

1. Considerable public funding of the transport infrastructure.
2. Investments by international programs and the national government in road infrastructure (particularly inter-city highways).
3. High quality of private and informal transport services.
4. Enhanced recognition of, and funding for green transport.
5. Adequate funding for a wide array of green transport aspects (e.g. technology, capacity building, operation, infrastructure etc.) so that all extra costs associated with green transport can be compensated;
6. Resources should be shifted from supporting non-sustainable transport to green mobility, and additional resources should be mobilized and scaled up.

7. Public funding at all levels (international and climate-related funds, national and local) to support green transport.

8. Private finance is mobilized, through the appropriate design of markets and establishing consistent, long-term incentives for green transport and through the application of public-private sector models to invest in and operate green transport systems (such as Bus Rapid Transit systems).

9. Financing flows from different sources are designed to complement each other, rather than acting on different goals.

Conclusions and prospects for further research. Analyzed approaches for transport greening most indicated that the upgrade the transport fund in Ukraine could be possible with the activation of electric vehicles using. The development of the electro cars market will open compelling economic, ecological and social advantages for the country. In addition, production of modern electro vehicles, electro buses and charging equipment will provide Ukraine an estimated GDP growth of 2-3% within twenty years. «Green» transport in Ukraine should be cost-effective. So, the main goals of transport greening should include: energy efficiency; decreasing of air pollution and greenhouse gasses; extending of the renewables using; waste minimization; efficient land using and less soil pollution; decreasing a noise; providing passenger and pedestrian safety. Transport greening programs will allow Ukraine to reduce greenhouse gas emissions substantially and to obtain additional funds under the Paris Climate agreement, which in exchange will increase the competitiveness of human capital.

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Економіка транспорту і сталий розвиток на Україні

Сучасний розвиток транспортних систем характеризується екологічними, технічними, соціальними та економічними суперечностями. Метою статті є аналіз та систематизація економічних аспектів зарубіжного досвіду екологізації транспорту з оцінкою перспективних шляхів його імплементації у вітчизняну практику. В статті представлено синтез економічних та організаційних передумов «озеленення» транспорту, що дозволить визначити шляхи та можливості його трансформації в контексті реалізації принципів сталого розвитку. Автори доводять, що наслідки забруднення навколишнього середовища, пов'язані з розвитком транспортної системи, забезпечують додаткові витрати в різних сферах суспільства, що дає можливість стверджувати про необхідність інтеграції результатів досліджень зеленої мобільності у прикладній діяльності. В статті узагальнено приклади реалізованих транспортних проектів та проаналізовано їх роль у просуванні сталого розвитку. Автори доводять, що всі програми та проекти на транспорті повинні базуватися на таких взаємопов'язаних принципах: планування транспорту та локалізація виробництва та споживання; переходу до екологічно ефективного транспорту; вдосконалення технології та палива. Крім того, пропонується враховувати принципи екологічного транспортування в критерії економічної ефективності на транспорті. Сформульовані стратегії переорієнтації транспортної галузі України на ресурсозберігаючі підходи. Обґрунтовано, що застосування енергоефективних підходів у транспорті призведе до соціально-екологічних та економічних вигід, включаючи екологічну, соціальну, охорону здоров'я, транспортний та міський компоненти. Автори проаналізували переваги та недоліки сучасних транспортних засобів у контексті реалізації принципів сталого розвитку, що дозволяє зрозуміти, які економічні сектори та підприємці мають бути залучені до процесу екологізації транспорту, створюючи основу для залучення державних та приватних інвестицій.

Ключові слова: транспортна система, сталий розвиток, сприяння екологізації зеленого транспорту, ефективність, переваги.

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