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ILCHENKO S.V.
Dr. Sc. (Economics),
Professor
Institute Of Market Problems And Economic&Ecological Research of the
National Academy Of Sciences Of Ukraine
Frantsuzskiy Boulevard, 29, Odessa, Ukraine
E-mail: ilchenko.svit@gmail.com
ORCID: 0000-0001-6924-2225

THEORETICAL PREREQUISITE OF "GREEN" ECONOMICS INNOVATION PARADIGM FORMATION IN THE SYSTEM OF URBAN TRANSPORT SUSTAINABLE DEVELOPMENT

Topicality. *The lack of understanding of the relationship between the state of the environment and the degree of degradation of urban agglomerations leads to an increase in socially necessary costs for the protection, use and restoration of the natural environment and compensation costs in support and quality of the environment, gradual decrease in the quality and quantity of natural assets, the aggravation of developmental problems cities as ecosystems of human life. At the same time, the growth of the economy leads to an increase in environmental pollution. This fact is confirmed by statistical data. Therefore, choosing a sustainable path of development, it is necessary to focus on mechanisms that will contribute to transforming the structure of the economy in such a way that its further development does not endanger the environment and does not diminish the quality of life of the citizens of this country. In this sense, it is advisable to form a new innovation paradigm of the "green economy" in the direction of meeting the objectives set by the goals of sustainable development.*

Aim and tasks*. The purpose of the paper is to identify and substantiate the prerequisites for the formation of an innovation paradigm of the "green economy", the onset of which should ensure the ecologization of urban transport in the system of its sustainable development.*

Research results*. The reasons, which are substantiated in the article, are proposed to be solved only by a holistic, global approach. Since qualitative transformations can not do without significant financial resources, the volumes of which are constantly reduced due to the influence of external factors, which also affects the developed countries of the world, the mechanisms that will enable them to get the desired result with minimal investment resources are the foreground. The article emphasizes the creation of acceptable conditions, or at least a departure from the policy of only administrative prohibitions, global control of everything and non-obstruction of the evolutionary development of events within the line of the framework conditions.*

Conclusions*. The article proposes a substantiated list of basic mechanisms that should be the basis for the operation and development of various urban transport systems. Emphasis is placed on the need for innovative development of transport, which is also expressed in the form of programs and strategies, which are supported by tax, subsidiary, legislative, legal and other preferences. The leading directions of this development are identified, summarized in the form of a list of priority and determinative actions.*

Keywords: *ecologization of transport, urban agglomerations, goals of sustainable development*

ІЛЬЧЕНКО С.В.
д-р екон. наук,
професор,
Інститут проблем ринку та економіко-екологічних досліджень НАНУ
Французький бульвар, 29, м. Одеса, Україна, 65044
E-mail: ilchenko.svit@gmail.com
ORCID: 0000-0001-6924-2225

ТЕОРЕТИЧНІ ПЕРЕДУМОВИ ФОРМУВАННЯ ІННОВАЦІЙНОЇ ПАРАДИГМИ «ЗЕЛЕНОЇ» ЕКОНОМІКИ В СИСТЕМІ СТАЛОГО РОЗВИТКУ МІСЬКОГО ТРАНСПОРТУ

Актуальність. *Відсутність розуміння взаємозв'язку між станом навколишнього середовища та ступенем деградації міських агломерацій веде до зростання суспільно необхідних витрат на охорону, використання та*

відтворення природного середовища та компенсаційних витрат на підтримку і забезпечення якісного стану довкілля, поступового зниження якості та кількості природних активів, загострення проблем розвитку міст як екосистем життя людини. У той же час, зростання економіки призводить до зростання забруднення навколишнього середовища. Цей факт підтверджується статистичними даними. Тому вибираючи стійкий шлях розвитку, необхідно орієнтуватися на механізми, які будуть сприяти перетворенню структури економіки таким чином, щоб її подальший розвиток не загрожував навколишньому середовищу і не знижував якості осередку життя громадян цієї країни. В цьому розумінні доцільно формування нової інноваційної парадигми "зеленої економіки" у напрямі виконання завдань, встановлених Цілями сталого розвитку.

***Мета та завдання**. Мета статті полягає у визначені та обґрунтуванні передумов формування інноваційної парадигми "зеленої економіки", настання яких має забезпечити екологізацію міського транспорту в системі його сталого розвитку.*

***Результати**. Обґрунтовані у статті рішення встановлених завдань пропонується впроваджувати лише шляхом цілісного, глобального підходу. Оскільки якісні трансформації не можуть обійтися без істотних фінансових ресурсів, обсяги яких постійно знижуються завдяки впливу зовнішніх факторів, що також стосується й розвинених країнах світу, то на перший план виступають саме ті механізми, які дадуть можливість при мінімальних інвестиційних ресурсах отримати бажаний результат. У статті робиться наголос на створення прийнятних умов або, як мінімум, відхід від політики лише адміністративних заборон, глобального контролю всього та непершкоджання еволюційному розвитку подій у межах сформованих рамкових умов.*

***Висновки**. У статті пропонується обґрунтований перелік базових механізмів, які мають бути покладені в основу функціонування і розвитку різних міських транспортних систем. Наголос зроблено на необхідність інноваційного розвитку транспорту, яке має виражається, також, у вигляді програм і стратегій, які підкріплюються податковими, субсидіарними, законодавчо-правовими та іншими преференціями. Визначені провідні напрями цього розвитку, підсумовані у вигляді переліку першочергових та визначальних дій.*

***Ключові слова:** екологізація транспорту, городські агломерації, цілі сталого розвитку*

Statement of a problem and its communication with important scientific and practical tasks. The development of urban agglomerations is characterized by two peculiarities: firstly, increasing the efficiency of production and, consequently, increasing the volume of its products, impose an additional burden on transport infrastructure, rolling stock, the natural environment and health of the population, on the other hand, forms the basis for the growth of the purchase the capacity of urban residents, an increase in the number of vehicles, and an increase in the mobility of citizens. Balancing these two effects is an urgent task in any city and country. Moreover, in the first and second cases it is necessary to take into account the level of loading on the natural environment of cities, since the realization of the main goal - the quality of the population life, it is not possible outside of this condition. In turn, looking for and finding an optimal solution is limited by many factors, among which, not least, the national paradigm of the national economy development, the entire state. And it is here that there are some difficulties - how focused and consistent is the approach to this task, how preconditions for the introduction of innovative methods, tools, mechanisms for their implementation. That is, the systematization of knowledge, the experience of implementing certain actions, the construction of the paradigm of innovation development within the idea of forming a "green" economy and "green" agglomerations of cities.

The analysis of the resent publications on a problem. Problems related to providing reliable methods for promoting sustainable development of our country are covered by many scholars [1-7]. Proposed United Nations program documents [8-9], which define the goals of such development for the near future, are the leading ones for those states that have set the goal of the population welfare. Ukrainian specialists have repeatedly been the flagships of the inevitable processes of creating a "green framework" in the system of modern programs of the national economy development. In other words, it was substantiated that the approach itself should "take as a basis" innovative ideas, form a complex of actions as a system of advanced, progressive views and implementations.

Allocation of previously unsolved parts of the general problem. The development of perspective plans for the construction of settlement transport systems, the justification of various approaches to the creation of modern, innovative transport communications, which would increase the level of population mobility, at the same time, functioned on the basis of non-obstruction of cities and towns environment, the health of their inhabitants, is the subject research not only of individual scholars, but also of scientific schools. These issues are complex, multidimensional, and that is the most difficult, interdisciplinary in nature. The step-by-step actions of each of the beneficiaries of these changes must finally be formed as a comprehensive plan for the development of green cities, which must be supported by financial mechanisms for their implementation.

Formulation of research objectives (problem statement). Taking into account the foregoing, the main purpose of the article is to determine the preconditions for constructing an innovation paradigm of the "green" economy in the system of sustainable development of settlement transport systems of Ukraine.

An outline of the main results and their justification. The analysis of statistical data has led to the conclusion about the excess emission of world transport systems of pollutants, which accounts for 25% of the world's total greenhouse gas emissions, in which 75% of the emissions of motor vehicles [10]. Other sources [11, 12] suggest that 50% of the world's population today is inhabited by cities, with 60-80% of energy use and 75% of carbon emissions coming from them. Rapid urbanization creates challenges for the population, first of all, from poor quality environment, lack of resources, limited access to them. However, in cities, thanks to the introduction of innovative transport solutions, it is possible to create conditions for the most comfortable life, which involves a number of conditions, not the last of which is access to the most important services. Available from the point of view of the transport system of the region and the city with a population density of 100-1000 (maximum 3000) per hectare, the areas allow for efficient organization of the public transport network and constitute a starting point for the creation of green cities [13].

The analysis of world trends shows the rapid growth of the population of cities. For example, the urban population of India has increased from 290 million people (2001) to 340 million people (2008) and is projected to reach 590 million people in 2030 [14]. In order to meet the growth in demand associated with such growth, an annual expenditure of 1,2 trillion US dollars is needed for the construction of 350-400 km subway lines and new roads up to 25,000 km. The same situation is taking place in the People's Republic of China, the urban population of China was 636 million people in 2010, and may grow to 905 million in 2030. It is projected that by 2050 this country will need annual investment in urban infrastructure of 800-900 billion Yuan, or about 10% of China's GDP in 2001 [15]. The quality of life of future generations depends on how these funds will be invested, including the presence or absence of problems with high concentrations of carbon emissions within urban agglomerations.

However, in relation to transport, there has been a steady trend towards the adoption of transport solutions, which are primarily built on the use of private motor transport, which is one of the main causes of climate change, environmental pollution and the emergence of a threat to human health. In cities, transport consumes more than half of all liquid fossil fuels and generates almost a quarter of world CO_2 emissions. According to the results of the study, environmental and social costs (costs of local air pollution, traffic accidents and traffic congestion) amount to 10 per cent or more of the GDP of the region or country and far exceed the amounts necessary to initiate the transition to "Green" economy [16].

The policy of "greening" transport should be built on three interrelated principles:

- Exception or reduction of extra trips due to integration of land use programs and transport planning, localization of production and consumption;
- Switching to more environmentally-friendly modes of transport such as public transport and non-motorized passenger transport, rail and water transport for freight, quantity of electric transport – passenger and freight transport.
- Improvement of technology and fuel used in the process of transportation, in order to reduce their negative impact on the environment, and reduce social costs.

The measures to be implemented, in particular, include: land-use planning, provision of compact or built-up urban transport corridors for urban planning, regulation of fuels and vehicles used, providing information for decision-making by users and companies. Economic instruments such as reforming the tax system in terms of granting preferential conditions in terms of taxes, fees and subsidies can be effective, which should also encourage the use of more environmentally friendly private vehicles and the transition to public and non-motorized transport. We offer several examples of creating preferential conditions for supporting innovative "green" solutions in the transport sector. In all, the consolidated government agencies use different tools and strategies to increase the efficiency of transportation systems and the quality of life of the population. London introduced a traffic tax in the central part of the city, which reduced the number of private car trips by 70,000 [17], and CO_2 emissions by 20% [18]. The electronic payment system for road charges and car quotas in Singapore has reduced the growth rate of car use and overall car availability [19]. The system of high-speed bus communication in Bogotá has led to a 14% reduction in emissions per passenger [20], and this practice has been successfully introduced in other cities. In Zurich, the tram is chosen as the main mode of transport instead of the metro, which is also becoming an example for many other cities in Europe [21]. The introduction of emission standards and vehicle use schemes has allowed to reduce dependence on private transport [22], and the

establishment of emission-free zones and the introduction of permits for the delivery of goods with time constraints addresses congestion and environmental pollution [23].

World experience confirms that the economic return on investment in public transport is almost twice as high as cost, along with solving purely transport problems, reducing the amount of sulphur in fuel vehicles would reduce the annual health care and related industry costs by 980 million US dollars [24]. Thanks to economic modelling, the annual investment in the transport sector of 0,34% of the net GDP (approximately $ 195 billion) in the period from 2010 to 2050 would have helped reduce the use of petroleum based fuel by a maximum of 80% compared to the overall development scenario and, at the same time, would increase the employment rate by 10%.

But the introduction of actions on the transformation of traditional approaches requires not only institutional transformations, but also changes in the consciousness of the citizens, their economic encouragement to participate in such transformations, the restructuring of industrial cycles and many other very radical actions.

It is clear that in this sense, the rules and norms, which are legally established, will form only framework conditions, but the development vectors must be established, clearly defined at the legislative level in order to provide the basis, the basis of further development of society in an extremely innovative new direction. In this sense, the role of science as a generator of grounded ideas, visions, is unclear from the beginning and incomprehensible (often) at the beginning, but weighted, timely, innovative.

It is expedient to assess the impact of transport activities on the environment on the basis of two main categories:

- atmospheric pollution and impact on climate change;
- noise pollution.

In this case, all types of transport and existing transport nodes (ports, airports, etc.) should be considered in a consistent manner.

The values of indicators of air pollution and noise impact are formed depending on the type of transport, the number of kilometres crossed and, to a greater extent, the characteristics of the vehicle itself.

In exhaust gases, engines of automobiles contain more than 170 harmful components, of which about 160 - derivatives of hydrocarbons, which are formed due to incomplete combustion of fuel in the engine. The period of their decay lasts from a few minutes to 4-5 years. The solid emissions from exhaust gases of cars include soot and lead compounds, which have the most harmful effects on the human body. In the exhaust gases of motor vehicles for 1 ton of combustion of fuel contains from 12 to 24 kg of nitrogen oxides, from 0,5 to 5 kg of hydrocarbons and ammonia, to 4-5% of carbon monoxide. Annual emissions from one car-800 kg of carbon monoxide, 40 kg of nitrogen oxides and more than 20 kg of various hydrocarbons. The size of these emissions depends on various factors - such as the fuel used, additives and oils, operating conditions, including speed of the car, the transport cycle, etc.

CO_2 emissions from vehicles represent one of the main sources of greenhouse gases - measured by the type and type of gases expressed in the equivalent of CO_2.

In order to take into account all of the above factors, a comprehensive calculation method is required. A common approach is to calculate the amount of emissions per kilometre of the path.

The main sources of noise pollution are rail, road and air transport. The following indicators are required to determine the level of noise exposure:

- download on the road;
- the structure of the traffic flow;
- speed of the traffic flow;
- distance on the axis "transport - facades of buildings";
- density of construction (number of houses / residents in the side of the road).

These data allow you to set the equivalent of a noise level, which is then compared to the standard (for example, a permissible noise threshold of 55 dB day and no more than 50dB at night).

Urbanization of the country, which leads to the accumulation of a large number of residents in cities, an increase in the number of personal vehicles from the population, an increase in cargo and passenger traffic in the traditional way of operating the transport system will lead to uncontrolled deterioration of the environment and, as a consequence, quality of population life. Anthropogenic and technogenic loading on the environment in Ukraine is very different from the indicators of developed countries. Life expectancy in Ukraine is on average 66 years (in Sweden – 80, in Poland – 74 years). The State Environmental Policy of Ukraine, approved by the

Law of Ukraine dated December 21, 2010, identified three priorities as strategic goals and objectives for the next 10 years in relation to the transport and road sector: the establishment of anti-noise screens, the creation of economic conditions for the development of clean transport infrastructure and increasing the share of public transport in the general infrastructure by 25%, as well as ensuring the ecological safety and reliability of the pipeline transport. In March 2010, Ukraine adopted the Energy Efficiency Program for the period from 2010 to 2015, which was intended to reduce Ukraine's energy consumption by 20%, reduced pollutant emissions to the environment by 15%, and decreased heat losses in the housing and communal sector by 50% compared to 2008. To accomplish these tasks was necessary an energy breakthrough, based on the large-scale implementation of low-carbon and energy-efficient technologies. Unfortunately, such a transition did not occur.

Today, most states are reviewing their Strategic Development Agreements, committing themselves to reducing all harmful sources of influence. Taking into account the fact that the largest part of the population lives in cities, one of the first roles belongs to the development programs of cities, towns and regions as components of global state strategies.

Despite the encouraging attention from the government to introduce the necessary mechanisms aimed at improving the environmental component of the entire transport system, much more effort is needed by:

- creation of preferential conditions for stimulating consumers to apply those technologies and make decisions about their lifestyle that would facilitate the transition from energy-intensive transport systems based on the use of organic energy sources to progressive ones - biofuels, hydrogen and electricity, with a gradual abandonment of biofuels;
- improvement of coordination and introduction of qualitatively new schemes of delivery of goods and passengers in the transport sector;
- development of government support programs to reduce the cost of promising technologies;
- increasing financing of innovative development by the state and creating a system of incentives to support Ukrainian researchers;
- introduction of flexible tax policy regarding venture companies, investment resources of individuals, aimed at solving the issues of ensuring environmental safety of the transport sector;
- the gradual construction of a fundamentally new infrastructure, including energy saving, for technological innovations, assuming and providing the necessary level of training of specialists for its maintenance and technical support;
- introduction of standards and incentives for the use of Euro class fuel;
- the formation of culture, fashion and the possibility of using non-motorized modes of transport in cities and suburbs, and a number of other major events.

It should be noted that transport and technological systems are social&technological systems for the transportation of people and goods. And these systems, consisting of vehicles, energy carriers, infrastructure, organizations, population, etc., can not be considered beyond the economic, social, cultural and geographical contexts. And programs to neutralize the extremely negative impact on people of polluting agents from the work of such systems, should be multi-vector. Below are some of the required directions:

- minimizing the needs of daily travel, especially over long distances, primarily due to the concentrated development of industrial, commercial and business life in the so-called "sleeping" areas of the city;
- additional measures to ensure the high quality of public transport services and increase the attractiveness of its use by all segments of the population;
- development of strategic programs for the formation of public opinion on the culture of hiking and cycling for short distances. Development of appropriate pedestrian and cycling infrastructure (facilitating their use as an alternative to private motor transport);
- promotion of the use of energy efficient and environmentally friendly and safe (silent) types of vehicles for the carriage of passengers and for the delivery of goods;
- the collection of payments for atmospheric air pollution by road, based on the economic assessment of losses, should be carried out at the regulatory rate (representing the amount of total damage that can be caused by products of combustion of fuel in the absence of medium-sized funds, reduced by 2 times) and a penalty rate (which is based on exceeding the actual loss over the normative);
- maximizing the city's potential mainly through improving the quality of life, attracting tourists, business partners and investors.

In general, the solution to all transport problems associated with the quality of life in the city, may not be unilateral. At a minimum, these problems should be taken into account in the form of various strategies, which

will later be formed into a general regional concept, which is part of the General National Concept or Program for the development of the country's transport and road complex.

An expert working group was set up in the European Union, which included 20 experts from different levels from 12 EU member states, as well as four members of the European Commission.

In the design and planning of urban transport systems in cities with a population of 100 thousand people or more, work should be based on the following basic principles:

- redistribution of space for private transport, cyclists, pedestrians;
- improving conditions for the movement of cyclists, pedestrians (both functionally and in terms of recreational facilities), safety and security guarantees with the help of specialized infrastructure, good lighting and high-quality social control.
- use and technical support of road cover, extinguishing noise, protective shielding of noise in the city zone.
- improvement of visual perception quality of the road space.

Among the European cities, London experience is interesting, where a five-pound sterling per car per day has been introduced for entry into the central part of the city of individual cars. The mode of paid entry is introduced on weekdays from 7 to 19 hours. In the centre of London, there is a stationary network of 688 television devices that automatically scan for car numbers.

The results of implementation of this system, which are received today, have shown its success:

- transportation delays decreased in the centre of the city by an average of 17%;
- the regularity of buses increased by 33%;
- the average speed of the buses has grown in the centre at "rush hour" from 10 to 12 km / h, in the zone adjacent to the centre of London - from 12 to 14 km / h;
- the number of car owners paying for entry per day amounted to an average of 100 thousand people. All income from entry fees estimated at £ 130 million per year is directed towards the development of public transport.

And yet, today, energy consumption and CO_2 emissions tend to increase, in spite of the repeated warnings by the Intergovernmental Panel on Climate Change (IPCC) that concluded that to maintain a long-term increase in average temperature in the range of 2,0°C – 2,4°C, the world's CO_2 emissions by 2050 should be reduced by at least 50% compared to 2000. Recent studies show that climate change is even faster than expected, and even the target of "50% by 2050" may not be sufficient to prevent dangerous climate change.

The indicator of the size of vehicles in the world (commercial and passenger) is rapidly increasing, and its growth is projected to 1,6 billion units by 2030 (today the value is about 1 billion). The greatest growth is observed in developing countries, where the indicator is close to saturation. For example, according to forecasts [25], between 2010 and 2030 the transport density is expected to increase by 1 000 people, from about 50 to 140 in China (an increase of 5,7% per year) and from 20 to 65% in India (growth 6,7% per year). The result of this trend will be a rapid deterioration of the environment. Already, there is a clear need for technologies that can balance the growing needs of the population in transportation and the need for careful treatment of the surrounding human space. However, many of the most promising low-carbon technologies today cost far more fuel-efficient technologies. Their cost can be reduced only through development - research, development, demonstration and implementation, as a result of which technologies will become cost-effective. In order to avoid decommissioning inefficient high-emission technologies in the next decade, there is an unprecedented intervention by governments that are urged to take urgent steps to implement a number of policy technology strategies in order to bridge the gap between their value and competitiveness, while objectively reflecting the degree of development and competitiveness of individual technologies and markets.

In recent years, much attention has been paid to the importance of policy measures that focus on the mechanism of carbon emissions as a way to stimulate the development and dissemination of “clean” technologies needed for the energy revolution. The Copenhagen agreement, which has been signed by many countries, recognizes market approaches as a way of improving economic efficiency, but such measures (for example, the sale of carbon emission quotas) are most likely not necessarily the most effective for short-term investments in more expensive technologies that will benefit from long-term emission reductions. Moreover, a truly low-carbon world market is likely to be created only after many years. And so far, it is advisable to use a wide range of other instruments that will help to create markets for advanced technologies that are in line with national policy goals and which are supported, including by regulatory enactments, tax incentives, private programs, subsidies and information public shares. However, it is necessary to provide for a gradual reduction

of state support later, until its complete liquidation after the technologies become competitive, or vice versa, if it turns out that they are unlikely to be able to become such. According to IEA estimates for 2010, to achieve 50% CO_2 emission reduction, state funding for low-carbon technologies should be in two - five times the current level.

The International Energy Agency's scenarios for building environmental strategies for the global community, united in the Blue Card program [26]. The dominant tasks should be to minimize risk, stimulate the spread of technology and reduce costs.

Conclusions and perspectives of further research. The fulfillment of the listed tasks is possible only in the presence of a holistic, global approach. On the other hand, such qualitative transformations can not do without significant financial resources, the volume of which is rapidly decreasing in parallel with the growth of public debt in many, including the developed countries of the world. At the forefront are those mechanisms that will make it possible for the minimum investment resources to get the desired result. The question is only to create acceptable conditions, or at least a departure from the policy of only administrative prohibitions, global control of everything, and non-obstruction of the evolutionary development of events within the line of the framework conditions.

The basis for the functioning and development of various urban transport systems should be the following basic, uniform for all forms, mechanisms:

- improvement of the system of transportation, increase its efficiency, ensure reliability and continuity, through high-quality awareness of users of all types of transport within the involved transport systems;
- taking into account tendencies of reduction of demand for certain types of transport as a result of reduction of physical movements of passengers and goods in the direction of their "virtualization" (distribution of telecommunication technologies, e-commerce, etc.);
- improving the quality of operational management through the conclusion of new interagency agreements - both formal and virtual - is most often in line with the interests of the state and individuals, which enables overcoming legislative, legal and sectoral restrictions;
- development of effective and efficient mechanisms for the selection of infrastructure projects, in particular with regard to information infrastructure, which will create additional potential for the transportation of passengers and cargo, with minimal impact on other important economic spheres such as land use, environmental protection, etc .;
- rationalization of the design and operating systems of the macro level, by switching traffic flows to intermodal transshipment points (water transport - railways, ground transport - aviation, etc.);
- increasing the availability of services by expanding their coverage across larger areas and segments of the population through the development of a distribution network known throughout the world as "hub-and-spoke" at national, regional and individual service levels.

Innovative development is particularly important in the form of programs and strategies that are supported by tax, subsidiary, legislative, and other preferences. The main directions of this development can be summarized as follows:

- total informatization of transport;
- creation of economical, resource-efficient and environmentally-friendly vehicles;
- formation of multimodal logistics centers;
- the creation of terminal cargo delivery systems;
- creation of transport and technological systems based on application of logistic technologies;
- development of container and piggyback technologies.

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