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Strategy Of Sustainable Development Of City Transport Systems

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Abstract

The aim of this work is to develop a strategy for the sustainable development of transport systems in big cities and to apply this strategy for Ekaterinburg city – the capital of the Ural Federal Region (Russia) in order to improve its economic, ecologic and social situation. The urgency of the study is due to the need for a unified algorithm with effective indicators (sets of indicators) for assessing the functioning of urban transport, its infrastructure systems and the architectural development and to find useful tools for city transport systems operation optimization in the direction of sustainable development.

Key words: green logistics; urban transport systems; sustainability; sustainable development; livability; ecology; economics; society; megacities; transit-oriented development.

Introduction

Transport systems have a significant influence on the urban environment that is aboutconditions of people life and city development. Alongside with all the benefits of modern sophisticated transportation, giving people the opportunity of quick and comfortable moving causes a lot of problems. The most striking of them include air, water, and soil pollution, noise and vibration exposure, dust and garbage accumulation; crashes and injures during traffic accidents, lowering of physical activity level. These matters may be dangerous for human health and life and be a thread for the livability of future generations, triggering a climate change. Transport systems are responsible for 25 percent of carbon emission (Taiyab, 2008). According to recent research, 23 percent of total energy consumption falls to transport sector (Jeon & Amekudzi, 2005), presupposing great expenditures, vulnerability to fuel price increases, and also harm for the environmentbecause of using 95 % non-renewable fossil fuel. Another group of issues is connected with traffic congestions, sprawl, and occupation of vast territories by transport infrastructure, which contributes to decrease access to working places,

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educational establishments, goods and services, friends and families, inequity in relation with limited mobility citizens. Thus, it is reasonable to assume that the society is increasing its demand for better customized logistic solutions, moving towards sustainability and livability. These problems can be resolved by giving force to green initiatives by using alternative energy sources and eco-friendly transportation modes (rail transport – Light Rail Rapid Transit (LRT), trolleybuses, cycling, walking), multimodal transportation, developing of public transport (introducing entire ticket and service for all public transport modes (Fishman, 2015), introducing such services as Bus Rapid Transit – BRT, High Occupancy Tolling (HOT) lanes), reducing the amount of private motorized transport by introduction of city entering congestion charge and paid parking lots, applying the methods of transit-oriented development (TOD) instead of traffic-adjacent orientation, using state of the art innovations in creating infrastructure (e. g., IT technologies for smart traffic lights, information of passengers by means of mobile phones applications).

This research issues lay in the field of "green" logistics areas, tasks and activity of which is discussed in the works of Thiele et al. (2011), Boile (2015), Gudmundsson (2001). Litman (2018) summarized more than 150 studies and has developed a matrix of sustainable development goals, objectives of transport systems sustainable development with sets of indicators. The cute problem of indicators and sets of indicators is reflected in investigation of Bogomolova (2012), Talberth et al. (2006), Lisovsky et al. (2014), Tarasova and Kuchinina (2015), Blumenfeld (2015). One of the efficient tools for solution the questions of sustainability in transport area is passenger transport hub, requirements for organizing of which are described in a work of Azarenkova and Stepanova (1997).

The general **aim** of the present research is to develop a strategy for sustainable development of urban transport systems. To achieve this aim we need to fulfill the following **tasks**: first, to analyze areas, goals and actors of green logistics; second, to present principles and define indicators of sustainability and livability, and third – to find appropriate tools for city transport systems sustainable development.

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/atlr

Method

Transport systems should be sustainable and cities livable, otherwise a lot of above mentioned problems may occur. To fulfill this task it is necessary to know what sustainability, livability, and sustainable development is (definition, goals, objectives, structure); to determine the most important zones to move forward, establish evaluating indicators and sets of indicators in order to assess the state; to find the tools and techniques for achieving the results, and to undertake actions towards sustainability and livability. This builds the algorithm or the strategy of sustainable development of city transport systems (Fig. 1).

Green livable city ***Sustainable transport systems*** ***Sustainable development***	***1. Sustainability and livability (definition, goals, objectives, structure). Most important zones for development (ABC-analysis).*** ∨
∧ ***3. Green tools, methods and techniques; actions towards sustainability and livability.***	***< 2. Indicators, sets of indicators.***

Figure 1.

The algorithm of sustainability and livability achievement

Source: Personal elaboration

In the research methods of integrating data of Russian and foreign expertise, statistic data analysis and analytic processing, ABC analysis, numeric calculations were used.

Discussion and Result

Sustainability is considered to keep in balance economic, social and environmental sectors, so called “triple bottom-line”, taking in consideration all long-term and indirect impacts. United States Environmental Protection Agency (EPA) suggests the definition of sustainability as creating and maintenance of human and

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http://proceedings.itltrisakti.ac.id/index.php/atlr

nature existence in harmony, fulfilling social and economic functions of present and future generations, protecting human health, recourses, and the habitat (The UN General Assembly. Report of the World Commission on Environment and Development, 1997).

According to Litman, *livability* "refers to the subset of sustainability goals and impacts that directly affect community members, including local economic development and environmental quality, equity, affordability, basic mobility for non-drivers, public safety and health, and community cohesion" (Litman, 2018, p.9).

A Canadian researcher T.Litman (2018), having analyzed more than 150 sources, provides a list of transport planning objectives with their explanations. To determine the most relevant for the present-day situation sustainability goals and transport planning objectives, ABC analysis was carried out. The results served to show that there is a close interrelation between transport planning objectives for sustainable development and general sustainability goals. Transport planning objectives (total amount is 8 objectives) with the highest rank are 6 objectives (**A1 group** 61 – 100 %):

1. **Transport Diversity 14 points – 87.5 %.** Travelers can choose from various modes, location and pricing options, particularly ones that are affordable, healthy, efficient, and accommodate non-drivers.
2. **Demand Management (efficient pricing & prioritization) 13 points – 81.25 %.** Road, parking, insurance and fuel are priced to encourage efficiency, and facilities are managed to favor higher value trips and more efficient modes.
3. **Resource (energy and land) Efficiency 12 points – 75 %.** Policies encourage energy and land efficiency.
4. **Land Use Accessibility (smart growth) 12 points – 75 %.** Policies support compact, mixed, connected, multi-modal land use development in order to improve land use accessibility and transport options.
5. **Affordability 11 points – 68.75 %.** Transport services provide affordable options so lower-income households spend less than 20% of their budgets to access basic goods, services and activities.

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6. **System Integration 10 points – 62.5 %.** The various components of the transport system are well integrated, such as pedestrian and cycling access to transit, and integrated transport and land use planning.

   Transport planning objective with the middle rank is (**B1 group** 21 – 60 %).

7. **Comprehensive and Inclusive Planning 8 points – 50%.** Planning is comprehensive (considers all significant objectives, impacts and options), integrated (decision-making is coordinated among different sectors, jurisdictions and agencies), and inclusive (all affected people are able to participate).

   Transport planning objective with the low rank is (**C1 group** 0 – 20 %).

8. **Effective Operations 3 points – 18 %.** Transport agencies, service providers and facilities are managed efficiently to minimize costs and maximize service quality.

   Among the sustainability goals, the total amount of which are 16, the most actual are 12 goals (**A2 group** 61 – 100 %):

   1) Economic development 7 points – 87.5 %
   2) Safety, security and health 7 points – 87.5 %
   3) Community development 7 points – 87.5 %
   4) Water pollution prevention 7 points – 87.5 %
   5) Economic productivity 6 points – 75 %
   6) Affordability 6 points – 75 %
   7) Climate stability 6 – 75 %
   8) Air pollution prevention 6 – 75 %
   9) Openspace preservation 6 points – 75 %
   10) Energy efficiency 5 points – 62 %
   11) Equity / Fairness 5 points – 62 %
   12) Heritage protection 5 points – 62 %

   As our results indicate, 5 of the goals from this group belong to environmental zone, 5 of the goals belong to social zone, and 2 –to economic zone.

   Goals with the middle rank (2 goals) are (**B2 group** 26 – 60 %):

   1) Operational efficiency 3 points –37.5 %
   2) Efficient Pricing 3 points – 37.5 %

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3) Goals with the low rank (2 goals) are (**C2 group** 0 – 25 %).
4) Noise prevention 2 points – 25 %
5) Good planning 2 points – 25 %

Although all the analyzed goals and objectives are important, we have chosen the scope of items with the highest importance – groups A1 and A2.

In order to have effective planning in the direction of sustainable development and optimize the operating of existing transport systems in big cities, it is necessary to estimate the state of the things. The complexity of the task lies in defining regular methods, indicators, and sets of indicators for evaluating performance towards sustainability and livability.

An indicator of sustainable development – is quantitative information that shows some change in the state of a system or environment in the course of a certain period of time Bogomolova (2012). There were a number of attempts to analyze the level of sustainability in development of urban transport systems. Blumenfeld (2015) analyzed eleven pieces of research with the total amount of 297 indicators and suggested a balanced set list of 16 indicators, describing sustainable transport development of big cities [30].

Litman (2018) developed a three-sectional set of indicators, based on economic, social, and environmental sectors. The model summarizes sustainability goals, objectives and performance indicators. On the base of Litman's model the more detailed matrix of objectives and their indicator sets for groups A1 and A2 were elaborated.

Having analyzed the most important directions of sustainable development of urban transport systems, sets of their correlated indicators, the attempt to find suitable tools and techniques to reach sustainable development are made. For this purpose, principles for organizing passenger transport hub (PTH) were studied.

Following Azarenkova and Stepanova (1997) the projects of newly built or reconstructed transport hubs should meet the suggested demands.

- In the Master Plan a transport hub organization should take into account the location of the developing area, the importance of the developing area among the urban

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centers, carefully include new constructions and elements into existing composition, preserving the integrity of the overall solution.

- Saving and rational use of urban areas must be considered.
- The organization of transport hubs is preferable near underground or railway stations (even if they are in design stage).
- Provide the necessary structure of buildings, transport and civil engineering constructions, and continually developing systems
- Consider composite-architectural style as well as the scale of the current and projected development of the city district to preserve the specific cultural, historical and other local heritage and features;
- Account for climatic characteristics of the construction area, natural landscape, topography and hydro geological factors;
- Offer measurement to ensure the protection of the environment from pollution by exhaust gases, wastewater, keeping standardized noise and vibration levels;
- Create favorable conditions for people with limited mobility (the disabled, the elderly, and passengers with children). Make the largest possible differentiation between the traffic and pedestrian flows on the main and relatively minor importance.
- It is advisable to combine the stopping points of unidirectional routes for various types of transport.
- Create a unified and coordinated schedule of urban ground passenger transport routes.
- Ensure free entrance to the complex buildings, structures and hub land sites of public, special (mail, luggage) and individual transport; keep throughput capacity of traffic system at the entrance to the hub not less than 10%.
- The estimated time of interchange between the ground and fast transport must not exceed 7 minutes, not including the waiting time.
- The maximum flow density in the core communication elements of a hub should be no more than 2 passengers per m^2.

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- The distance from ground public transport stops to the hub entrance should not exceed 100 meters, the amount of pedestrian paths and motorway crossings should be reduced.
- Ensure equipment of all major areas of transport hub with security systems.
- Passengers waiting area should be protected against atmospheric precipitation and equipped with heating and air conditioning.

After comparison of content of sustainable development directions of urban transport systems, sets of their indicators with principles for organizing such tool as passenger transport hub, it occurs that all the demands are met, and this tool can be used for reaching the sustainable development goal.

Implementation of research results – the urban transport systems sustainable development algorithm is relevant for transport system improvement in Ekaterinburg – the capital of the Ural Federal Region (UFD), because more than 1/3 of the population of UFD as well as of the whole Russia is concentrated in large cities.

Analysis of the transport situation in Yekaterinburg shows the presence and functioning of the main types of urban and suburban transport with priority use of personal road and public bus transport.

Analysis of the environmental situation in Yekaterinburg proved an unfavorable situation. The main air pollutants are industrial enterprises and cars (the share of air pollution from exhaust gases is 88%). In 2016, the total amount of pollutants in Yekaterinburg amounted to 1,021 thousand tons, 788 thousand tons were thrown out without cleaning. The amount of CO_2 emissions was 1200 tons. The total cost of measures to preserve clean air is 2,655 ml c.u. (Federal Service of State Statistics, 2016).

Taking into account the data on the transport and environmental situation in Yekaterinburg, the economic effect of savings from the introduction of PTH was calculated as follows:

1. The annual effect of saving money from reducing CO_2 emissions in the organization of the PTH is 627 800 c.u.
2. The annual effect of saving money from reducing energy consumption with the organization of PTH is 35 040 000 c.u.

ISSN: 2622-5778 (online)
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http://proceedings.itltrisakti.ac.id/index.php/atlr

3. The annual effect of reducing the cost of transportation by reducing the number of cars at the entrance to Yekaterinburg is 310 688 000 c.u.
4. The annual effect of savings from reducing the cost of travel through the use of THP for citizens for 1 person amounted to 8 395 c.u.
5. Annual effect from reduced travel time (in terms of GRP) in the implementation of the PTH can be up to 32 344 569 c.u.

PHT of agglomeration value (level 3) of the local public center, located in the peripheral zone of the city, is designed to provide transport links within the city and with adjacent municipalities of neighboring territories with the prospect of development a complex of regional and Federal importance.

Conclusion

Within the framework of this research, a strategy for sustainable development of urban transport systems has been elaborated. Sustainable development is a major line in the branch of so called “green”, environmental or ecological logistics. The first step of the strategy is identifying goals, objectives and directions of the sustainable development process. This step includes defining of basic concepts, which are most frequently used to describe the areas, principles and actors of environmental logistics.

The concept of "sustainable development" includes balanced actions to achieve economic, environmental and social goals by finding and implementing methods and tools to meet the needs of the present generation with the opportunity for future generations to meet their needs in the areas of natural resources, scientific and technical, social and individual development. The process is aimed to improve the quality of life, to solve long-term problems, and to take into account all direct and indirect factors. The general objectives of sustainable development are conditionally divided into three factors: economic, social and environmental.

The second step in the strategy of sustainable development of transport systems consists of finding of indicators (set of indicators) for assessing the level of development of transport systems in large cities. The set of developed indicators contains six directions with the highest rank of importance (%): Transport Diversity (87.5 %),

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Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/atlr

Demand Management (efficient pricing & prioritization) (81.25 %), Resource (energy and land) Efficiency (75 %), Land Use Accessibility (smart growth) (75 %), Affordability (68.75 %), System Integration (62.5 %). Transport Diversity, currently identified as the main one, requiring immediate development and taking measures to maintain safe and efficient living conditions.

Indicators and indicator sets of the 6 most important transport planning directions were established. The classification of indicators (indicator sets) is presented in three sectors: economic, social and environmental. This set of indicators makes it possible to assess the conditions of the transport operation uniformly and to manage the processes.

Passenger transport hub – a tool based on the developed complex for achieving sustainable development of cities and their transportation systems was found as principles of its organizing correspond to six main directions of urban transport systems sustainable development and twelve goals of sustainable development, which build economic, ecological and social A-zone, being strategically important for present time. Implementation of elaborated algorithm for urban systems sustainable development made it possible to lay a foundation for plan of Ekaterinburg urban transport system optimization.

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