TRANSPORT AND ENVIRONMENT: NEED FOR SUSTAINABLE SOLUTIONS

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Abstract: Transport has irrepressible contribution for the effective development of economy and society. But, these contributions are exceeded by harmful environmental consequences that transport growth causes especially in urban areas. Air pollution, acid rain, noise, climate change are just few of the problems which every urban area is dealing with. Hence, it is very important to provide development of the transport that at the same time could increase its sustainability and minimize environmental degradation. Numerous sustainable transport solutions are available with a potential to decrease these negative influences and promote mobility with higher sustainability. This paper presents a review of sustainable solutions, successfully applied in practice, as guidance for those urban areas that are dealing with the environmental problems from transport, but still are a step behind in undertaking activities.

KEYWORDS: TRANSPORT, ENVIRONMENT, SUSTAINABILITY

1. Introduction

Transport is a cause for many serious environmental problems, especially in urban areas. Urban congestion with the current trends of transport growth is expected to be worse. Although the significant reduction in the vehicle exhaust emissions has been accomplished, the poor air quality remains as a biggest problem [1]. Transport also contributes for other environmental problems, to mention just the formation of acid rain and global warming as more significant. Therefore, to be able to control or minimize these problems, urban transport system needs to be improved towards sustainability.

In order to recommend sustainable solutions, firstly, a categorization of environmental problems for which transport has significant impact, is presented. Then, several sustainable solutions are proposed, selected from the current practice from European towns, where their implementation has given good results. These solutions could be viewed in the term as a starting point for those urban areas, such as macedonian towns, that are dealing with serious environmental problems caused by transport, but still don’t have a starting point for effective definition or taking the initiative for concrete solutions.

2. Transport and environment

2.1. Environmental impacts from transport

The high dependence of the vehicles in urban transport leads to the inevitable harmful impacts at the environment. Although the vehicle performances have been continuously improved in term of better energetic efficacy and lower emissions and noise levels, the increasing number of vehicles in urban areas diminishes all of these improvements [2].

Taking aside the number of vehicle and the level of congestion at urban streets, the range of harmful impacts from the vehicles depends of:

- engine type (diesel, petrol)
- vehicle category (passenger cars, high duty vehicles, buses etc.)
- technological – constructive characteristics
- fuel type (fossil fuel or alternative fuel)
- the mode of vehicle usage and
- the level of vehicle maintenance.

Dealing with the serious problems in the environment is feasible only if those problems are precisely defined. Therefore, when selecting the solutions for control and management of environmental problems, categorization of the impacts that transport has on the environment is of vital importance (table 1).

Table 1: Categorization of environmental impacts caused by transport

<table>
<thead>
<tr>
<th>Category</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>local level</td>
<td>- urban air pollution, with a direct health effect</td>
</tr>
<tr>
<td></td>
<td>- water pollution</td>
</tr>
<tr>
<td></td>
<td>- soil pollution</td>
</tr>
<tr>
<td></td>
<td>- waste</td>
</tr>
<tr>
<td></td>
<td>- noise</td>
</tr>
<tr>
<td></td>
<td>- esthetic impact and fragmentation</td>
</tr>
<tr>
<td>regional level</td>
<td>- acid rains</td>
</tr>
<tr>
<td>global level</td>
<td>- global warming and climate changes</td>
</tr>
<tr>
<td></td>
<td>- decrease of the ozone layer</td>
</tr>
<tr>
<td></td>
<td>- decrease of the natural resources</td>
</tr>
</tbody>
</table>

At local level, the location where emissions are generated is the location of their impact. At regional and global level the location of emission generation is of less of importance. For example, the health impacts of the emissions of particles and hydrocarbons are highest in the urban areas, where their concentrations are highest; carbon dioxide emissions are most significant for the global level, and the location of the sources of carbon dioxide here doesn’t have any significance.

The bigger part of the impacts is felt in urban areas, where higher concentrations of vehicles are located. Hence, urban areas have priority for study and research of the problems with exhaust emission pollution [3].

At local level, nitrogen oxides (especially nitrogen dioxide), hydrocarbons, particles and carbon monoxide cause air pollution, which results with numerous health issues (table 2). The regional impacts are presented through acid rains, with nitrogen and sulfur oxides having the biggest contribution for their formation. At global level, vehicles emit carbon dioxide, whose increase of concentrations brings to the climate change and global warming.

At global level, transport contributes for worsening of the problem with global warming. This is connected with a change of many climate aspects, for which higher frequency, duration and intensity is predicted in the future:

- weather events: storms, fires, floods, droughts, heat waves etc.
- changes in the ecosystems
- losses of species in flora and fauna
- changes in agricultural production (decrease of crops) etc.

It is evident that increase in the global temperature will influence at all the aspects of the planetary eco-system and ecological balance of the earth [4].
Road fees, awareness campaigns, parking restrictions, other physical and regulative measures for land use, good deliveries from the city center fees (cordon fees), bus priorities, public transport services, speed limitations, traffic calming, low-emissions zones, other physical and regulative measures for traffic flows and modal distribution.

2.2. The range of environmental impacts: data for environmental degradation

According to the report of the European Commission, it has been estimated that in 2014 specific air pollutants have caused the following state of premature mortality in EU-28 [5]:
- PM$_{2.5}$ have caused around 399,000 cases
- NO$_2$ have caused around 75,000 cases
- O$_3$ have caused around 13,600 cases.

The consequences from the exposure to specific pollutant are defined by:
- pollutant concentration
- exposure duration in the polluted areas.

Concentrations of local pollutants, especially particles and nitrogen oxides, are several times higher near the roadways compared with the total ambient levels. Air pollution is higher in those urban areas where geographic and climatic conditions trap pollution and produce ozone.

Highly exposed groups are:
- persons living near the roadways with high capacity flows
- persons in the “street canyons” with high traffic intensity
- persons spending long time on roads because of their profession.

The most exposed group are the drivers themselves, who constantly travelling through “tunnel” of polluted air can be exposed more than three times to higher local air pollution, compared with the cyclists and pedestrians near the roads [6].

Referring acid rains, it has been projected that until 2020 only 4% from the total eco-systems in EY-28 will exceed the critical levels of acidification, if the current legislation is completely implemented [7].

IPCC (Intergovernmental Panel on Climate Change) considers that the ambitious reduction of 50-80% of the global CO$_2$ emissions is needed until 2050 (compared with 2000 levels), in order to achieve [8]:
- limitation of the temperature increase from 2-2.4°C
- stabilization of CO$_2$ concentrations to 450 ppm.

However, the IPCC foresees that until 2100, by different scenarios, the increase of the global temperature will be in the range 0.9 - 4 °C [8].

### 3. Sustainable transport solution

Sustainability in transport could be achieved through solutions that are relevant and important in longer time period. Sustainability options should be implemented after qualitative and extensive planning and more importantly, through integration of urban and transport planning and designing.

Sustainable solutions applicable in urban areas dealing with the environmental problems could be categorized in several categories (table 3):

**Table 2: Range of impacts and effect of pollutants from vehicle exhaust emissions**

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Impact</th>
<th>Harmful effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>global</td>
<td>climate change</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>local</td>
<td>health impacts</td>
</tr>
<tr>
<td>Particles</td>
<td>local</td>
<td>health impacts</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>local and regional</td>
<td>health impacts, ozone formation</td>
</tr>
<tr>
<td>Lead</td>
<td>local</td>
<td>health impacts</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>local and regional</td>
<td>health impacts, ozone formation, acid rain</td>
</tr>
<tr>
<td>Ozone</td>
<td>local</td>
<td>health impacts</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>local and regional</td>
<td>health impacts, acid rains</td>
</tr>
<tr>
<td>Benzene</td>
<td>local</td>
<td>health impacts</td>
</tr>
</tbody>
</table>

**Table 3: Categorization of sustainable solutions in transport [9]**

<table>
<thead>
<tr>
<th>Sustainable solution</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport demand</td>
<td>- road fees, - parking fees, - city center fees (cordon fees), - public transport fees, - regulation for land use planning.</td>
</tr>
<tr>
<td>Traffic management</td>
<td>- parking restrictions, - low-emissions zones, - traffic calming, - speed limitations, - bus priorities, - other physical and regulative measures for traffic flows and modal distribution.</td>
</tr>
<tr>
<td>Effectiveness of transport mode</td>
<td>- mobility management, - promotion of walking and cycling - good deliveries from the terminals to the urban centers.</td>
</tr>
<tr>
<td>Improvement of transport services</td>
<td>- effective public transport, - effective passengers’ transfer.</td>
</tr>
<tr>
<td>Public campaigns</td>
<td>- information campaigns, - awareness campaigns.</td>
</tr>
</tbody>
</table>

Actually, sustainability in transport is a long-term policy in which sustainable balance between mobility and protection of the environment is defined and should be accomplished. Proposed sustainable (and other) solutions should be combined between each other for bigger effectiveness and should be based at clearly defined and implemented political obligations.

### 3.1. Transport demand

**Introduction of fees**

When introducing fees in transport, it is necessary to build a consensus at national and local level. This is very feasible and economic effective approach, although very often has political connotation. Local authorities, urban planners and transport operators have available practical guidance for evaluation of the costs and for financing of urban transport systems. Electronic payment on road is very popular, but also other payment measures, such as parking fees and cordon fees, are more financially effective and more practical [9]. Cordon fee is partially effective when used in congested central areas or during the peak periods. Parking fee is also effective referring the limitation of cars in urban areas where exists a continuous high demand.
Integration of transport and land use planning

Research shows that there isn’t a simple strategy which significantly will decrease traffic congestion levels in urban areas in short or long term. Hence, a policy is needed that will change the way of land use in a long term, which will be directed to the reduction of the vehicle usage. Very good lessons are identified from the current practices for combined land use planning and transport planning [9]:

- these politics are successful only if the attractiveness of car travelling is decreased (slower or more expensive travel)
- policies directed to the limitation of the car in city centers aren’t harmful for the economic progress of those centers.

3.2. Traffic management

Implemented solely or in combination, suggested activities for traffic management can improve environmental impacts from transport and support attractiveness of green transport policies. This can contribute for measurable difference of the urban life quality, encouraging the local authorities to meet specified policy targets.

3.3. Effectiveness of transport mode

Mobility management

Mobility management includes information services and mechanisms for coordination for better use of the current transport capacities, which could minimize the number of travel by car. This could result with a change of the transport mode, for example, through green travel plans, car pooling, dedicated lanes for high occupancy vehicles etc [9]. Mobility management also tries to make more effective usage of current public transport developing strategies for improvement of public transport services.

Cycling and walking promotion

Different cities have different success in the usage of this strategy, and hence there is a strong interest for learning from the wider European experiences [9]. Providing the continuous network of walking and cycling lines, segregation of the walking and cycling lines, increasing the number of parking places for cyclists in urban centers, reduction of the vehicle speed to 30 km/h are just some of the measures that could contribute for promotion of cycling and walking.

3.4. Improvement of transport services

An effective framework should be directed to the improvement of the performances of public transport through controlled competition, implementation of effective public transport services and financial support for the operators. Research shows that if improvement of public transport services are solely implemented, they are far ineffective for the stimulation of modal change. In combination with other measures, such as parking and cordon fees, zones with limited access etc. contribute for the highest reductions in number of car travels.

For encouragement of the passenger to use public transport, passenger transfer between different transport modes should be especially efficacious and user-friendly [9]. In the past, the attention was put on the operators’ effectiveness. Today, practical guidance for users, planners, public transport operators and managers of the terminals are developed. Also, market research and modeling tools for designing more efficient transfer are developed, available through manuals or Internet [9].

3.5. Introduction of clean-fuel vehicles

In the next several decades, Europe should change its fuels sources in transport, in order to decrease the high dependence of imported oil. Alternative fuels contribute for the mitigation of global warming and air quality improvement. Cleaner vehicles provide improvement of urban area, but they are facing with the barriers such as high price and lack of fuel infrastructure. Policies for support of alternative fuels are [9]:

- fiscal stimulations for introduction of particular fuel at the market
- definition of low-emission zones with access only for clean vehicles
- contractions between local authorities and operators for promotion of clean vehicles and regulatory framework for their implementation by the national government.

3.6. Public campaigns

Information campaigns give information for all the changes in urban transport and for future transport plans supporting transport modes directed to the sustainable transport solutions. Awareness campaigns provide change in travel behavioral and should be repeated in specific time intervals – in contrary, they will lose their power to impact at the behavioral. If both types of campaigns are directed to specific groups: schools, working places and local communities, they have stronger and long term effects [9].

4. European good practices for sustainable transport solutions

The average modal change achieved by these sustainable solutions for seven European towns where testing was performed, showed a reduction of 4.5% in the usage of vehicles and increase of 12% in the usage of public transport [9]. This corresponds with an energy savings of 7% and similar reductions in the carbon dioxide emissions. Particle emissions were reduced for almost 20% [9].

Usage of the information systems, buses monitoring and driver/passenger information is the most effective measure that decreases the travel times and reduces the emissions for 20% [9].

Modeling results show that fees could reduce traffic flows by 30% in the peak period, mostly by encouraging the drivers to travel in different time or using different routes [9].

The best results for the environment were achieved for the towns who decided to limit the access for cars in order to improve public transport system [9]. This implies that the new vehicle technologies are most effective when combined with the transport management measures.

Some towns achieved reduction of 50% in the emissions using vehicle with alternative fuel, which positively had impacted at local air quality [9]. Electrical energy and gaseous fuels were the most tested option, as well as biotuels and hybrid vehicles.

5. Research development for transport: current and future trends

Research in the transport has shown that the problems which urban transport is facing with could be surpasses only with radical change, introducing proved and new sustainable solutions as a part of one integrated strategy [9]. Research defines a range of advantages that are feasible and provides information base and useful recommendations as a support for the future implementation of these and other solutions.

Directions for the current research are:

- definition, implementation and testing of strategies which integrate more sustainable solutions
- in depth analysis of the results for selected and implemented options
- development of new solutions, for example integrated payment schemes, integration of intelligent systems for management of transport and passenger services etc.

These directions are designed to prove that integrated strategies are capable of achieving significant change in the modal change and reduction in traffic congestion [9].

Research shows that payment measures have the potential to be one of the most used in urban transport management. Still, additional efforts are needed for their practical implementation
before these measures will get the necessary social and political acceptance.

Future research referring sustainable solutions will have a need for a wide range of support tools, such as [9]:
- compilation of good practices
- definition of indicators for environmental and urban life quality
- methods for selection, design and assessment of suitable and applicable sustainable solutions
- experience sharing and training of all the stakeholders involved in the process of transport sustainability.

6. Conclusion

Transport is a cause for very serious environmental problems today, ranging from local to global level. In presented analysis, categorization of sustainable solutions is given using European good practices that have a potential to decrease or mitigate negative environmental impacts from transport. The aim of the analysis is to increase the awareness for the importance of sustainability course in transport and to give support to the policy creators who design and plan implementation of these sustainable solutions.

The European cities today have implemented different sustainable solutions in transport. The main acquisition of their success could be merging of those experiences and as a result creation of information, methods and instructions for more wider and more successful use. This is of special importance for those urban areas who are facing with environmental degradation from transport, but who are still lacking in ideas or activities to deal with the problems. The paper could serve as an initiative intended to start with a change in their transport system towards sustainability.

For better effect, a combination of solutions could be created, if financial or political circumstances allow, using the mutual experiences and practical suggestions from urban planners from different cities. Those solutions with improved communication of involved stakeholders and better cooperation will distinguished themselves as dominant and more effective solutions.

References

[8] https://www.ipcc.ch/