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The evaluation of the environmental impact and the external factors of urban transport in Constanta

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Abstract. Transport activities are known to have a substantial negative environmental impact especially when referring to the urban transport. Studies have shown that external costs (as accidents, congestion, air emissions, climate change or noise) are an important subject of the European Union, that is why were carried out several research projects. This paper will highlight the current requirements and methodologies used by the European Union regarding the impact of the external costs of urban transport in most of the growth poles of Europe. Taking into consideration that Constanta is considered to be one of the seven major growth poles of Romania for the 2014-2020 period, this study aims at analyzing how the results of similar studies made in others centers of the European Union can be applied in Constanta, showing different methodologies and evaluations regarding the external costs and their impact. We will analyze how the conclusions obtained in previous projects are applicable to data collected by us throughout a field research on the technical description of the means of transport used in this city. As methodology, we will use one that was adopted by the European Union regarding the estimation of urban external costs, taking into consideration that each externality has a different method for estimating it. The results of this study may be useful in developing the sustainable urban mobility plan for Constanta, as a strategic plan design to reduce the impact of urban transport for a better quality of life at present and in the future. Through this paper we will get an insight into the urban transport in Constanta, but also data on external costs generated by the urban transport, given that road transport is considered to be the most polluting transport mode.

1. Introduction

Over the last years there has been a remarkable growth of interest in environmental impacts, due to the fact that they are significant and growing [1]. These impacts fall within three important categories: direct impacts (here we emphasize the immediate consequence of transport activities on the environment, impacts where the relationships between cause and effect are well understood), indirect impacts (the secondary (or tertiary) effects of transport activities on environmental systems, which involved relationships that are difficult to establish) and cumulative impacts (the multiplicative or synergetic consequences of transport activities, which involved effects that are often unpredicted) [2].

The evaluation of the environmental impact and the external costs of urban transport are an important element taken into consideration by the European Union within its strategic policy goals. The two most important documents of the European Commission, the Green Paper towards a new culture for urban mobility (COM(2007) 551) and the Action Plan on Urban Mobility (COM(2009) 490), support the need of a shift in transport, by reducing greenhouse gas emissions and pollution in



order to achieve a smarter, safe, secure, more accessible and more environmentally friendly urban transport by using specialized vehicles with alternative fuels, but also using cleaner options like walking and cycling.

When referring to urban transport, it is clear that its environmental impact is higher due to the stop-start nature of many urban traffic conditions, which is exacerbated by growing congestion levels, despite recent improvement in vehicle fuel efficiency. We also need to highlight some points of the 2011 Transport White Paper concerning the environmental impact of urban transport that support the idea of a much cleaner urban transport: cities are the one that are most affected by this impact triggered by the high proportion of road accidents (almost 70 % of them occur within urban areas), congestion, noise exposure and poor air quality, cities being the ones that in the end will benefit from this switch while also taking into consideration the use of more specialized passenger vehicles that will use alternative propulsion systems and fuels [3].

We need to emphasize five activities related to transport that in the end affect the environment: the first one refers to infrastructure construction, the second one takes into consideration its maintenance and the last ones refer to vehicles: vehicle and parts manufacture, vehicle travel, vehicle maintenance and support and disposal of used vehicles and parts [4].

It is well known that transport contributes significantly to economic growth, but as we have mentioned earlier the transport also brings about negative impacts, most forms of transport giving rise to side effects that cannot be expressed in monetary terms [5]. When side effects of a certain activity impose a cost upon society, we may speak of such a cost as an external cost (see table 1), but it is important to point out that these costs aren't generally produced by the transport users, they are considered to be social costs imposed on others, but not paid for by the infrastructure user, as "internal costs" are.

Table 1. Total external costs for EU-27 (with the exemption of Malta and Cyprus, but including Norway and Switzerland) for passenger transport by cost category and transport mode.

Cost category	Road				Rail	Aviation
	Passenger cars	Buses & coaches	Motorcycles & mopeds	Total road passenger transport	(passenger transport)	(passenger transport)
	€/ (1,000 pkm*a)	€/ (1,000 pkm*a)	€/ (1,000 pkm*a)	€/ (1,000 pkm*a)	€/ (1,000 pkm*a)	€/ (1,000 pkm*a)
Accidents	32.3	32.3	32.3	32.3	0.6	0.5
Air pollution	5.5	6.0	11.8	5.7	2.6	0.9
Noise	1.7	1.6	14.4	2.0	1.2	1.0
Biodiversity losses	0.2	0.4	0.1	0.2	0.0	0.1
Nature and landscape	0.6	0.3	0.5	0.6	0.2	0.6
Soil and water pollution	0.3	0.9	0.3	0.4	0.5	0.0
Urban effects	1.0	0.4	0.8	0.9	0.6	0.0

Source: CE Delft, Infrast, Fraunhofer ISI, *External Costs of Transport in Europe, Update Study for 2008*, Delft, CE Delft, pp. 10 (2011)

Studies have shown that the current situation in urban areas could be regarded as a cycle of urban decline, due to the road transport which, despite of the fact that it brings lots of benefits to its users it also produces more traffic jams, leading to a decrease in the efficiency of public urban transport, but also in the quality of life in urban districts (due to accidents and to the high level of pollution). Nowadays there is a trend for the companies to move their headquarters to suburban areas, but this

only leads to a higher level of pollution, because in those areas the provision of public transport is very low, so that workers are forced to travel by car [7]. The table below presents the relevant cost categories per urban transport mode showing that beside cycling, which is the most eco-friendly type of transport, train and tram are less polluting than urban road transport (car, trucks, bus, mopeds). Rail urban projects seem to be an optimal solution to road transport, as they reduce the environmental impacts, thanks to their benefits: regular, safe, with medium-high capacity.

The most important environmental impacts that need to be taken into account when referring to the urban transport are costs of congestion, noise, air pollution, climate change, accidents and the tear and wear of the use of the infrastructure.

Table 2. Relevant cost categories per urban transport mode.

Transport mode	Wear & tear	Climate	Air pollution	Noise	Accidents	Congestion
Car	X	X	X	X	X	X
Truck	X	X	X	X	X	X
Mopeds/ motorcycle	X	X	X	X	X	X
Cycling					X	
Bus	X	X	X	X	X	X
Train	X	X	X	X	X	
Tram	X	X	X	X	X	

Source: Bossche M Beekman R. Baanders B. Scholten B. 2012 Study on Urban Aspects of the Internalisation of External Costs - MOVE/B4/310-1/2011, Final report, DG MOVE, Rotterdam, pp. 21

2. Methodologies

Different methodologies and evaluations of external costs and their impact have been developed, but only two of them have been analyzed within European Union's projects: Cost-Benefit Analysis (CBA) and Multicriteria Analysis (MCA) [7]. Even if the first one is more objective than the second one, due to the fact that it uses monetary values to measure all the effects, it cannot allow quantifying all the effects of external cost, because most environmental and social effects are difficult to account for.

The Multicriteria Analysis consists in an assessment that may be carried out under the objective of sustainable development, considering three important dimensions: economic, social and environmental sustainability. The analysis sets some objectives that need to be evaluated, each objective being measured within two scenarios (the reference scenario and the real scenario) by one or more specific criteria that will be measured through a combination of quantitative and qualitative indicators. It is important that every effect be aggregated in a final single value that will be individual social utility for each criterion. So, the final impact will be the weighted sum of all indicators multiplied by the weight assigned to their corresponding criterion as presented below:

$$\text{Socio-economic-environmental Utility} = \sum_{i=1}^n w_i \cdot x_i \quad (1)$$

Where w_i are the weights and x_i the individual social utilities of each of the n indicators.

For example regarding the environmental improvement, the criteria will refer to external costs, which may establish the following indicators: air pollution, reduction of pollutant emissions (Tons/year of CO, SO₂, NO_x, etc.), percentage of persons that are less affected by noise, reduction of accident costs per year (Euro/car-km) [7].

As stated earlier, the most appropriate method of determining external costs is the Multicriteria Analysis. Through this method, adopted on an European level, there should be a clearer emphasis of external costs and also of the measures needed in the process of their internalization.

3. The external costs of urban transport in Constanta

The costs which affect the citizens directly are the noise level costs (due to the noise in the streets with a high daily average intensity), the sanitary costs- air pollution (due to the harming emissions of vehicles), the congestion costs (due to the increased number of cars, that cause losses of time), but also the costs of injuries or death due to accidents of the urban traffic [9], but two of them are considered to be the most important in Constanta: noise and air pollution costs.

a. Air pollution from urban transport

According to R. Gorham some factors can be identified that contribute to the air pollution from urban transport, influencing the amount of emissions, such as: the excessive use of vehicles, the age of the vehicle fleet and its technology used, poor vehicle maintenance and the unavailability or improper use of appropriate fuels [10].

According to the information provided by the Public Transportation Company of Constanta, 52,112,498 people were transported in 2012. When referring to the number of routes needed for urban road transport in Constanta, there are 26 routes, totaling 366 km, stopping at 549 bus stops. We also need point out that in February 2013 the total number of kilometers traveled daily by a single bus was of 174 km [13].

In 2013 Constanta's bus fleet was made up of 5 types of buses:

- MAZ 103-041: 112 buses;
- MAZ 103-065: 15 buses;
- MAZ 203-076: 15 buses;
- MAZ 107-468: 50 buses;
- AYATS: 10 buses.

Inner road network amounts in Constanta 410 km of streets, out of which 320 km of medium and light traffic streets and 90 km of heavy traffic streets [12]. The number of hours spent in traffic in Constanta totals 34,200 vehicles/ hour for cars, 1,300 vehicles/ hour for taxis and 6,100 passengers/ hour for public transport. The daily average travel speed of cars reaches 42 km/ h and for public transport an average speed of 32 km/ h is estimated.

According to assessments for the calculated year, motorized traffic in Constanta generates an amount of emissions per day as follows: 0.18 tons of NO_x, 1.1 tons of CO, 0.09 tons/ particles of unburned hydrocarbons, 33.4 tons of SO₂ and 102.5 tons of CO₂.

b. The noise level from urban transport

Disorders of the human body functions due to noise are directly proportional to its intensity, frequency and duration [11].

- Acoustic intensity describes how the sound power of a source is spread through the environment and it is the power that passes through an imaginary surface element usually towards the direction of propagation of sound waves. Sound intensity level, measured in [dB] takes into account the physiological behavior of the ear. Propagation speed of the sound waves depends on the characteristics of the environment in which it propagates. Speed expression of the sound through air is:

$$c = \left(\frac{\gamma \cdot R \cdot T}{M} \right)^{1/2} \quad (2)$$

Where: γ is the adiabatic exponent of ideal gas; T – absolute temperature of the air; M – his molar mass. $R = 8.3 \cdot 10^3 [J \cdot Kmol^{-1} \cdot K^{-1}]$ - universal gas constant;

- Frequency which is the number of complete cycles of a sound in a unit of time, measured in Hertz (Hz). The ear perceives only audible sounds range between 16 and 16,000 Hz, but it does not perceive any ultrasound (acoustic oscillations with frequencies above 16,000 Hz) or infrasound frequency below 16 Hz.

Table 3. The level of acoustic intensity of different sources.

Noisy sound source	Intensity of different sources [dB]
Threshold of audibility	0
The ticking of a mechanic clock	30
Loud conversation	50-65
Usual road traffice	65-70
Railway traffic	56 -90
Intense traffic, symphonic orchestra	90
Thunder	90-100

Source: Găltan, A., *Noise pollution in rail and urban rail transport*, AGIR Journal (2012)

Regarding the number of people exposed to noise from motorized traffic in Constanta, according to information supplied by Constanta City Hall in the study "Development of strategic noise map for Constanta" [12] we can notice that:

- 99800 individuals, 32% of the population is exposed to noise levels between 55-59 dB;
- 56500 individuals, 18% of the population is exposed to noise levels between 60-64 dB;
- 52 600 individuals, 17% of the population is exposed to noise levels between 65-69 dB;
- 26200 persons, 9% of the population is exposed to noise levels between 70-74 dB;
- 700 people, less than 1% of the population is exposed to noise levels between 75 dB.

4. Conclusions

The analysis carried out in the research on the environmental effects of urban transport in Constanta emphasizes the fact that, due to the population density, and the fact that it is a harbour city, Constanta is among the top 5 cities in Romania affected by pollution caused by transport. As a further evidence of this we need to point out that Constanta was designated as one of the seven regional urban growth poles, for which the elaboration of a Sustainable Urban Mobility Plan is considered to be a priority.

As stated before the environmental impact of urban transport occurs mainly by air pollution from urban transport and its associated noise. So, we need to highlight that by 2011 public transport in Constanta included trolleybuses, trams and buses, but as shown in this study the buses are the only urban transport means that is still functional. Changing the urban public transport fleet led to a decrease in noise produced by trams, but at the same time is also led to traffic flows by eliminating trams. We should also emphasis the significant increase in the level of pollutants released into the atmosphere through road transport.

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