

REORGANIZING STUDENTS ACCES IN UNIVERSITY POLITEHNICA OF BUCHAREST CAMPUS AND INFLUENCES ON CAR TRAFFIC EXTERNALITIES

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Rezumat

Activitățile de transport sunt considerate drept unul dintre cei mai mari factori care contribuie la emisiile de gaze cu efect de seră (GES). Chiar dacă în alte sectoare economice tendința este de reducere a emisiilor gazelor cu efect de seră, sectorul transporturilor s-a confruntat cu o creștere continuă, cu efecte negative asupra mediului. Datorită potențialului său dăunător pentru locuitorii marilor zone urbane, este necesară o atenție specială deoarece modalitățile de utilizare a terenului, caracteristicile rețelei de transport și distribuția atât spațială cât și temporală a activităților umane adesea duc la congestia traficului. Universitățile reprezintă un pol important de atracție datorită rolului lor de centre de predare, cercetare și ocupare a forței de muncă, iar mobilitatea generată de acestea trebuie luată în considerare. Această cercetare a vizat atât dezvoltarea unei analize a emisiilor de seră în zonele urbane aglomerate cât și prezentarea influenței construcției unui nou pod pietonal între campusul Universitatea Politehnica din București și căminele studențești. O analiză economică este efectuată pentru a sublinia că noua construcție va duce la beneficii în ceea ce privește reducerea timpului de călătorie, costurile de funcționare a vehiculului, nivelul emisiilor de gaze cu efect de seră etc.

Cuvinte cheie: emisii de gaze cu efect de seră, emisii de substanțe acidifiante, analiză economică

Abstract

Transport activities are regarded as one of the greatest contributors to greenhouse gas (GHG) emissions. Even though in other economic sectors the trend is to reduce the greenhouse emissions, the transportation field has been facing a continuous growth with negative effects on the environment. Due to its harmful potential for the inhabitants of large urban areas, a special attention is required as the land use individualities, transport network features and both spatial and temporal distribution of human activities often leads to traffic congestion. Universities represent an important pole of attraction because of their role as centers of

teaching, research and employment and the mobility generated by them must be taken into account. This research aimed to both develop an analysis of greenhouse emissions in urban congested areas and present the influence of a new pedestrian bridge between University Politehnica of Bucharest campus and student dormitories. An economic analysis is conducted to emphasize that the new construction will lead to benefits in terms of the reduction of travel time, vehicle operating costs, the level of greenhouse gas emissions, etc.

Keywords: greenhouse gases emissions, acidifying emission, economic analysis

1. INTRODUCTION

The transport sector is regarded as one of the most important sources of greenhouse gases (GHG) emissions in member countries of the European Union, such as nitrogen oxides (38.4%) ammonia (1.9%) and sulphur dioxide (0.2%) emissions. The NO_x exceedance is partially because the sector has grown more than anticipated and partially because vehicle emission standards have not always provided the expected level of NO_x reductions [12]. Moreover, according to the European Commission, it was the only source that presented an increase between 1990 and 2011 (19%), having a share of 20.2% from total emissions [13]. The Göteborg and the EU Directive on National Emission Ceilings (NECD - 2001/81/EC) set emission ceilings for the acidifying pollutants that states should have met by 2010. Within most European Environment Agency (EEA) member states (20 of 32), emissions of the three acidifying pollutants (SO₂, NO_x and NH₃) have decreased significantly between 1990 and 2012 [5]. The EU-28 met its overall target to reduce emissions of SO₂ and NH₃ as specified by the NECD while Finland and Spain exceeded the ammonia limits.

Furthermore, according to the Paris Agreement, the EU and its Member States governments agreed on a long term goal of keeping the increase in global average temperature to well below 2°C compared to pre-industrial levels and binding target to decrease GHG emissions by 2030 at least by 40% compared to 1990 [8]. Limiting warming to any level implies that the total amount of CO₂ that can ever be emitted into the atmosphere is finite. From a geophysical perspective, global CO₂ emissions thus need to become net zero. About two thirds of the available budget for keeping warming to below 2 °C have already been emitted, and increasing trends in CO₂ emissions indicate that global emissions urgently need to start to decline in order not to foreclose the possibility of holding warming to well below 2 °C. The Paris Agreement implicitly acknowledges these insights and aims to reach a global peak in GHG emissions as soon as possible together with achieving “a balance” between the anthropogenic emissions and the removal of GHG emissions in the second half of this century [11].

Although many European countries meet their acidifying emission ceilings, a special attention should be paid to transport sensitive areas (such as urban and high industrialized zones). In such areas, the air pollution at local or regional level has a negative impact because of the high pollutants concentration, due to specific climate conditions, to the canyon effect or atmospheric inversion process which allow the capture of emissions on inferior air layers, soil and water [1], [6], [13]–[16]. Since 2002, NO_x average annual mean concentrations at urban background sites have fallen by just 9%, while the reported NO_x emissions for the EU-27 decreased by 23% [12].

Acidifying emissions cause damage to ecosystems, to human health, to buildings, to cultural/historical monuments and to materials (corrosion). The effects associated with each pollutant depend on its potential to acidify and the properties of the ecosystems and materials. Nitrogen oxides, ammonia and sulphur dioxide contribute to acid deposition and eutrophication which directly disturb soil and water [2]. The acid deposition leads to adverse effects on aquatic ecosystems and damage to crops, forests and other vegetation. Nevertheless, the areas subject to acid deposition beyond critical loads in 2010 still exceed 10% of the EEA-32 natural ecosystems. Only in five of the EEA-32 member states the area at risk is estimated to be lower than 50% [13]. NO₂ is associated with direct adverse effects on human health because at high concentrations it can cause inflammation of the airways.

The aim of the present paper is to present a methodology for estimating GHG emissions in urban congested areas based on the Tier 3 approach of Emission Inventory Guidebook issued by The European Environment Agency. Tier 3 approach calculates exhaust emissions using a combination of technical data (such as engine capacity, type of fuel, emission standard) with activity data (mileage and average speed). The influence of the possible construction of a new pedestrian walkway between the UPB Campus and the Regie Student Complex is presented in terms of an economic analysis with emphasis on time travel savings, the reduction of vehicle operating costs, of air pollution and GHG emissions levels.

2. GREENHOUSE GASES EMISSIONS EVALUATION IN URBAN CONGESTED AREAS

The car traffic emissions with the highest greenhouse effect are CO₂, CH₄ and N₂O. CO₂ emissions are estimated based on the fuel consumption. CH₄ and N₂O are estimated based on the specific emission factors covering different traffic situation (urban, rural, highway) and engine characteristics. NO_x and NH₃ are

directly estimated, based on the specific emission factors covering different traffic situation and engine characteristics. SO₂ emissions are estimated based on the fuel consumption.

If we consider an oxygenated fuel with the generic chemical formula C_xH_yO_z, the end of pipe mass of CO₂ that is emitted by vehicles with the engine technology *k*, combusting the fuel *m* is:

$$E_{CO_2,k,m} = 44.011 \cdot \left(\frac{FC_{k,m}}{12.011 + 1.088 \cdot r_{H:C,m} + 16 \cdot r_{O:C,m}} - \frac{E_{k,m}^{CO}}{28.011} - \frac{E_{k,m}^{VOC}}{13.85} - \frac{E_{k,m}^{EC}}{12.011} - \frac{E_{k,m}^{OC}}{13.85} \right) \quad (1)$$

where:

$E_{CO_2,k,m}$ – CO₂ exhaust emission [g/km];

$FC_{k,m}$ – the fuel consumption of the vehicles [g/km];

$E_{k,m}^{VOC}$ – volatile organic components exhaust emission [g/km];

$E_{k,m}^{CO}$ – carbon monoxide exhaust emission [g/km];

$E_{k,m}^{EC}$ – elemental carbon exhaust emission [g/km];

$E_{k,m}^{OC}$ – organic carbon exhaust emission [g/km];

$r_{H:C,m}$ – the ratio of hydrogen to carbon atoms in the fuel;

$r_{O:C,m}$ – the ratio of oxygen to carbon atoms in the fuel.

Eq. 1 takes into consideration the emission of carbon (C) atoms in the form of carbon monoxide (CO) and volatile organic components (VOC). European Environmental Agency offers generic functions for estimating the fuel consumption (FC), CO and VOC emissions in relation to the vehicle type, fuel, engine capacity, engine emission standards and vehicle mean speed [4]. These functions having quadratic, power, polynomial form or a combination of them, have been estimated through statistical analysis of the empirical data, providing for most of them coefficients of determination higher than 0.9.

Based on the complementary studies [9] [10] done by different research teams, EEA estimated the N₂O emission factors by vehicle type, fuel, and engine technology. The N₂O emissions are not strongly dependent on vehicle average speed as CO₂ emissions are, but mainly on fuel and engine type. Diesel vehicles have lower N₂O emissions than catalyst equipped cars.

Table 1. Limits for N₂O emission factors [4]

Vehicle type	Fuel	N ₂ O emission factor [mg/km]
Passenger car	Gasoline	5 – 23
	Diesel	0 – 10
	LPG	0 – 24
Light- duty vehicle	Gasoline	10 – 28
	Diesel	0 – 9
Bus and coach	Diesel	1 – 40
	CNG	0
Heavy-duty vehicle	Diesel	7 – 53
Two-wheels vehicle	Gasoline	1 – 2

The CH₄ emission factors are directly estimated and not computed based on fuel consumption. The emission factors are discriminated according to vehicle type, fuel, engine technology and road category. The limits of the variation of CH₄ emission for different car/traffic characteristic are presented in Table 2.

Table 2. Limits for CH₄ emission factors [4]

Vehicle type	Fuel	CH ₄ emission factor [mg/km]		
		Urban	Rural	Highway
Passenger car and light-duty vehicle	Gasoline	2 - 131	2 - 86	0 - 41
	Diesel	0 - 28	0 - 12	0 - 8
	LPG	80	35	25
Heavy-duty vehicle, bus and coach	Diesel	85 - 175	23 - 80	20 - 70
	CNG	980 - 6800		
Two-wheels vehicle	Gasoline	150 - 219		

EEA also offers generic functions for estimating the nitrous oxides emissions in relation to the vehicle type, fuel, engine capacity, engine emission standards and vehicle mean speed [4]. These functions having exponential, power, logarithmical, polynomial form or a combination of them have been estimated through statistical analysis of the empirical data, providing for most of them coefficients of determination higher than 0.85. For instance, the emission factors for Euro 1 and later gasoline passenger cars have the generic function:

$$e_{Euro1,G}^{NOx} = \frac{a + c \times v + e \times v^2}{a + b \times v + d \times v^2}, \quad (2)$$

where:

$e_{Euro1,G}^{NOx}$ is the NO_x emission factor for gasoline Euro 1 vehicles [g/km];

v - vehicle mean speed [km/h];

$a-e$ - calibration coefficients specific to engine capacity.

The SO₂ emission factor is computed based on fuel consumption, assuming that all sulphur in the fuel is transformed completely into dioxide:

$$e_{k,m}^{SO_2} = 2 \times k_{S,m} \times FC_{k,m}, \quad (3)$$

where:

$e_{k,m}^{SO_2}$ is the SO₂ emission factor for vehicles with engine technology k and fuel type m [g/km];

$k_{S,m}$ – weight-related sulphur content in fuel of type m ;

$FC_{k,m}$ – fuel consumption [g/km].

The fuel consumption is highly sensitive to the average speed and has different generic function according to the technical characteristics of the vehicles and fuel [4]. The weight-related sulphur content is dependent on fuel type and production technology (Table 3).

Table 3. Fuel weight-related sulphur content in Romania

Fuel	Market share	Sulphur content [mg/kg]			
		Min.	Max.	Mean	Limit
Gasoline (95≤RON* <98)	16.45%	4	14	8	10
Gasoline (RON≥98)	10.24%	3	22	8	10
Diesel	73.31%	2	294	12	10

* RON – research octane number

Source: Romanian Transport Ministry – Fuel Quality Monitoring Report 2010

The NH₃ emission factors are calculated according to:

$$e_{k,m,r}^{NH_3} = [a \times Mileage + b] \times EF_{base} \quad (4)$$

where:

$e_{k,m,r}^{NH_3}$ is the NH₃ emission factor for vehicles with engine technology k , fuel type m driving on road type r [mg/km];

$Mileage$ – vehicle mileage [km];

EF_{base} – base emission factor [mg/km];

a, b – calibration coefficients.

The average mileages for each country and vehicle category are available on COPERT 4. The NH₃ base emission factors are not strongly dependent on vehicle average speed as NO_x and SO₂ emissions factors are. The emissions of GHG can be aggregated into CO₂ equivalent taking into consideration the relative effect to the climate change determined by the global warming potentials (GWP). Table 4 presents GWP for methane and nitrous oxide.

Table 4. Potential acidification equivalent [7]

Gas	Radiation efficiency [Wm ⁻² /ppbv]	GWP (20 years time horizon)
Carbon dioxide CO ₂	1.8 * 10 ⁻⁵	1
Nitrogen oxides NO _x	3.1 * 10 ⁻³	62
Methane CH ₄	3.7 * 10 ⁻⁴	275

The equivalent CO₂ emissions of vehicles crossing a specific area during a given time interval should be computed as:

$$E_{eq,CO_2} = \sum_{i=1}^n d_{i,k,m,r} \cdot (GWP_{CO_2} \cdot e_{CO_2} + GWP_{CH_4} \cdot e_{CH_4} + GWP_{N_2O} \cdot e_{N_2O}) \quad (5)$$

where:

$d_{i,k,m,r}$ is the mileage per vehicle [km] driven on road r by vehicle I of technology k and fuel type m;

GWP_j is the global warming potential for pollutant j;

e_j represents the emission factor [g/km] for pollutant j by vehicle of technology k, fuel type m on road type r ;

N is the number of vehicles [veh] that cross the study area.

The acidifying emissions can be aggregated into SO₂ equivalent taking into consideration the potential acidification equivalent (PAE).

Table 5. Potential acidification equivalent (PAE)

Emission	Potential acidification equivalent
Sulphur dioxide SO ₂	1
Nitrogen oxides NO _x	0.7
Ammonia NH ₃	1.88

3. CASE STUDY – THE INFLUENCE OF A PEDESTRIAN WALKWAY BETWEEN UNIVERSITY POLITEHNICA OF BUCHAREST CAMPUS AND REGIE STUDENT DORMITORIES

3.1. Description of the proposed pedestrian walkway

The project for the construction of the above-ground pedestrian passage connecting the UPB campus with the area of the southern dormitories in the Regie Student Complex is complementary to other residential development projects and the transport infrastructure in Bucharest. Splaiul Independenței belongs to the

major axis E – V of Bucharest, which involves major traffic flows with origin and destination in the extended study area, but especially transit flows to / from the A1 highway, Militari, Drumul Taberei and Crângași neighbourhoods and new areas developed in the neighboring localities in the western part of Ilfov County. The above-ground pedestrian crossing crosses the Dâmbovița River and the Splaiul Independenței, an artery with three traffic lanes and two sidewalks in each direction (Figure 1).

The construction of the proposed pedestrian walkway contributes to a better fluency of the road traffic on Splaiul Independenței, to the reduction of the congestion in the extended study area, with direct effects on the times spent in traffic and the pedestrian crossing times from the area of the Regie Student Complex to the UPB campus, the level of pollutants and GHG emissions, noise levels and the reduction of road accidents number.



Figure 1. Overview of the proposed pedestrian walkway

3.2. Economic analysis

An economic analysis takes into account both costs (like initial investment, approvals, projection, annual maintenance and repairs) and benefits such as consumer surplus (travel time savings, reduction of vehicle operating costs) and the reduction of the externalities (air pollution, GHG emissions, noises, accidents). Costs are entered in the analysis at economic value, estimated at 87%

of the financial value, taking into account monetary transfers determined by labor costs (tax effects) and its proportion of total costs (30%).

Table 6. Conditions regarding the evaluation of time savings

Vehicles occupancy rate (pers.)	1.5
LDV occupancy rate (pers.)	1.2
Buses occupancy rate (pers.)	30
Travel purpose for cars, buses:	
➤ at work	80%
➤ another purpose	20%
Travel purpose for LDV:	
➤ at work	100%
Unit time value – commuting to work (EUR/h)	6
Unit time value – travel for purposes other than work (EUR/h)	2

Travel time savings due to project implementation are estimated based on traffic patterns made for the analysis period. The volume of traffic, average speeds, distance traveled, occupancy of vehicles and purpose of travel are taken into account. The evaluation of the saved travel times due to the implementation of the project is based on the economic theory of marginal productivity. The value of time spent in the workplace takes into account the average net income in the study region and adjustments that reflect additional employee benefits, social and health contributions. The value of time not dedicated to travel to work will be considered 1/3 of the value of working time. The total value of the users' surplus due to travel time savings is shown in Table 7.

Table 7. The values of travel time savings

Semănătoarea → Grozăvești Direction		Operating														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vehicle hourly flow	veh/h	838	838	838	838	838	838	838	838	838	838	838	838	838	838	838
LDV hourly flow	veh/h	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
Bus hourly flow	veh/h	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Travel time reduction	min	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
The value of travel time savings	thousand EUR	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94
Grozăvești → Semănătoarea Direction		Operating														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vehicle hourly flow	veh/h	936	936	936	936	936	936	936	936	936	936	936	936	936	936	936
LDV hourly flow	veh/h	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
Bus hourly flow	veh/h	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Travel time reduction	min	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
The value of travel time savings	thousand EUR	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31

The costs of vehicles use include elements such as expenses for fuel, oil, tires, wear, repairs, insurance, etc. The increase of the traffic flow determines the reduction of the number of stops / starts and the increase of the average traffic speed, with effects in the decrease of the fuel consumption. Reducing the fuel costs of vehicle users is the quantifiable element that will be taken into account in the economic analysis.

Other expenses remain constant or vary with a negligible share. Fuel consumption takes into account traffic flows, traffic composition, type of engine, average travel speed, infrastructure characteristics (length, slope). The price of fuel is 1.2 EUR / l petrol and 1.24 EUR / l diesel. Prices are considered fixed for the duration of the analysis. Based on the data obtained from the traffic models, the reductions in vehicle use costs are estimated in Table 8.

Table 8. Reduction of vehicle operating costs

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Basic scenario	Annual petrol consumption (l)	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1	225709.1
	Annual diesel consumption (l)	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3	95492.3
Project scenario	Annual petrol consumption (l)	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6	197563.6
	Annual diesel consumption (l)	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6	83584.6
Reducing fuel consumption	Petrol (l)	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5	28145.5
	Diesel (l)	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7	11907.7
Reducing vehicle use costs	thousands EUR	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5

The unit values of the costs of air pollutants are at 22.893 EUR/t for NO_x, 1.796 EUR/t for VOC; 231.620 EUR/t for PM_{2.5} and 117.000 EUR/t for PM₁₀. For CO₂, whose emission allowances are tradable on the market, a cost of 33 EUR / t is considered, with an annual upward trend of 1 EUR / t. For the traffic conditions foreseen during the analysis period, the reduction of the costs of air pollution and greenhouse gas emissions can be found in Table 9.

Table 9. Costs reduction due to air pollution and GHG (thousand EUR)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NO_x	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
VOC	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
PM	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
Total air pollution	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20
Total GHG	12.87	13.26	13.65	14.04	14.43	14.82	15.21	15.60	15.99	16.38	16.77	17.16	17.55	17.94	18.33

Accident costs has two components:

- *direct expenses* which consist of medical expenses, those subsequent to hospitalization (fixed assets, permanent/temporary disabilities), administrative (emergency services, investigations, legal) and insurance expenses;
- *indirect expenses*, which reflect the net losses for the company (goods and services that could have been produced by the person who suffered an accident).

The calculation method takes into account VOSL (Value of Statistical Life) and the social benefits obtained by reducing the number of vehicle-pedestrian accidents due to the implementation of the project. Table 10 presents the statistical values associated with accident costs.

Table 10. Accident costs

	Fatal accident [EUR]	Severe accident [EUR]	Easy accident [EUR]
VOSL	400.000	52.000	4.000
Direct expenses	40.000	7.000	300
Total cost	440.000	59.00	4.300

The execution of the overpass pedestrian walkway project allows the separation of pedestrian and vehicle flows. As a consequence, the risks of accidents between vehicles and pedestrians are eliminated. The statistical data from the pedestrian vehicle accident analysis area are presented in Table 11.

Tabel 11. Vehicle – pedestrian accidents [nr. accidents/year]

Deadly accidents	-
Severe accidents	1
Light accidents	3

Given the annual number of accidents that will be avoided by the construction of the pedestrian crossing, we will determine the annual benefits shown in table 12.

Table 12. Annual benefits due to the reduction in the number of accidents

	Fatal accident [EUR]	Severe accident [EUR]	Easy accident [EUR]
Accident cost	440.000	59.000	7.000
Accidents annual number	0	1	3
Annual accidents cost reduction	0	59.000	21.000

From the calculation of noise emissions, there are no social benefits due to the change in noise level. Based on the costs and economic benefits associated with the pedestrian crossing project, the discounted cash flows are shown in Table

13. A social discount rate of 5% was used. The economic net present value (ENPV) of the project is 694.630 EUR while the economical return rate (ERR) is 11%. As a result, the project has economic sustainability and can be financed from public funds.

Table 13. Cash flows - economic analysis

		NPV 5%	Construction	Operating														
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Construction costs	thousand EUR	-1,102.46	-1102.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expenses for approvals, design	thousand EUR	-220.49	-220.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repair expenses	thousand EUR	-203.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-330.74	0.00	0.00	0.00	0.00	0.00
Expenses with maintenance	thousand EUR	-114.43	0.00	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02
Residual value	thousand EUR	371.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	771.72
Total economic costs	thousand EUR	-1,269.22	-1,322.96	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-11.02	-341.76	-11.02	-11.02	-11.02	-11.02	760.70
B1: travel time	thousand EUR	54.49	0.00	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25
B2: vehicle use	thousand EUR	503.41	0.00	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50
B3: air pollution	thousand EUR	417.26	0.00	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20	40.20
B4: GHG	thousand EUR	158.31	0.00	12.87	13.26	13.65	14.04	14.43	14.82	15.21	15.60	15.99	16.38	16.77	17.16	17.55	17.94	18.33
B5: accidents	thousand EUR	830.37	0.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
B6: noises	thousand EUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total economic benefits	thousand EUR	1,963.85	0.00	186.82	187.21	187.60	187.99	188.38	188.77	189.16	189.55	189.94	190.33	190.72	191.11	191.50	191.89	192.28
ENPV	thousand EUR	694.63	-1322.96	175.80	176.19	176.58	176.97	177.36	177.75	178.14	178.53	178.92	-151.43	179.70	180.09	180.48	180.87	952.98
ERR		11%																

4. CONCLUSIONS

As the transport sector is considered of the most important sources of GHG and acidifying emissions among EU member states, there has been a permanent concern to reduce the impact on the environment. Special attention should be paid to transport sensitive zones transport such as urban areas as GHG and acidifying emissions have a negative impact due to high pollutants concentration, policy makers should take into account new solutions to satisfy mobility, economic and social needs in order to minimize the negative external effects on the environment.

The case study presented in this paper outlines how the construction of a pedestrian walkway between the UPB Campus and the Regie Student Complex reduces the level of different GHG and acidifying emissions as human activities for road traffic are responsible for the existing high levels. The new construction also produces benefits in terms of travel time savings for the directions considered, the reduction of vehicle operating costs, the number of accidents and their related costs.

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