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LJULIN MOTORWAY ENVIRONMENTAL IMPACT ASSESSMENT

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Abstract. Ljulin motorway environmental impact assessment on the ambient air quality due to vehicles exhaust noxious atmospheric pollutants is made in the present study. Three alternatives version of the road-beds is examined - Green (G), Yellow (Y) and Orange (O) and compared with Zero and Blue+Brown variants.

Keywords: Environmental Impact Assessment, Air Pollution, Vehicles' Emissions, Pan-European Corridor IV, Ljulin highway.

Introduction

The concept of pan-European transport policy and corridors was born during the preparatory work for the 1st Pan-European Transport Conference organised by the European Union (Commission, Parliament) and the European Conference of the Ministries of Transport (ECMT) in 1991 in Prague. The purpose was to speed up the development of transport routes throughout Europe and to further contribute to smoother economic exchanges. With the enlargement process becoming a priority in Europe, the corridor concept started gaining ground. The Corridors were defined in their actual form by the 3rd Pan-European Transport Conference in Helsinki, 1997. The southern branch of Corridor IV provides the link running from Dresden/Nuremberg (Germany), via Praga (Czech Republic) Vienna (Austria), Bratislava (Slovakia), Budapest (Hungary), Craiova (Romania), Sofia (Bulgaria) to Thessaloniki (Greece) and to Istambul (Turkey). Along it there are to main infrastructure projects for Bulgaria - construction of a second combined rail and road bridge over the Danube River at Vidin-Calafat (DANUBE BRIDGE II) and construction of the notorious LULIN motorway.

Air Pollution prognosis

The environmental impact assessment on the ambient air quality due to vehicles exhaust noxious atmospheric pollutants is made on three alternatives version of the road-beds - GREEN (G), YELLOW (Y) and ORANGE (O). First of them (G) is evaluated up to the area of Kurlez villa-zone, as long as in the southern part it stands apart of the residential areas, unlike the other two road-beds.

According to the European legislation and the respective national legislation the prognosis of the expected air pollution will be made by the Regulatory Model for Calculating of the Vehicles' Emissions and Pollutants' Concentration in the Surface Layer - Software TRAFFIC ORACLE. The program consists of two main modules - ***EMISSIONS*** and ***DIFFUSION***.

1.Emission calculations

The evaluation of the emissions from the vehicles on the LULIN motorway is based on the data over main vehicles category number (Passenger Cars (PC), Light Duty Vehicles (LDV), Heavy Duty Vehicles (HDV) and Busses, made from Central Laboratory on Roads and Bridges for 2005, 2010 and 2020 (Ljulin highway EIA, 2003) and the relevant long-term prognosis of the traffic flow.

Only the "high growth of the traffic" (great negative influence on the environment) for 2005 scenario is considered.

Table 1. Vehicle category splitting for 2005

2005 / Vehicle split categories	Vehicle categories		growth	
			low	high
	PC		6 702	8 812
	HDV		1 568	1 988
	Busses		298	320
	LDV		1 594	2 034
1 Passenger Cars (<1.4l)	56%	11%	751	987
2 Passenger Cars (1.4 - 2.0l)		31%	2 064	2 714
3 Passenger Cars (>1.4l)		14%	938	1 234
4 Passenger Cars (diesel>2.0l)		20%	1 340	1 762
5 Passenger Cars (LPG)		24%	0	0
6 Passenger Cars (two stroke gasoline)		0%	1 608	2 115
7 Light Duty Vehicles (gasoline)		25%	399	509
8 Light Duty Vehicles (diesel)		75%	1 196	1 526
9 Moderate Duty Vehicles		26%	408	517
10 Heavy Duty Vehicles		23%	361	457
11 Heavy Duty Vehicles with trailer		51%	800	1 014
12 Urban Buses		0%	0	0
13 Coaches		100%	298	320

For the purposes of the calculations, the traffic flow must be split by vehicle categories (according to *Table 1*.) having in mind the following assumptions (based on elaborate information from Bulgarian Traffic Police, during the ***TRAFFIC ORACLE*** model development - N.Gromkova (2003a)) for:

1. 20% of **Passenger Cars** are diesel -category 4;
2. 24% of **Passenger Cars** are LPG - category 5;
3. The rest (56%) from **Passenger Cars** are divided between categories 1, 2 and 3 as follows: 20%, 55% and 25%, which gives 11%, 31% and 14% respectively;
4. 25% from Light Duty Vehicles are gasoline - category 7;
5. The rest 75% of Light Duty Vehicles are diesel - category 8;
6. The Heavy Duty Vehicles - categories 9, 10, and 11 are 26%, 23% and 51% respectively;
7. 100% from the Buses are Coaches - category 13.

On emissions calculating the distinct in emission derived from the vehicles during their motion up or down the slope is taken into account (the average slope is 4%).

2. Disperse calculations

2.1 Annual pollution concentrations

The prognosis of air pollution concentration is carried out by second module ***DIFFUSION.*** This program task makes statistical or episodic simulation of the expected concentrations for a specific pollutant - N.Gromkova (2003b).

INPUTS

- *Model Input* - regular receptor grid, where the disperse calculations will be done in an area of 11600 x 14200 m (58 steps in West-East direction and 71 steps in South-North direction - each of 200 m).
- *Meteorological Input* - the annual climatic wind roses from Sofia and Pernik (Fig. 1 and Fig. 2) are used for the northern and southern branches of the road-beds respectively.

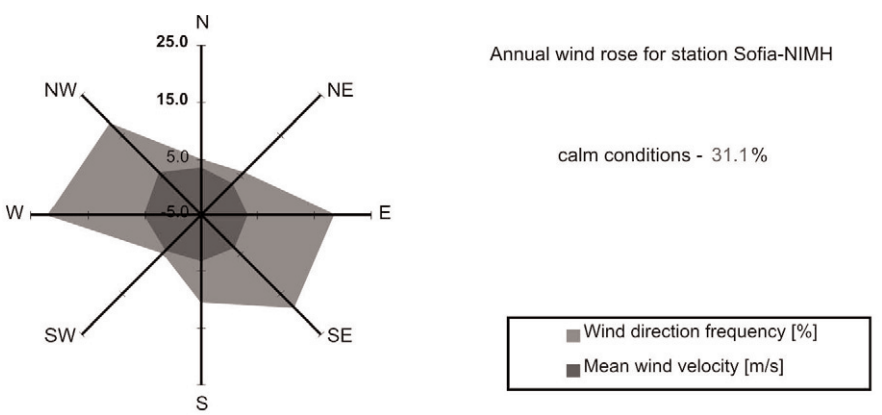

Fig. 1

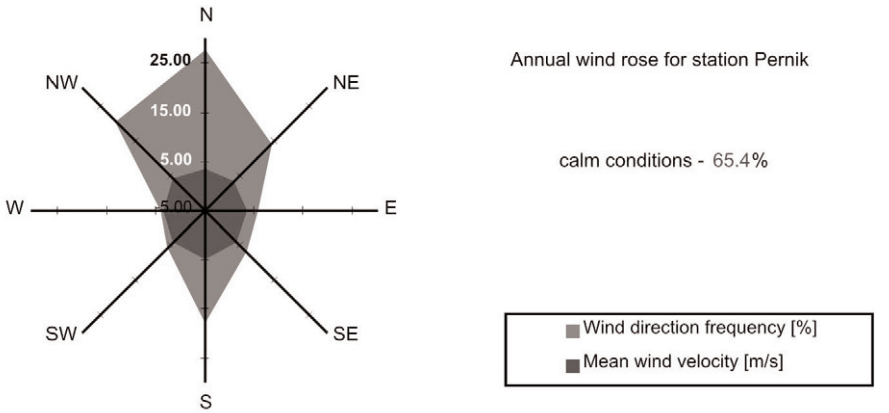

Fig. 2

• *Source parameters* - The respective input information about a particular line source is: X_1, Y_1, X_2 and Y_2 coordinates of a line segment [m]; width of the road [m] and emission rate [g.m^{-1}.s^{-1})], obtained by the detailed methodology. A "high growth" regime for the traffic is chosen for the year of 2005. (For the O variant, which divides in north-western and south-eastern branch to north of Kniajevo residential district, two different variants are considered: O2- with traffic, divided equally between these two branches and O1 - only the north-western branch functioning.)

The irregular receptors are added in the calculation grid, which are situated at distances of 30, 50 and 100 m to the both banquette sides of the traffic lines, conforming to the width of the road.

RESULTS

Since the annual climatic wind rose is applied, the isopleths of expected concentrations for the different variants of the road-bed - G, Y, O1 and O2 can be compared with annual Limit Value (LV) for appropriate pollutant.

In *Table 2* the maximum concentrations are shown only for pollutants with available annual LV in the Bulgarian legislation.

According Regulation 9/1999:

- The annual LV for the oxides of nitrogen (NO_x) is 0.04mg/m^3 that have tobe reached in 2010. For the previous years there exists the Margin of Tolerance (MT) and the value of LV+MT is 0.05mg/m^3 for 2005. The annual Lower Assessment Threshold (LAT) for protecting the human health is 65% of LV, namely 0.026 mg/m^3.
- The Annual LV for PM_{10} is 0.02mg/m^3 that have to be reached in 2008. For the previous years there is a MT and the value of LV+MT is 0.039 mg/m^3 for 2005. The annual LAT for human health protecting is 0.01 mg/m^3.

According Regulation 14/1997 the annual LV for Cd and Pb are 0.00001 mg/m^3 and 0.0005 mg/m^3 respectively.

Table 2. Pollutants concentration for 2005

Pollutant	**NOx**	**Cd**	**Pb**	**PM_{10}**
Annual LV+MT for 2005 [mg/m3]	**0.05****	**1.0E-05 ***	**5.0E-04 ****	**0.039****
Annual LAT [mg/m3]	*0.026***	-	-	*0.01***
Maximum annual concentration [mg/m3]	**variant G**	**Sofia - rose NIMH**		
	0.03904	3.996E-08	4.585E-06	0.0032
	variant Y	**Sofia - rose NIMH**		
	0.04032	4.13E-08	4.74E-06	0.0033
	variant Y	**Pernik - rose**		
	0.08747	8.34E-08	9.57E-06	0.0067
	variant O1	**Sofia - rose NIMH**		
	0.03678	4.35E-08	4.99E-06	0.0035
	variant O2	**Sofia - rose NIMH**		
	0.03681	4.22E-08	4.84E-06	0.0034
	variant O1	**Pernik - rose**		
	0.09557	9.12E-08	1.05E-05	0.0073

* Regulation 14, 1997 - *threshold limit values for hazardous substances in ambient air within settlement areas*;
** Regulation 9, 1999 (DIRECTIVE 1999/30/EC) - l*imit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air;*

As is seen, only the concentration of the oxides of nitrogen exceeds both the LV and the LAT (the values in **Bold** and in *Italic* respectively - Table 2). For the northern parts of the road-bed of LJULIN motorway there are the exceeding of the LAT in the narrow and small areas around the traffic way - G, Y and O1, excluding O2, when the traffic till Kniajevo splits on two branches. In the southern parts of the Y and the O variants the concentration of the oxides of nitrogen is above LV, but in the immediate vicinity around the object.

2.2 Maximum single concentrations

This dispersion task calculates the maximum single concentration at the most disadvantageous for the source configuration meteorological conditions for a particular pollutant.

INPUTS

• *Model Input* - regular receptor grid, where the disperse calculations will be done in an area of 11600 x 14200 m (58 steps in West-East direction and 71 steps in South-North direction - each of 200 m).

• *Meteorological Input* - the dispersion rate can be characterized by Pasquill stability class. That is why the calculations make a loop over combinations of meteorological parameters (Table 3), where the stability classes are defined by the prevailing meteorological conditions of surface wind speed measured at 10 meters above ground level and day-time incoming solar radiation or the night-time percentage of cloud cover.

Table 3. Pasquill stabilities classes (adapted from Turner 1994)

	Daytime			Night-time*	
Wind speed	Incoming Solar Radiation			Cloud Cover	
[m/s]	strong	moderate	slight	>50%	<50%
<2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

*Night is defined as period from 1 h before sunset to 1 h after sunrise;
A - extremely unstable, B - moderately unstable, C - slightly unstable, D - neutral, E - slightly stable, F - moderately stable turbulent conditions.

• *Source Input* - same as in chapter 2.1.

RESULTS

In Table 4 the expected maximum single concentrations only for NOX pollutants with available maximum or diurnal LV in the Bulgarian legislation are generalized (the values in **Bold** are those exceeding the respective LV and the *Italic* ones - LAT).

Table 4. Maximal single concentrations

Pollutant	**Maximum Single Concentrations[mg/m³]**		**Meteorological Conditions**	**LV(1h)+MT [mg/m³]**	**LAT [mg/m3]**
NO_x	**Northern road-beds**			**0.25***	*0.1**
	0.1740	**G and Y**	Wind speed 1m/s; Wind direction 0° ; Stability class B		
	0.1699	**O2 and O1**	Wind speed 1m/s; Wind direction 225° ; Stability class B		
	Southern road-beds				
	0.1742	**Y**	Wind speed 1m/s; Wind direction 225° ; Stability class B		
	0.1348	**O**	Wind speed 1m/s; Wind direction 45° ; Stability class C		

** Regulation No 14, 1997 - threshold limit values for hazardous substances in ambient air within settlement areas;*
*** Regulation No 9, 1999 (DIRECTIVE 1999/30/EC) - limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air;*

The most unfavourable meteorological conditions, when the maximum single NO_x concentrations exceed the LAT for the human health, are observed for moderately (class B) and slightly unstable (class C) stratification and weak wind (1-2 m/s). The spread of the pollutants under those conditions will be achieved comparatively fast and a single-time higher ground level concentration could be observed near to the source in clear and calm weather (light wind speed) in the early morning hours when it is sunny.

As seen from Table 4 the unfavourable wind directions are:

- For the Northern parts of the different variants:
  - **G** and **Y** - winds from north with probability 4.7%;
  - **O** - winds from south-west with probability 4.3%.
- For the Southern parts of each variant:
  - **Y** - southwestern wind with probability 5.4%;
  - **O** - northeastern wind with probability 14.1%.

For the rest of the pollutants the concentrations are in the prescribed from the Bulgarian legislation allowances.

2.3 Banquette receptors concentration

On *Table 5* are shown the maximum and averaged concentration in irregular points, sited on both banquette sides of the roads at distances of 30, 50 and 100 m along the different variants of the road-bed of "Ljulin" highway only for pollutants with available single LV in the Bulgarian legislation.

From the above table is clear, that when considering the annual roses of the wind, only the climatic concentrations (in defined point) for nitrogen oxides exceed the LV on the road itself (0 m). The averaged concentrations in all the receptors exceed the LAT only on the road. At 100 m distance from the roadway even the maximum concentrations are below the LV.

2.4 Analysis

The principle effects on ambient air quality that are correlated with the construction of the new traffic communications can be summarised as follows for:

- **Urban area** - in the built-up city regions (so-called street canyons) the impact assessment of main urban roads is potentially dangerous. An important role for the higher pollution in the urban areas in comparison with the highways have:

1. the junction with traffic lights - in regime of traffic lights stop an over noxious emissions are obseved;
2. in the urban areas normally exist other sources of air pollutants (residential and industrial) which could increase the effect of the traffic pollution;
3. in the cases when the urban area is in a region with prolonged and intensive insolation the so-called "photochemical smog" is observed. Its adverse effect on the human health is obvious.

- **Highways** - the above-mentioned considerations does not refer to, because:

1. significant abatement of gas emissions through the thermal-stable driving regime of work of the automobile engines;
2. the constantly high velocities of the vehicles on the highway;
3. the exhaust-pipe of the vehicle is cold and low source and the contamination from it does not distributed at great distance - it reaches at least to the end of the easement (servitut?)(100 m) of the highway, in absence of the street canyon;

Specifically for the region on consideration - the "Ljulin" highway area:

1. the duration of the insolation doesn't exceed 45% of the possible for these latitude;
2. in all the low-mountain part of the region during the most time of the year the experienced wind is west-northwesters, which are an important factor for the pollutants spreading. The same stands for the mountain-valley winds, observed in anticyclones in the summer;
3. only in the region of Dragitchevo there exists a real possibility for combination between the industrial and home-heating pollution and the pollution through the automobile traffic. An important factor for this are the frequent temperature inversions in the hollow;
4. frequent temperature inversions in both the hollows are with capacity up to 100-150 m and reach the lowest northern parts of the road-beds - the region of Filipovtsi and the region of the neighbourhood Dragitchevo in their southern parts. The towns at the foot of the Ljulin-mountain are seldom damaged from this meteorological phenomena because of their higher altitude above the sea

level and because the temperature inversions are important for higher and warmer sources.

The **Zero** variant (the old highway Pernik-Sofia) - the highest danger of polluting the villages Dragithcevo, Vladaa, Gorna Bania and Suhodol and the Kniajevo neighbourhood because the existinf roadway follows the lowest part of the Vladaia defile, which has the leest aeration in comparison with the rest variants of the highway and doesn't permit higher velocities.

Variant **Blue+Brown**- all disadvantageous of **Zero** variant are diminished for the possibility of serious pollution of the air. Some higher possibility of pollution exists for north-western parts of Malo Butchino and Dragitchevo because the prevailing north-western winds and proximity of the both villages to the road-bed in conditions of traffic jam there. For the neighbourhoods Filipovtsi and Suhodol no differences from the present state are expected. For Bankia this variant doesn't lead to change for the worse of the air quality, since the influence of the traffic on the highway is insignificant in comparison with the influence of the low velocity vehicle flux in the Bankia itself.

Variant **Green** - it is more unfavourable for Suhodol, since it crosses its north-western part. It is more infavourable for Dragitchevo too, as it stands closely in comparison with the up-mentioned variant. For the rest of the villages and for the guarded zone type "B" this variant is better than the up-mentioned one because the road-bed is farther.

Variant **Yellow** - it has the same estimation in the northern part as the Green, but in the southern part it is most unfavourable for Dragitchevo because it comes too close to it.

Variant **Orange** - the location of the south-east branch of its road-bed (at north from Kniajevo) is unfavourable for Gorna Bania and Kniajevo. For the rest of the villages and neighbourhoods the influence is the same as is for the Green and the Yellow variants.

Conclusions

1. The communication artery "Ljulin" will improve markedly the air quality of the southern catenary of Sofia Ring-road. The project will also provide favourable conditions for maintaining a more uniform driving condition which in turn will lead to a reduction of fuel consumption, a better fuel combustion and a respective reduction of the emissions related to this.
2. The pollutant dispersion modelling for the new road-beds of "Ljulin" highway shows that only the oxides of nitrogen will have direct negative effect on well defined parts of the road.

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Оценка въздействието върху околната среда от автомагистрала "ЛЮЛИН"

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Резюме: В настоящата статия е направена оценката на въздействието върху качеството на атмосферния въздух от вредните вещества в отработилите газове от двигателите с вътрешно горене на моторните превозни средства (МПС), движещи се по новата магистрала "Люлин". Три алтернативи на пътното трасе са изследвани: зелен вариант (G), Жълт (Y) и Оранжев (O), като са сравнени с нулевата алтернатива и Син+Кафяв вариант на трасето.