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**Project Advisory Support Service**

**AA 010343 – MEF PASSA 2**

**Assessment of CO2 and air pollutant emissions for road projects in Romania**

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Contents

[1. Context/ Introduction 3](#_Toc71361196)

[2. Traffic data and model 3](#_Toc71361197)

[3. Excel files 3](#_Toc71361198)

[4. Assessment of fuel consumption by type of vehicles and type of fuels, depending on speeds 4](#_Toc71361199)

[5. Assessment of the CO2 and air pollutant emissions based on fuel consumption 5](#_Toc71361200)

[6. Calculation of the network-wide fuel consumption, in the with and without project scenarios 7](#_Toc71361201)

[7. Calculation of the network-wide CO2 and air pollutant emissions, in the with and without project scenarios, and of the related socio-economic costs 7](#_Toc71361202)

[8. Comparison between the with and without project scenarios, enabling to determine the impact generated by the project 8](#_Toc71361203)

[9. Case of electric vehicles 8](#_Toc71361204)

[10. CBA model verification 9](#_Toc71361205)

[Annexes: 9](#_Toc71361206)

# Context/ Introduction

The scope of this document is to present how CO2 and air pollutants emissions generated by the operation of new road projects have been assessed, in the framework of the EIB PASSA support to the Ministry of Transport for the development of an investment plan. The overall scope has been to perform a cost-benefit analysis of a number of 25 road projects (motorway sections), enabling to take into account the socio-economic return of these projects in a prioritisation exercise.

It has to be mentioned that none of these motorway projects is foreseen as being subject to tolling, so that no financial revenues are generated by any of the projects. Therefore, financial analysis were meaningless and the analysis has been exclusively a socio-economic one.

The calculations of CO2 and air pollutant emissions have been based on the following steps:

* Assessment of fuel consumption by type of vehicles and type of fuels, depending on speeds,
* Assessment of the CO2 and air pollutant emissions based on fuel consumption,
* Calculation of the network-wide fuel consumption, in the with and without project scenarios,
* Calculation of the network-wide CO2 and air pollutant emissions, in the with and without project scenarios, and of the related socio-economic costs,
* Comparison between the with and without project scenarios, enabling to determine the impact generated by the project.

# Traffic data and model

The traffic data have been provided by Cestrin, the research directorate of the Road Company CNAIR, using the road model they have developed. The Cestrin traffic model is based on the national transport model developed for the General Transport Master Plan. However, it focuses on the road network. Furthermore, the national transport model is based on 2011 traffic data while the Cestrin traffic model has been recalibrated taking into account the 2015 traffic census performed country-wide.

The development of the Cestrin traffic model has been followed by Jaspers. The traffic model is not strictly certified or validated by Jaspers but is considered as a sound and reliable basis for traffic modelling and forecasting.

The model represents the road network used for interurban trips. It therefore includes all national roads, a significant part of the county roads as well as the most important streets (i.e. those used by interurban traffic). In total, the model includes more than 12500 individual links or segments of roads.

For each of the 25 projects being assessed, as well as for the without project scenario, Cestrin has provided traffic data for the entire network (each of the 12 500 links), for the following time horizons: 2025, 2030, 2035, 2040, 2045 and 2050.

For each link, the following data is provided: link identification, length, location (urban/rural), free flow speed, number of cars, light trucks, heavy trucks and buses, speed for cars, light trucks, heavy trucks and buses. The speed levels for each type of vehicle are derived from speed / flow relationships taking into account the road capacity, the free flow speed and the actual traffic levels.

# Excel files

The entire set of Excel files represents 27 files, as follows:

* “ACB baza generala.xls”: this is the central file, presenting (i) all assumptions and parameters, (ii) the network-wide costs and values for each scenarios and (iii) the CBA calculations for each of the 25 projects.
* “calcul retea fp.xls”: this file is the calculation of network-wide costs and values in the without project situation (fp= fara proiect, without project in Romanian). It is composed of 6 sheets with the calculations for each link in each of the years for which Cestrin provided data and the 7th sheet “efecte socio eco fp” is the recapitulation of the network wide total costs and values for each of these years as well as the interpolation for the intermediate years. This sheets is then copied in the ACB baza generala.xls file.
* “calcul retea 1 ploiesti pascani.xls”: this file has the same structure than the previous one, but it calculates network wide costs and values related to the situation with project no. 1, respectively Ploiesti – Pascani motorway.

Similarly, the 24 other files present the calculations related to the 24 other projects.

# Assessment of fuel consumption by type of vehicles and type of fuels, depending on speeds

The formula of calculation of fuel consumption in function of the speed has the following form:

L = a/V + b + c\*V + d\* V^2

Where L is the consumption in litre per km, V is the speed in km/h and a, b, c and d coefficients as per the following table:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | a | b | c | d |
|  | petrol |  |  |  |
| Passenger car | 0.964022581 | 0.041448030 | -0.000045416 | 0.000002013 |
| Light truck | 1.556463336 | 0.064253320 | -0.000074448 | 0.000001006 |
|  | diesel |  |  |  |
| Passenger car | 0.437094041 | 0.05861649 | -0.00052488 | 4.13E-06 |
| Light truck (and microbus) | 1.045268333 | 0.05790142 | -0.000432895 | 8.03E-06 |
| OGV1 (2 axles, 3 or 4 axles) | 1.477368474 | 0.24561521 | -0.003572413 | 3.06E-05 |
| OGV2 (articulated) | 3.390702946 | 0.39437905 | -0.004642285 | 3.59E-05 |
| Bus | 4.115603124 | 0.30646481 | -0.00420643 | 3.65E-05 |

These coefficients are those defined within the General Transport Master Plan. They are actually using coefficients used in the UK developed WebTag model[[1]](#footnote-1), which is generally recognised as state of the art in this regard.

The results of the formula can be presented as per the following figure, showing, for the different types of vehicles and fuels, the consumption of fuel in litre / 100 km in function of the speed level.

The formula as well as the above figure can be found in the sheet “VOC” of the file “ACB baza generala.xls”. It is used in order to calculate part of the vehicle operating costs, but also as a basis for CO 2 and air pollutant emissions.

On the same sheet (lines 31 to 44), coefficients are defined for progressive reduction of fuel consumption over time. This actually reflects the technological progress. The coefficients used are those defined by the UK Webtag version July 2017. Since Webtag does not provide any coefficient further to 2035, as a prudential approach, the analysis considers no further reduction of fuel consumption.

The lines 46 to 53 of the same sheet define the fuel consumption reduction coefficients using the base year 2020 as reference year (value 100).

# Assessment of the CO2 and air pollutant emissions based on fuel consumption

The CO2 emissions are defined as a function of the fuel consumption and as a function (with a much smaller impact) of engine oil consumption, itself depending on fuel consumption.

All values are derived from the EMEP/EEA air pollutant emission inventory guidebook 2016 - Update June 2017, using the Tier 1 method.

Since the emission factors are provided in g or kg / kg of fuel, the following conversion factors are used to convert litres of fuel into kg[[2]](#footnote-2):

|  |  |
| --- | --- |
|  | kg |
| petrol - 1 litre = | 0.7372 |
| diesel - 1 litre = | 0.8508 |

For CO2, the following parameters are used, as described in “ACB baza generala.xls” sheet “CO2”:

|  |  |  |
| --- | --- | --- |
| Fuel related |  | kg CO2 / kg fuel |
| All vehicles | Petrol | 3.180 |
| All vehicles | Diesel | 3.140 |
|  |  |  |
| Engine oil related |  | g CO2 / kg fuel |
| Passenger cars | Petrol | 8.84 |
|  | Diesel | 8.74 |
| Light trucks | Petrol | 6.07 |
|  | Diesel | 6.41 |
| Heavy trucks and buses | Diesel | 2.54 |

The following air pollutants are being retained in the analysis: NOx, NMVOC, SO2 and PM. It is mentioned that these are retained since these are the main pollutants and also those for which a monetary value is being defined in the Handbook for external costs in transport, produced for DG Move.

For NOX, the following emission factors are used, as described in “ACB baza generala.xls” sheet “Poluare aer”:

|  |  |  |
| --- | --- | --- |
| NOx |  | g/kg fuel |
| Passenger cars | Petrol | 8.73 |
|  | Diesel | 12.96 |
| Light trucks | Petrol | 13.22 |
|  | Diesel | 14.91 |
| Heavy trucks and buses | Diesel | 33.37 |

For NMVOC, the following emission factors are used, as described in “ACB baza generala.xls” sheet “Poluare aer”:

|  |  |  |
| --- | --- | --- |
| NOx |  | g/kg fuel |
| Passenger cars | Petrol | 10.05 |
|  | Diesel | 0.7 |
| Light trucks | Petrol | 14.59 |
|  | Diesel | 1.54 |
| Heavy trucks and buses | Diesel | 1.92 |

For SO2, the following emission factors are used, as described in “ACB baza generala.xls” sheet “Poluare aer”:

The formula used is: E (g) = 2 x sulfur (g / g fuel) x fuel consumption (g). This formula can also be written as: 2 x sulfur (g / kg fuel) x fuel consumption (kg).

The standard maximum level of sulphur is 10 mg / kg fuel. Considering that this maximum admissible level is the actual level, this leads to a content of sulphur of 0.01 g / kg fuel.

Therefore, the emission factor for SO2 is: 2 g/ kg of fuel consumed.

For PM (fine particles), two emission factors are being used: the first one is related to fuel while the second one is related to vehicle-km (non-exhaust emissions), as follows:

|  |  |  |
| --- | --- | --- |
| PM exhaust |  | g/kg fuel |
| Passenger cars | Petrol | 0.03 |
|  | Diesel | 1.1 |
| Light trucks | Petrol | 0.02 |
|  | Diesel | 1.52 |
| Heavy trucks and buses | Diesel | 0.94 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Tyres and breaks | Road surface | total |
| PM 2.5 non-exhaust | g/veh-km | g/veh-km | g/veh-km |
| Passenger cars | 0.0074 | 0.0041 | 0.0115 |
| Light trucks | 0.0117 | 0.0041 | 0.0158 |
| Heavy trucks and buses | 0.0316 | 0.0205 | 0.0521 |

# Calculation of the network-wide fuel consumption, in the with and without project scenarios

The consumption of fuel is calculated in the Excel files named “calcul retea […].xls”.

The calculation is made in two steps:

* Step 1 (columns AO to AX): based on the speed for each link and each type of vehicles, the formula described in chapter 4 above is applied. The result is multiplied by the length of the link in km, the number of vehicles of the related type and 365 to obtain a total number of litres per year for the link.
* Step 2 (columns CP to CX): the number of litres per year is transformed into kg per year and, depending on the related year, the coefficient of reduction of fuel consumption is also applied.

# Calculation of the network-wide CO2 and air pollutant emissions, in the with and without project scenarios, and of the related socio-economic costs

The CO2 and air pollutants emissions (in tons) are calculated for each link of the network and then added to obtain network-wide values. The calculation is made in the Excel files named “calcul retea […].xls”, on the following columns:

* NOx: columns CZ to DJ
* NMVOC: columns DN to DX
* SO2: column EB
* PM: columns EF to EP
* CO2: columns FD to FN.

The network-wide values are then reported in the sheet “efecte socio eco” for each of the traffic study years and interpolated for the intermediate years.

# Comparison between the with and without project scenarios, enabling to determine the impact generated by the project

The values in the sheets „efecte socio eco” from the Excel files named “calcul retea […].xls” are transferred to the Excel file „ACB baza generala”, for each project (and for the without project situation).

In order to determine the impact generated by the project, the network-wide emissions in the without project situation are subtracted with the network-wide emissions in the with project situation. In case the result is negative, this means that the project generates net emissions.

This comparison is made in the sheets “ACB XX” (where XX is the number of the project being analysed), rows 70 to 79 for each year of the analysis period. On rows 81 to 90, the total values, cumulated for the analysis period, are being presented.

# Case of electric vehicles

In annexes to the present document are presented two other documents elaborated by the EIB PAS Team, in Romanian language, namely:

* “Scenariu de evoluție a numărului de autoturisme electrice în România”: this document presents a forecast of the evolution of the passenger cars fleet in Romania, a forecast of the evolution of the fleet of electric passenger cars and, as a result, the possible evolution of the share of electric cars within the overall passenger cars fleet in Romania. These forecasts are based on the continuation of existing trends, i.e. assuming a continuation of the incentive support to purchase of electric cars but without taking into account any future regulatory measure such as the interdiction of purchase or production of passenger cars using internal fuel combustion. Although such regulatory measures are quite likely to occur in the future, it would be imprudent, at this stage, to consider them in a forecast. Therefore, the evolution of the share of electric cars is seen as based on a fairly conservative approach.
* “Vehicule electrice în ACB”: this document presents the way electric passenger cars are being treated within the CBA. In particular, it defines the electric consumption of electric cars by km, and, based on the Romanian electricity mix and taking into account the efficiency of electricity production on one side, transport and distribution on the other side, the CO2 and air pollutants emissions related to 1 kWh at the electric car plug.

The parameters and values for electric passenger cars have then been introduced in the CBA analysis. They are presented in the sheet “veh electrice” of the Excel file “ACB baza generala.xls” and used in the calculations in the Excel files “calcul retea […].xls”, where specific columns are dedicated to electric cars, within the columns mentioned in chapter 7 above.

As regards electric vehicles, the following can be mentioned:

* For the time being, the technological state of progress allows to consider electric vehicles in interurban traffic for passenger cars only. While electric vehicles are also a viable option for urban public transport, it is not developed in a way that would reasonably enable to consider electric freight vehicles or long distance public transport (minibuses, buses).
* Due to substantial State support, Romania currently has, in absolute numbers, one of the largest fleet of electric passenger cars in the UE. The absolute number of electric cars in Romania is significantly higher than that in countries like Italy, Portugal, Belgium or Denmark.
* In the absence of other elements, it has reasonably been considered that the share of electric vehicles engaged into interurban traffic will be the same as the share of electric vehicles within the passenger cars fleet. While electric mobility (even for passenger cars) is easier in urban and short distance trips, two elements have been taken into account when making this assumption:
  + as presented in the General Transport Master Plan, more than 95% of interurban trips using passenger cars are made on distances of less than 175 km while the average length of trips is below 100 km; even with the present average autonomy of electric cars, such distances are easily within reach.
  + electric passenger cars are obviously much newer than the average passenger cars (average age of the passenger cars fleet is between 10 and 15 years in Romania), implying that electric cars are likely much more reliable.
* Taking into consideration electric cars in the model leads to some reduction of CO2 and air pollutant emissions as against considering only petrol and diesel passenger cars. Such reduction is however fairly limited, in line with the limited share of electric cars within the overall cars fleet. Furthermore, the use of electric cars is considered in both the with and without project situations, so that, incrementally, the impact is extremely limited.

# CBA model verification

The CBA Excel model has not been validated in a formal way. However, the different calculations and assumptions (parameters values) have been reviewed and partly corrected by Jaspers.

The CBA Excel model has been used for several projects approved under ESIF, including major projects subject to formal review and approval of the European Commission (including IQR) such as the construction of the Danube bridge in Braila.

# Annexes:

* Scenariu de evoluție a numărului de autoturisme electrice în România
* Vehicule electrice în ACB

1. [TAG Data Book - GOV.UK (www.gov.uk)](https://www.gov.uk/government/publications/tag-data-book) [↑](#footnote-ref-1)
2. “ACB baza generala.xls” sheet “Poluare aer”, rows 56 to 58 [↑](#footnote-ref-2)