AN APPROACH FOR DETERMINATION OF THE ECOLOGICAL EFFICIENCY OF INTERMODAL FREIGHT TRANSPORT

ПОДХОД ЗА ОТЧИТАНЕ ЕКОЛОГИЧНАТА ЕФЕКТИВНОСТ ОТ ИНТЕРМОДАЛНИ ПРЕВОЗИ

ПОДХОД К ОПРЕДЕЛЕНИЮ ЭКОЛОГИЧЕСКОЙ ЭФФЕКТИВНОСТИ ИНТЕРМОДАЛЬНЫХ ГРУЗОВЫХ ПЕРЕВОЗОК

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Abstract: *The main issues are considered in this topic: the mathematical model to determine the ecological efficiency of intermodalal freight transport; there are calculations for the rail route Dragoman-Svilengrad; the results obtained are shown.*
KEYWORDS: RAILROAD CONVEYANCE, FREIGHT, AUTOMOTIVE, RO-LA, TIR, ECOLOGICAL EFFICIENCY

1. Introduction

Intermodal freight transportation, are increasingly used in many European countries. One of the main reasons for the development of this transportation is the seeking new opportunities for the successful resolution of transportation problems associated with environmental pollution. For example, road freight transport has a significant impact on pollution of environment. Therefore, there are national ceilings / standards / limit levels emitted harmful emissions from internal combustion engines, in the European directives , such as mandatory requirements applied in the organization and implementation of transport processes. To achieve these standards should be used appropriate methods, methodologies and approaches for integrated determination of environmental efficiency of the implementation of intermodal transport.

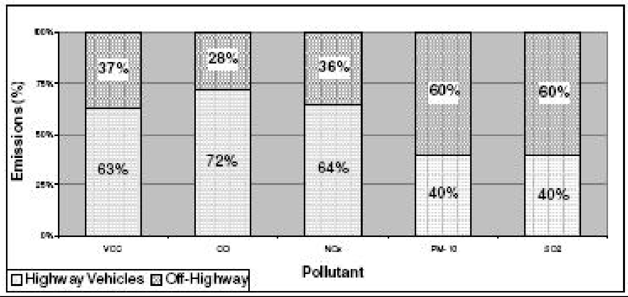
Study of literature shows that for calculating the environmental performance of road transport, there are basically three approaches - *simplified, detailed* and *complex*. The application of these approaches in practice allows to adequately reflecting the degree of influence of harmful emissions from vehicle engines driving the truck.

For intermodal transport, however, we participate and other modes of transport, i.e. rail. Thus, for electrified sections should be applied approach for determining the amount of emission of greenhouse gases from electricity power necessary for the implementation of train movements.

This report examined a approach for integrated determination of environmental efficiency by the use of intermodal freight technology on RO-LA (Rollende Landstrasse) taking into account the impact and the emission factors in train movement.

Air pollutants emitted from freight trucks and rail used in freight transportation include:

NOx	nitrogen oxides – (equivalent NO2)
VOC	volatile organic compounds
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
N_2O	nitrous oxide
PM	particulate matter
SO_2	sulphur dioxide
NH_3	ammonia
Cd	cadmium
Pb	lead
PAH*	poli. aromatic hydrocarbons
DIOX	Dioxins and furans
PCBs	Polychlorinated biphenyls



Source: (U.S. Environmental Protection Agency (EPA), 2005a)

Figure1. Contribution to National Emissions

2. Approaches for determining the emissions from movement of the vehicle under its own power

Based on the reviewed approaches, methods and software (models, calculators, etc..) applied to determine the level of emission of greenhouse gases in the movements of cars [1] [2] [3], [8], can be made following main conclusions:

- The main three modes of engine operation - *idle, hot* and *cold*;
- travel conditions - *urban, outside the city* and *highway*;
- technical equipment - vehicle, engine, catalyst, etc.;
- performance - gross weight, speeds, gradients and more.

Simplified approach

This approach is based on the use of emission parameters defined on the basis of *fuel consumption* (harmful emissions from combustion of unit quantity of fuel - diesel).Operation mode of the engine - *hot* and condition to travel - *outside the location / highway.*

(1) $$E^{cx}_{AT,i} = L_{AT}.EF_i, \quad [g]$$

Where:

$E^{cx}_{AT,i}$: the total emissions output of a given air pollutant i;

L_{AT} : the distance [km] ;

EF_i : the emission factor EF for the pollutant i, [g/km].

Detailed approach

And this approach is based too on the use of emission parameters defined on the basis of fuel consumption. Three main travel conditions are used; *urban, outside the city* and *highway*. The emissions for each of them is derived from summing the emissions from two-mode engine's - *hot* and *cold* (only for *urban*).May be established indicators for measuring tilt the route and age of vehicle.

(2) $E_i^{общо,j} = E_i^{студен,j} + E_i^{топъл,j}$, [g]

Where:

E_i : the total emissions output of a given air pollutant i;

j : travel conditions - *urban, outside the city* and *highway*.

Complex approach

It is used in software products (*Mobile6,Module "emissions " of the software package TRAFFIC ORACLE*), simulating the transportation process. It is based on: the technical characteristics of vehicles – year of production (environmental standard), age, technical introduced to reduce pollution and others; gross and net weight; actual route of movement and the modes of the engine; standard fuel, external temperature and more.

3. Methodological consistency

The basic parameters and stages used in the present approach are as follows:

- Definition of emission factors of influence;
- Option of a combined transport:

The *first* type is called *Ro-La* transport accompanied with wagons the carriage of a truck driver. All trucks are boarded at platform wagons. This significantly increases the cost carriage which is effective up to 1000 km.;

The *second* type are *Ro-La unaccompanied* transport of car trailers and bodywork with pocket-wagon, in which on train only upload trailers without tractors. Problem is finding specialized coaches and the availability of terminals for unloading;

In the *third* type of *Ro-La* transport are combined containerships and unaccompanied shipments with pocket-wagons.

- determine distances of the road (L_{AT}[km.]) and the rail route ($L_{жпт}$ [km.]);

- determine the number of vehicles in a train that is equal of the number of specialized platform wagons,

(3) $$N_a^{ВЛ} = \frac{Q_{c.\max} - Q_{cn}}{q_{авт} + q_{ВАГ}} \text{ [Nr];}$$

Where:

$Q_{c.\max}$: maximum weight for train , t ;

Q_{cn} : mass of the wagon-lit, t ;

$q_{авт}$: vehicle weight, t ;

$q_{ВАГ}$: weight of a platform wagon (tare) , t .

- Calculation of harmful emissions from movement of vehicles under its own power - $E_{AT,i}^{сх}$ [g]

(4) $$E_{AT,i}^{сх} = K_a L_{AT}.EF_i,[g]$$

Where:

$E_{AT,i}^{сх}$: the total emissions output of a given air pollutant i;

L_{AT} : the distance, [km] ;

EF_i : the emission factor EF for the pollutant i, [g/km];

K_a : coefficient reporting additional factors of influence.

- Calculation of harmful emissions from a train carried freight vehicles – $E_{ВЛ}$ [g]

(5) $$E_{ВЛ,i} = k_в.Q_{бр.}.L_{вл.}.Рел.EFел_i,[g]$$

Where:

$Q_{бр.}$ – gross weight of the train, t;

$L_{вл.}$: the distance, km;

Рел : electricity consumed, kWh/GT.t.км;

$EFел_i$: the emission factor EF for the pollutant i, g/kWh;

$K_в$: coefficient reporting additional factors of influence.

(6) $$E_{AT,i}^{жт} = \frac{E_{ВЛ,i}}{N_A^{ВЛ}},[g]$$

Where:

$E_{AT,i}^{жт}$: the total emissions output of a given air pollutant i, of a vehicle;

$E_{ВЛ,i}$: the total emissions output of a given air pollutant i, of a train carried freight vehicles;

$N_A^{ВЛ}$: the number of vehicles in a train.

- Comparison of results from both types of movement and determine the effectiveness on the condition, referred for a vehicle

(7) $$E_{AT}^{жт} < E_{AT}^{сх}$$

- Calculation of ecological efficiency in value – Пек

(8) $П_{ек} = (E_{AT}^{сх} - E_{AT}^{жт}).C_{EF}$, лв. or /EUR/

Where:

C_{EF} - corresponding emission rate;

Using the proposed approach and methodological consistency, are made specific calculations to account the ecological efficiency for RO-LA route Dragoman-Svilengrad.

The possible technological options for handling the vehicles: Halkaly (by Istanbul) and transit through Bulgaria; processing terminals in Svilengrad and Dragoman.

In this report used data on the emission factors (according method “CORINAIR-94”), to distance km (Table. 1).

Table1.

vehicles	pollutant, g/km					
	NO_X	VOC	CH_4	CO	CO_2	N_2O
Truck and busses (average fuel 30,8 l/100 km)	10,9	2,08	0,06	8,71	800	0,03

In this report – average fuel **35** l/100 km.

Calculation of harmful emissions of CO_2 for rail route is done.

3. Results

Using the proposed approach and methodological consistency are made specific calculations to account the ecological efficiency for RO-LA route Dragoman-Svilengrad. For baseline data are used in the published [9] results of calculations on:

- length of road route **351 km**;
- length of rail route **356 km**;
- gross weight of the train **1450** t;
- locomotives - leading and supporting **46** ser;
- max. number of wagons carrying trucks in a train **24**.

The emission factors:

- road transport – Table 1;
- railway transport:

- Emission factor for $\mathbf{CO_2}$ 0,465 t/MWh, referred in [2], nationally for electricity production in 2008;

. In work [4] are given data on energy consumption in freight train traffic from various sources, but is not indicated at what kind of traction are those values / electric or diesel/. In [1] at an output of 1900 kW, power consumption is around 0,029 kWh / br.t. km. In the course of calculations is used value 28,45 Wh / br.t.km, based on reporting data in real rail train freight traffic.

In calculating the eco-efficiency in terms of value - Пек, was used emission rate of EUR **30** per tonne, in line with published in [2] data.

Calculated results, based on formulas 1, 4, 5 and 6:

- the harmful emissions from movement of vehicles under its own power /Table 2/:

Table 2

Vehicles,бр	Pollutant, g					
	NO_X	VOC	CH_4	CO	CO_2	N_2O
1	4591,08	876,096	25,272	3668,652	336960	12,636
24	110185,9	21026,3	606,528	88047,648	8087040	303,264

- harmful emissions /CO_2/ from a train carried freight vehicles:
- $E_{ВЛ}$ = **6720924** g.;
- $E_{AT}^{жст}$ = **280038,5** g.

Eco-efficiency for CO_2 in Ro-La:
- for train - **673920** g.;
- for vehicle - **56921,5** g.

Eco-efficiency in value:
- for train **-41,04** EUR.;
- for vehicle - **1,71** EUR.

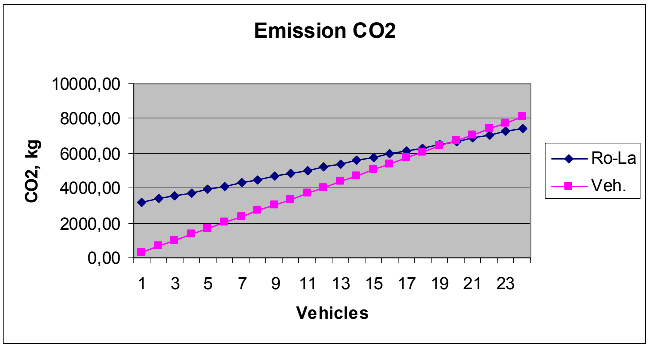


Figure2. Distribution of CO_2 emissions, depending on the number of vehicles under its own power, and in train.

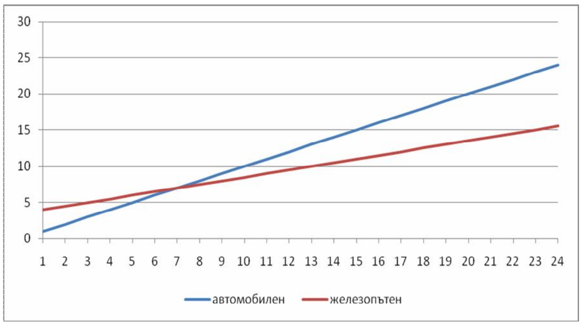


Figure3. Energy costs for freight, depending on the number of vehicles

4. Conclusions

Using of these methodological consistency and mathematical formalism adequately reflect complex impact of intermodal transport, particularly RO-LA, to the emissions and environment.

Proposals in this paper an integrated approach allows recording not only the quantity of emission of greenhouse gases in the movement of cars under its own power, but the amount of emissions at power consumption required for the implementation of train movements.

Only the CO_2 emissions are used in calculating the eco-efficiency because only for it are found reference values for electricity production in the country.

To achieve the environmental effectiveness of the implementation of the RO-LA transportation is not appropriate to carry less than 20 vehicles of a train for the route under consideration /Figure 2/. It should be borne in mind that the percentage of energy costs in road transport is much greater than that of rail / Figure3/.

Obtained from the calculation results are largely influenced by future changes from the basic's transport's parameters, in the direction of increase or decrease.

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