SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2019 **Issue:** 07 **Volume:** 75

Published: 24.07.2019 **http://T-Science.org**

QR – Issue QR – Article

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ECOLOGICAL FEATURES OF TRANSPORT

***Abstract**: As claimed by World Health Organisation, the quality of air is worsening year by year. This case primarily arises from energy, transport and production policies of nations and towns, beginning to be the straight reason for international issues related to the greenhouse effect. Currently, the ecological features of transport are quite topical problems, especially energy expenditure along with greenhouse gas (GHG) production. The current study examines and estimates the eventual energy expenditure and greenhouse gas emissions for two types of passenger transport, particularly road and railroad. The collation was carried out for diesel railroad vehicles and also for passenger vehicles with various forms of fuel (gasolene and diesel). The outcomes demonstrate the eventual ecological features calculated per capita in the Republic of Azerbaijan.*

***Key words**: Quality of air; ecological features; energy expenditure; fuels; greenhouse gas production; transport vehicle.*

***Language**: English*

Citation: Rahimov, E. A. (2019). Ecological features of transport. *ISJ Theoretical & Applied Science, 07 (75),* 284-288.

Soi: http://s-o-i.org/1.1/TAS-07-75-46 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2019.07.75.46

***Classifiers**: ecology.*

Introduction.

Mobility is one of the most important human needs in this century. Average number of trips and the average travelled distance per man is constantly rising. Transport is becoming a very important element of human existence which has very negative impact on the environment by noise, vibration, accidents, area needs, congestions and energy intensity [1]. Entering energy is transformed in to the movement of vehicles which provide the required transfer of goods and people in the area. It is caused during the transportation processes. Therefore, the transport depends on the supply of energy. Today, the transportation is largely dependent on oil, as the vast majority of vehicles are driven engines combusting petroleum products - hydrocarbon fuels [2,3].

Railway transport is representative mode of transport where most railway vehicles are now powered by electric traction motors, so the rate of dependence on oil is lower than previous modes. But the fact is that in most countries the electricity is produced through petroleum products or coal [4,5]. All of these are non-renewable natural resources and their stocks have steadily declined.

Standard EN 16 258:2012.

This European standard specifies a general methodology for calculation and declaration of energy consumption and GHG emissions in connection with any services (cargo, passengers or both) [6]. It specifies general principles, definitions, system boundaries, methods of calculation, allocation rules (allocation, assignment) and recommendations on information to support standardized, accurate, reliable and verifiable declarations regarding energy consumption and greenhouse gas emissions associated with any freight service. It also contains examples of the use of these principles. The calculation for one given transport service must be performed using the following three main steps:

- Step 1: Identification of the various sections of the service
- Step 2: Calculation of energy consumption and greenhouse gas emissions for each section
- Step 3: Sum of the results for each section.

The standard does not consider only the secondary emissions produced and energy consumed during combustion of the fuel (energy conversion from fuel to mechanical energy), but also primary emissions incurred in the extraction, production and distribution:

- ew – well-to-wheels energy factor for the defined fuel,
- gw – well-to-wheels emission factor for the defined fuel,
- et – tank-to-wheels energy factor for the defined fuel,
- gt – tank-to-wheels emission factor for the defined fuel.

Well-to-wheels factor covers also primary and secondary emissions and consumption. Somewhere, this factor is also called life-cycle analysis/assessment (LCA). Tank-to-Wheels factor considers only secondary emissions and consumption. That standard specifies a general methodology for calculation and the declared value for the energetic factor and factor in greenhouse gas emissions must be selected in accordance with Annex A [7,8]. Emission gases are composed of several individual components (gases).

Each of them has different chemical and physical properties and thus participates in environmental degradation differently. In order to compare emissions from different activities, fuels, vehicles when emissions have different tracks, it is necessary to designate one representative unit usable for the comparison. This is the CO_2 equivalent, which is a measure of impact of specific emissions and likens it to the impact of CO_2. The label is CO_{2e} (equivalent) [9,10].

Calculation methodology.

Software Railway dynamics has been used to calculate the energy consumption of the train. The power consumption of the train has been calculated on the basis of predefined and selected values on the defined route. The software works with imported maps and elevation profile of railway routes. Based on these defaults and selected parameters (locomotive type, train weight, train length, axle load, number and location of stops) power consumption was calculated in kWh.

This software can be used to calculate energy consumption and operational or driving time of some arbitrary train on some arbitrary railway track. It is needed to import data of train and track for calculation [11]. It is necessary to use the principle well-to-wheels for relevant comparison of the results for different types of consumed energy. Calculated energy is the mechanical work needed to move the vehicle. If is it transformed into units of MJ, it can be subsequently converted to total consumed energy. It means that the well-to-wheels principle is using factors e_w, g_w (EN 16 258:2012) or f_{LCA}, or total energy efficiency η_{TE} [12].

For the consumption of vehicles equipped by combustion engines is used following equation.

$$E_{TF} = FC_V \times e_w = [(E_{ME} \times m_{pe}) \times \frac{1}{\rho F}] \times e_w \quad [MJ] \quad (1)$$

where E_{TF} total energy consumed by diesel vehicles [MJ]

FC_V fuel consumption of vehicle [l, dm^3]

E_{ME} mechanical energy consumed by the movement of the train (train dynamics software result) [kWh]

m_{Pe} vehicle engine specific fuel consumption [g/kWh]

ρ_F fuel (diesel) specific weight (density) [g/dm^3]

e_W energetic factor „wtw“ for defined fuel from [MJ/dm^3]

For the GHG production calculation, the consumed amount of diesel fuel should be multiplied by an emission factor for that fuel from Appendix A of the EN standard.

$$G_{TF} = FC_V \times g_w [(E_{ME} \times m_{pe}) \frac{1}{\rho F}] \times g_w \quad [gCO_{2e}] \quad (2)$$

where G_{TF} the total amount of emissions produced by diesel vehicles [gCO_{2e}]

g_W emission factor for defined fuel [tCO_{2e}/MWh]

The basic units of MJ and gCO_2 were chosen for the calculation because they are the units declared in the standard. However, for better comparison and expression, it is possible to expressed individual amounts in other units, for example GJ, kJ, tCO_2, $kgCO_{2e}$ or a combination of them, in the case of proportional expressing of quantities [13].

Railway transport.

In this case study we consider the transport along one chosen in the Republic of Azerbaijan. This track connects the capital city Baku and a town Sumgayit. An overall distance between two cities is 30 kilometres. The calculation for this model study was done on the track in bidirectional ways, so one way down the hill and the other way up the hill.

This elevation is seen in the energy consumption which is higher for uphill track, from Baku to Sumgayit. Only the numbers as the results from transport in both directions are in the evaluation table and graphs. Simulation of the energy consumption was done for railway vehicle used in the Republic of Azerbaijan in a regional passenger transport.

Passenger car transport.

If we want to use a methodology for the calculation of energy intensity and GHG production in transport for passenger cars with different fuel types, it is suitable to use the following example.

Let us consider a vehicle frequently used in Azerbaijan which represents the middle-class vehicle of an unnamed manufacturer who offers this type of vehicle with two types of propulsion – gasoline and diesel with approximately the same engine power. Vehicle mark and model are not important in this case, but performance, weight parameters and fuel consumption of the vehicle are relevant.

Curb weight of the vehicle is about 1 500 kg and the engine power of vehicle is about 80 kW. For this type of the vehicle, fuel consumption may range from 6 to 7 litres of gasoline per 100 km; in the case of diesel engines it may be from 5 to 6 litres per 100 km [14].

Fuel and energy consumptions stated by the manufacturer were used for the purposes of this calculation. The consumption was measured according to the standard. Consumption indicated by the manufacturer in the combined NEDC cycle is taken into account [15]. Energy consumption and GHG production from a global aspect, thus primary as well as secondary impacts are taken into account.

Evaluation.

The calculated results are written in the following table (table 1).

Table 1. Final evaluation

Mode and type	Rail	Road	
(vehicle nr., traction)	813-913	Gasoline	Diesel
Occupancy (%)	100-20	100 - 20	100 - 20
Energy Consumption (kJ/pskm)	256-1045	443 - 2011	395 - 1789
GHG Production (g/pskm)	19,4-79,3	33,9 – 153,6	29,9 - 135,8

The simulated fuel consumption of the diesel train was compared to the real consumption of this train operated on this track. This simulated result was validated because the simulation error was only -8%. So, every consumption result was increased of the value 8% to be closer to the reality.

Energy consumption (kJ/pskm)

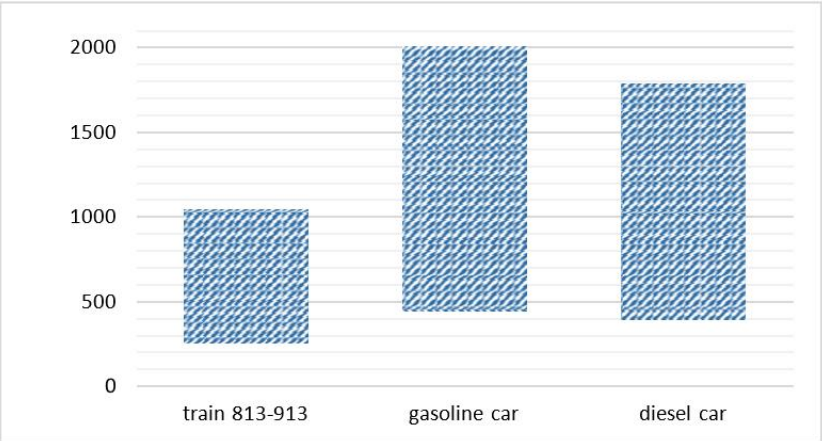

Fig. 1. Final evaluation

The results from the table 1 describe the most energy intension vehicle drive. It is the gasoline passenger car. Its energy consumption and GHG production is 10 % higher than the same diesel car in whole spectre of vehicle occupancy. Public transport is environmental friendlier than the individual. The energy intensity and the GHG production of the diesel train is lower despite the high tara weight of the train. It is reached thanks to high passenger number.

The energy intensity of gasoline car is 70 % higher and of diesel car 50 % higher in the comparison with the railway vehicle. The same scenario is by the GHG production. It is valid for the full occupancy of the vehicles. The difference (energy and GHG) is increasing between the road and railway vehicles with the decreasing of vehicle occupancy. The difference of the gasoline car represents 90 % higher environmental impact and 70 % of the diesel car by the 20 % occupancy.

Conclusion.

The results of this simulation do not determine which traction is better, greener or friendlier to the environment of Azerbaijan Republic:

- It is not possible to do it, because the energy efficiency and GHG production is not dependent only on the type of fuel but also on the occupancy usage. It is necessary to load the trains with the adequate number of passengers (suitable choice of the train according to the transport flow). The efficiency of vehicles is decreasing with decreasing of the actual vehicle occupancy.
- Evaluation shows that also the "not green transport vehicles" – passenger cars – can be very effective in energy consumption and GHG production in the Republic of Azerbaijan. Sometimes they can be more effective than public transport but only by higher occupancy, so not by car driving only with the driver but with 4 or 5 passengers in the car. Meaning of this result is in the clearance that vehicle capacity usage is very important by evaluation and comparison of different transport modes or different transport vehicles in point of view of their environmental impacts.
- The capacity usage is depended on the demand of potential passengers, transport infrastructure and the public transport services offer in the regions of Azerbaijan Republic. It is not easy to say which transport mode or transport vehicle is better to use because of many influences like mentioned above.

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