Environmental impacts of railway transportation systems

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Abstract: - The transport plays an important role in everyday life, and has significant economic, environmental influence globally but it also has direct health effect on societies` life. Nowadays when the climate change represents real challenge for the world to try to ensure an environmentally more sustainable future, the researchers and the political leaders are looking for renewable energy sources and environmentally friendly systems to reduce the air -, noise pollution, the energy consumption, etc.
The aim of this paper is to compare railway transportation system with other means of transportation, on regional and European level, emphasizing its unexploited sources and advantages over other systems.

Key-Words: -Environment, transportation, railway, eco-friendly, energy, electricity, emission.

1 Introduction

Transport has significant detrimental effects on the built and natural environment,and hence on individuals' lives. It is the only sector in the EU in which greenhouse gas emissions haveconsistently risen since 1990. It also contributes significantly to global warming and therefore it is obvious that current transport patterns are unsustainable. Without mitigation measures, the transportwill be unsustainable in medium to long term. The environmental aspects of transport sustainability are concerning the atmospheric and noise pollution, landtake, resource use, the effects of waste disposal on the natural environment and the effects ofthe above on humans, flora and fauna. These environmental aspects of transport cover its full life-cycle. The largest impacts come from transport use, but also the effects of development and construction of infrastructure and vehicles are considered, as well as the waste from their disposal add to the environmental costs of transport. [1, 12]

2 Rail compared to other modes of transport

In this section of the paper is analyzedand compared the influence of the European railway transportation system on the environment, taking into account the following aspects: CO_2 emission, energy efficiency, electricity production, land take and noise emission.

2.1 CO_2 emissions

Transport causes around one quarter of Europe CO_2 emissions. Since 1990 Europe greenhouse gas (GHG) emissions from domestic transport increased significantly. More than 70% of total domestic transport emissions are due to road transport.Rail only accounts for 0.6% for diesel emissions and for less than 2% includingemissions for electricity production (fig. 1) [1,4].

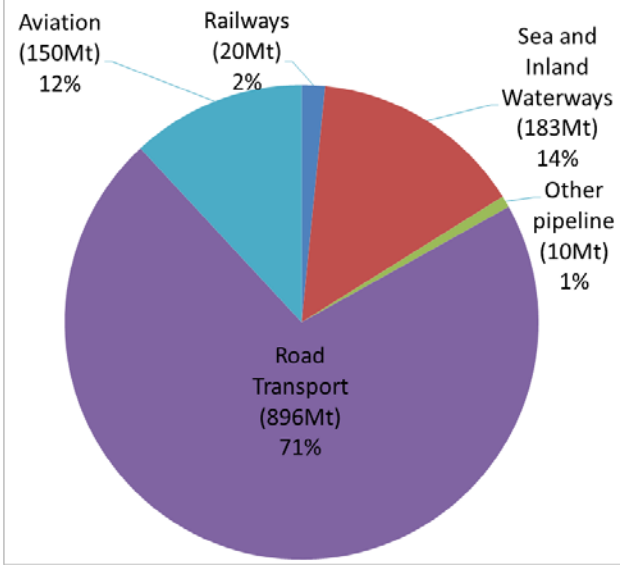

Fig.1 CO_2 emissions in European Union by transport mode (million tons / percentage) [1,2]

The diagrams below compare the total CO_2 emissions from transporting 100 tons of average goods from Cluj-Napoca, Romania railway stationto the port of Rotterdam, Netherlands, and comparethe total CO_2 emissions from transporting 1 passenger

between the centres of the above mentioned cities (2000km).The values of the CO_2 emissions include also the production and distribution of electricity or fuel.

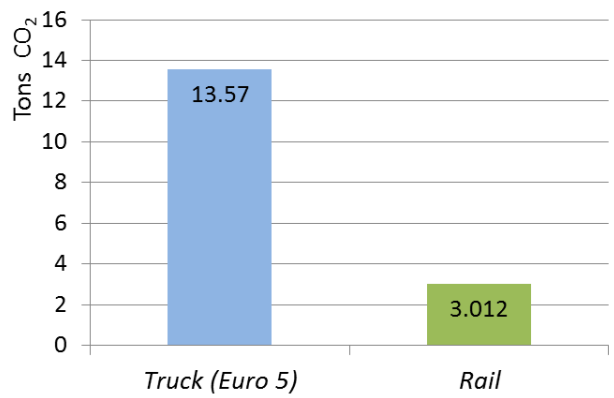

Fig. 2 Carbon dioxide emissions, transporting 100 tons cargo from ClujNapoca to Rotterdam [11]

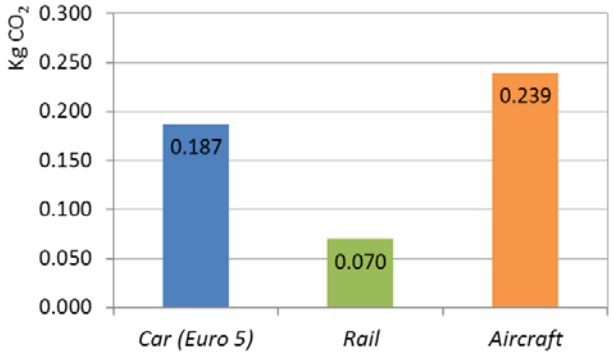

Fig. 3 Carbon dioxide emissions, transporting 1 passenger from Cluj-Napoca to Rottredam [12]

2.2 Energy efficiency

Since 1970, transport activity has more than doubled in Europe: +185 % for the transport of goods and +145 % for the transport of people [1,4].

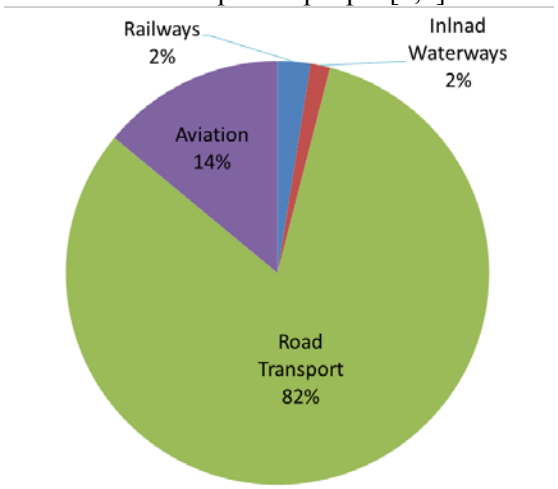

Fig. 4 Energy consumption by transport mode in European Union (million tons oil equivalent) [1,3]

In the EU, the final energy consumption of the transport sector equals to 31% of the total European wide consumption.

Railways' share of the transport energy consumption is 2% (fig. 4), while its market share is between 6% (passenger) and 10% (freight). Approximately 85% of total energy consumed by the rail sector is used directly for rail traction as illustrated in the figure below.

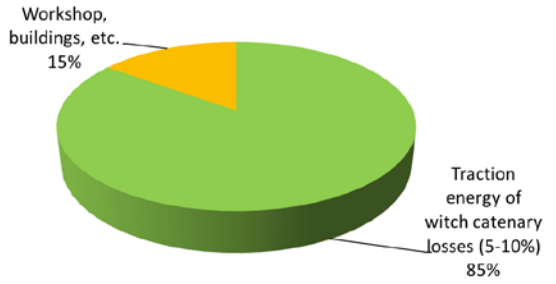

Fig. 5 Total energy used by the rail sector

Similarly to the previous section in the following charts iscompared the total primary energy consumption (including the values for production and distribution of electricity and fuel)using different transportation modes (rail, road, aviation) for passenger - (1 person) and freight transport (100 tons of average goods) from Cluj-Napoca, Romania to Rotterdam, Netherlands.

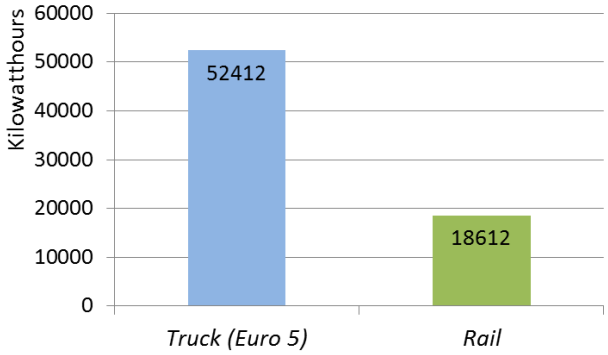

Fig. 6 P rimary energy consumption, transporting 100 tons cargo from ClujNapoca to Rotterdam [11]

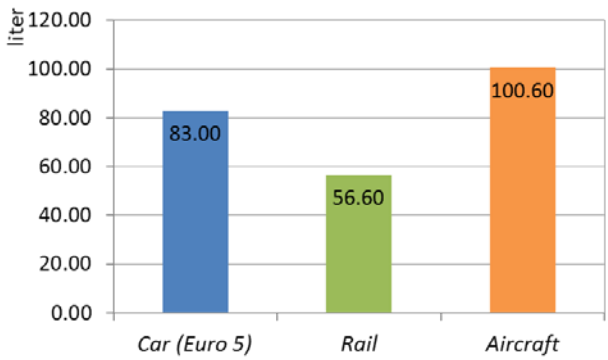

Fig. 7 P rimary energy consumption, transporting 1 person from Cluj-Napoca to Rotterdam [12]

2.3 Electricity mix

Gas, solids (coal) and oil are the three fossil fuels that cause additional CO_2 when incinerated in power plants. Nuclear and renewables (hydro, biomass, wind, solar and geothermal) are considered the two CO_2 neutral energy sources. At present, therenewable energy only accounts for 14% of EU electricity production (see below), but researchers seek to raise this to 20% by 2020 [4,6].

Table 1 European Union electricity production mix, 2000 – 2014 [1]

Energy sources	2000	2011
Coal products	32%	27%
Oil products	6%	2%
Gas	16%	21%
Nuclear	32%	28%
Renewable	14%	22%

Table 2 European Union railway energy sources mix, 2000 – 2014 [1]

Energy sources	2000	2011
Coal products	18%	17%
Oil products	47%	39%
Gas	9%	13%
Nuclear	18%	17%
Renewable	8%	14%

Due to its use of electricity, rail is the only motorized mode of transport which is capable of shifting from fossil fuels to renewableenergy without any separate investment in the propulsion units, simply by changing the energy sources in the electric energy production [4].

2.4 Land take

The negative consequences of land use are associated with three factors.

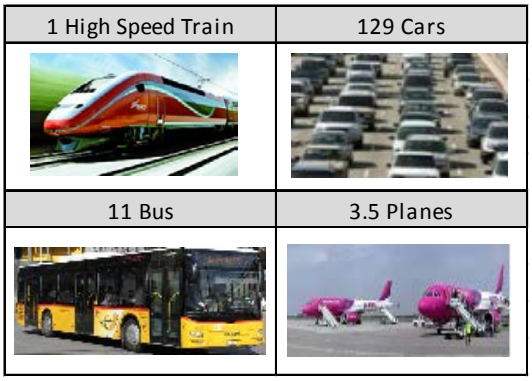

Fig. 8 Rail capacity compared to other transportation modes

Firstly, the actual space taken for infrastructure leads to the sealing of the top soil, as well as disturbances resulting from noise, resource use, waste dumping and pollution.

Secondly, transport networks which connect cities add to the fragmentation and degradation of the natural or urban landscape due to the "barrier" effects of their infrastructure. Finally, the urban sprawlinvolves the inefficient development and use of urban land [4, 7].

Roads account for 98% of total transport infrastructure compared with rail [8].

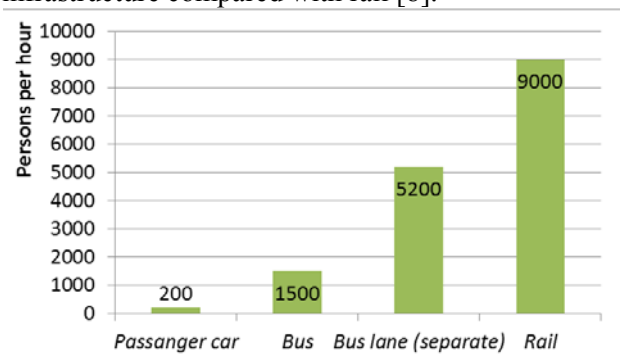

Fig. 9 Capacity of urban transport modes per meterof infrastructure width [1,10]

2.5 Noise emission

Noise is one of the key concerns for people living near transport infrastructure. The fast growing demand for transport in Europe leads to disturbance of an increasing number of citizens during day and night time [4, 5].

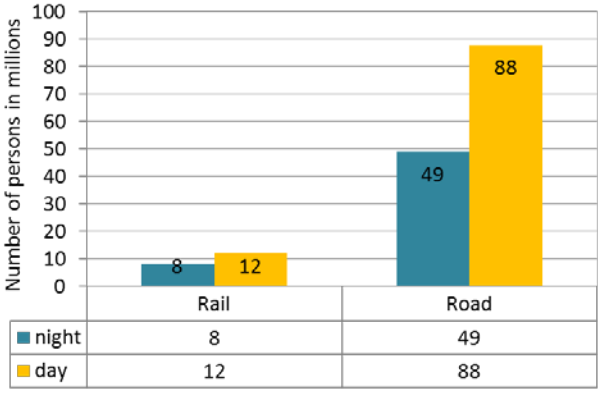

Fig. 10 Total number of persons above 55dB (day) and above 50dB (night) in millions [1,10]

In general, three different sources of railway noise are identified:

- Engine noise;
- Rolling noise;
- Aerodynamic noise.

Railway noise is largely a problem of freight trains and trains containing older wagons or engines, and

is a particularly severe problem during the night. Rolling noise is generally higher from poorly maintained rail vehicles, and from trains running on poorly maintained infrastructure. Aerodynamic noise is particularly relevant for high speed lines where, in most cases, noise limiting measures like noise barriers are implemented [1, 2].
The most important noise source is rolling noise, which affects all kinds of train.

3 Discussions and problem solutions

Both passengers and freight transport activity increased by more than 20% between 1995 and 2011 in Europe; in that period, rail activity increased by 5.5%, dropping its share from 8.7% to 7.5% [1, 2, 4].
Travelling by rail means on average 3 to 10 times less CO_2 emissions compared to road or air transport.With 7÷10% of market share rail contributes to less than 2% of the European transport sector's CO_2 emissions (fig. 1).From 1990 to 2011 the European railways cut their CO_2 emissionsby 21% in absolute terms. For specific emissions (emissions per passenger-km or tone-km) during the same period, the railways reduced their CO_2 emissions per passenger-km by 14%, and pertone - km by 28% [1, 4, 12].
As the figure 2 shows in the case of the freight transport, the CO_2 emissions from rail are more than 4 times less on 2000km distance (between ClujNapoca and Rotterdam) than from trucks.
For passenger transport, going by rail is on average 2-3 times more efficient than taking the car and more than 3-4 times better than taking the plane on the same route (fig. 3).
In the energy efficiency subject the European Environmental Agency predicts a rise of 21% in energy consumption for transport from 2000 to 2030 [1, 4].
Rail is on average 2 - 5 times more energy efficient than road, shipping and aviation,including also the consumption of energy for production and distribution of electricity or fuel used by the railway system. As it can be seen on the figures 6 and 7, rail is more energy efficient thancars and planes in passenger transportation, and approximately three timesmore efficient thanlorries in freight transportation (on the 2000km route between ClujNapoca and Rotterdam).
The rail sector can improve its energy efficiency if increases the length of electrified tracks and tries to back down from diesel traction. This trend seems to be outlined on European wide.
The use of diesel energy decreased by 31% in European railways between 1990 and 2011, while the use of electric energy increased by 14% [1]. Unfortunately the situation is not so optimistic because the decreasing of diesel energy means in many cases the definitely closer of rail lines which used diesel traction as a result of economic and political decisions.
But it is a positive point that the rail electric traction increased its share from 2005 to 2011, reaching 86% of train-km for freight and 81% for passenger service [1].
Electric railways could achieve zero CO_2 emissions if the electricity production is obtained from renewable energy sources.
Based on the values in the tables 1 and 2 the renewable energy sector increased in the European electricity production and also accounts for 14 % of railway energy sources but even so islessercompared to the oil sources. It is important to remark that the rail sector has many sources and alternatives in realizing a sustainable transportation system because it is able to shift immediately from fossil fuels to renewable energy without great investments in its current system.
There are also many exceptions in Europe whereover 90% of renewable sources are used for railway energy production: Norway, Sweden, Netherlands. For example the Dutch railway system will operate completely until 2018 using wind energy [1, 8].
From 1975 to 2011 theworldwide railway track length decreased by 9%, while the length of the roadsincreased to more than double [1, 4]. The situation is similar in Europe too.Investment in transport infrastructure in the EU still overwhelmingly favours road over rail.
According to surveys made by European Commission and International Union of Railway, road infrastructure uses 37 times more land than rail infrastructure, while only carrying 3.5 times more transport units than rail [1, 12]. The high capacity of rail transportation is shown on figure 8 compared to the other transportation modes. On the figure 9 it can be seen that the rail sector might have a significant importance in decreasing of congested urban traffic, reducing the local air pollution in cities, which nowadays, is a very important challenge for the big towns everywhere in the world. But the noise pollution remains one of the greatest challengefor railway traffic and railway engineering.Although the railway compared to the road traffic has advantages (figure 10), but it still has to develop, because of the noise as the most

environmental problem for people living close to the railways.
Infrastructure companies and railway operators are working on progressively reducing the noise emissions from rail. There are many suggestions for reduction of noise: noise barriers along the railway tracks using of insulated windows, replacing the brake blocks from cast iron to composite materials.
The most common type of superstructure used in Europe and in the world is still the ballasted track.
Another solution for reducing the noise level is the good maintenance and optimization of the railway superstructures made up of rails, fastening systems, sleepers and the ballast layer. Therefore an elastic connection between these elements plays key role in absorbing the vibration energy and thereby in reducing of noise. The elasticity of the system can be achieved by a good maintained ballast layer, with elastic fastening system, and with implementation of structural optimized sleepers using elastic sleeper pads bellow the ties. These composite pads improve the track geometry and reduce the vibration caused by the rolling stock [9, 11].

4 Conclusions

According to the previously presented results it seems clearly that, at the time when climate change is a central element in all economic, technological, environmental decision making and choices, the world`s transportation system should be changed because this sector almost has the largest contribution to the climate change and energy consumption.
The rail system with its advantages in almost every environmental questions and conditions over the other transportation sectors becomes the right alternative solution.
In the future, the ensuring of a more sustainable transport system consists of combining the strengths and advantages of all transport modes in on integrated system. The key of this system should be represented by the transfer hubs (centers) which connect the different transportation possibilities.
Comparing heavy or spacious cargo, passenger transportation, short or long distance, rail is the most energy efficient and eco-friendly transport mode if used appropriately.
Unfortunately there are many countries in Europe too, mainly in Eastern Europe (ex.: Romania, Bulgaria) where the railway system needs to be developed, modernized completely to catch up to the level of modern railways.
But it is important to modernize the older railway systemsand construct new lines in Europe using electric traction, and renewable energy sources in order to the railway increase its share of transportation services with its environmentally friendly advantages.
It is essential to mention that the backbone of a sustainable, eco-friendly transportation system may be only the railway sector.

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