Strategies of Developing Road Transport by Controlling Automotives’ Emissions to Reduce Local and Global Environment Impacts

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Abstract: - This research paper presents an overview of policies and methods of controlling the emissions caused by motor vehicles and road traffic to reduce local and global pollution. The main reason is the fact that individual mobility and modern freight transport system should include the idea of people’s well-being, quality of life, freedom, all these being parts of the social and cultural context. In this case, the mobility of tomorrow will be more environment-friendly, resource lean, quieter, safer, adapted to individual mobility needs and seamless logistics. Highly efficient, innovative power train technologies and alternative fuels will have a key-role in this respect. Therefore, effective policies must meet multiple objectives, such as:

✓ Establishing a balance among different solutions of power trains: ICEs, Hybrid, and Electric Vehicle. Oil-based fuels will continue to be the foundation of mobility in the coming years. The main reasons lie in the extremely high energy density of diesel and petrol, whereby large distances can be covered using a relatively small volume of fuel, and in efficient combustion engine technology. The introduction of electric vehicles on the market will encompass: hybrids (micro, mild, full and plug-in hybrid electric vehicle – PHEV), range extender electric vehicle (REEV), battery electric vehicle (BEV) and fuel cell vehicles (FCV).

✓ Providing security of fuel’s supply by using alternative fuels. Such alternative fuels can be methyl or ethyl esters (bio diesels), biogases (digester gas, wood gas, gas from biomass gasification, and so on), alcohols from biomass (methanol, ethanol, and so on), vegetable oils, animal fats, etc., or even hydrogen.

✓ Defining a conclusive mobility concept. This concept is materialized through a sustainable, consistent transport policy for economic growth and efficient environmental protection; investment in good transport routes based on needs and promotion of intelligent traffic systems as real-time traffic information, dynamic parking space management, fleet management systems and power trains assistance systems, ICT in logistics.

✓ Reducing chemical and noise pollution caused by motor vehicles by controlling emissions. At present, all studies shows that is no doubt that the internal combustion engine (ICE) will be the main propulsion technology for road transport for a long time, there is no doubt that we have to find alternative fuels, simultaneously, the alternative fuels should decrease the noxious emissions (NOx, particles) and decrease the net greenhouse gas emissions (CO2). Bio fuels constitute a central pillar of sustainable mobility and they have the advantage of not requiring essentially new engines or a new infrastructure

Key-Words: - environment, engine, pollution, emission, modelling, optimisation, noise, traffic flows.

1 Introduction
European urban areas face a number of major environmental challenges and the scale and intensity of the problems can vary, thus, in this case, a common set of issues can be identified. These ones are related to poor air quality, traffic volumes and congestion, high levels of ambient noise lack of the recreational areas, high level of greenhouse gas emissions or other factors of this kind. These environmental challenges constitutes a major problem and have significant impacts on human health, environment and economic performance.
Likewise, it is generally agreed that transport is one of the major contributor to pollution of the atmosphere. Transport is the sector in which the negative emission derived from transport demand and increasing share of road transport, mostly outgrew the positive emission derived from fuel efficiency and fuel shift. This increase was observed for both passenger transport and freight transport. These increases were mainly due to growing transport demand, characterised by large increases in passenger kilometres and tonne kilometres. For passenger road transport, a relative decrease in the use of public transport is also noteworthy. Efficiency improvements in passenger cars have not been sufficient to counteract this trend. For freight road transport, an increased share of road freight transport as opposed to other transport modes supplemented the increased transport demand for goods. Therefore, the modal shift can lead to a wrong direction. At EU level,
political decisions have been taken to counterbalance the ever increasing transport emissions. Such policies aim, for example, at promoting the use of biofuels, promoting modal shift to rail and an integrated European railway area, and providing better consumer information on cars. As regards motor vehicles, measures for automobile traffic, such as physical-distribution measures to curb truck trips with an increased efficiency of commodity forwarding and measures to encourage the introduction of less-polluting automobile have been carried out, in addition to the strengthening of controls on emissions from individual automobiles themselves.

Between 1990 and 2007, the reports showed that CO₂ emissions from transport rose by 29% in the EU-27. The EU has adopted the European Strategic Energy Technology Plan (SET-Plan) as a road-vehicle to accelerate the development and the large scale use of low carbon technologies that influences upon the current R & D activities and achievements in Europe. The SET-plan proposes a new innovation model based on a collective approach to be applied to research, development and demonstration planning and implementation in the EU countries.

One of the main priorities in EU climate change policy is the reduction of CO₂ emissions from new cars. To limit average CO₂ emissions from new passenger cars sold in the EU to 120g/km by 2010 is one of the major goals. A three-folded strategy is adopted. The first element of this policy was an agreement stated among car producers to limit average CO₂ emissions from new cars to 140g/km by 2008/2009 representing a reduction of about 25% compared with the mid-1990s. The second element takes into consideration the consumers, who, being determined to have the choice among the most fuel-efficient cars, EU legislation require mandatory labelling and provision of consumer information at the point of sale about each car’s fuel economy and CO₂ emissions. The third element of the strategy is the fiscal one. The European Commission has proposed a legislation requiring the Member States to apply car registration taxes and/or circulation taxes to be related of at least 50% of the tax to the level of a vehicle’s CO₂ emissions.

Fluorinated industrial gases have a global warming effect considered hundreds or even thousands of times greater than that of CO₂. Under these circumstances, the EU takes measures confronting the ever-growing problem of leakage of fluorinated gases from the air conditioning systems of cars and other road vehicles. Using biofuels derived from agricultural crops absorbing carbon during their growing process, can help to reduce CO₂ emissions from transport by substituting conventional fossil fuels. Consequently, the EU’s SET-plan has set itself an indicative target of achieving a 5.75% share for biofuels in the petrol and diesel market by 2010. Thus, most Member States have introduced fuel tax exemptions in favour of biofuels. Significant CO₂ savings are expected from a new approach of road charging road network for heavy goods vehicles.

Environmental policy in Romania is based on the European regulations, directives, decisions, recommendations and on the principles of all environmental action programs (1-6), such as:

- precaution in taking decisions regarding the environment;
- the principle of preventive action;
- withholding the polluters to their sources;
- the principle of "polluter pay";
- long-term use of natural resources;
- public information and involvement in decision-making;
- access to justice regarding the environment;
- development of international cooperation for environmental protection.

Competent agencies/bodies when enforcing and managing environmental law in Romania take into consideration these principles.

2 Establishing a balance among different solutions of power trains: ICEs, Hybrid, and Electric Vehicle.

The changes taking place in the global automotive industry related to alternative powertrains and fuels affect each country or region in a different way. Managing and monitoring vehicles’ fuel consumption and emissions is a priority of each country or region’s own policy. This policy depends on the number of new vehicles annually registered in each country and on the total numbers of fleets vehicles that can vary.

Today’s the impact of vehicle’s emissions on the global environment is undeniable. In fact, each automotive powertrain is easy to define, instead it includes all those components which directly or indirectly generate power and transfer in the same to the surface on which the vehicle runs. Various driving factors should be taken into consideration when constantly and steadily design and development of powertrain systems are achieved. Vehicle manufactures strongly focus on offering differentiated powertrain features that help to address the demands of consumers and meet environmental challenges.

An important element of this effort is the development of alternative powertrains to the internal combustion engine (ICE). While a number of these alternatives present a great expectation for improving energy efficiency or reduced emissions, some early technical
solutions lack the power density of ICEs and deficiency implies that either performance must be compromised or the rest of the vehicle must be made lighter.

The expected and easily applied alternative powertrains designed for a short-coming future are divided into four categories:
- The hybrid electric vehicle (HEV)
- The fuel-cell vehicle (FCEV)
- The battery-powered electric vehicle (BEV)
- The compressed natural gas vehicle (CNGV)

In order to compare the system efficiency of vehicles that use different energy carriers, the primary energy efficiency is used as a measure for comparison. Primary energy efficiency takes into account all energy use “from the well to the wheel”. The well to wheel analyses estimates:
- greenhouse gas emissions,
- energy efficiency,
- industrial costs

of powertrain options and automotive fuels. The well to wheel (WTW) analysis can be focused on:
- fuel production (well to tank analysis- WTT);
- vehicle operation (tank to wheel analysis- TTW) (see Fig.1).

These analyses permit the evaluation of the current and future direction of alternative powertrains and fuels.

Applying new technologies for combustion as:
- Advanced common rail combustion systems (ACCP);
- Homogeneous charge compression ignition (HCCI);
- Partial homogeneous charge compression ignition (pHCCI);
- Controlled auto ignition (CAI);
- Premixed charge compression ignition (PCCI);
- Highly premixed charge compression ignition (HPCC);
- Homogeneous charge late injection (HCLI);
- Highly premixed late injection (HPLI);

In this case, it is possible to achieve significant improvements of energetic consumption and environmental parameters.

Different studies show that the internal combustion engines (ICEs) have the potential to increase the fuel efficiency by 2020 – ICE gasoline by up to 30 percent (at 50 percent higher production costs) and ICE diesel by up to 20 percent (at 15% higher production cost). Diesel engines become the strongest powertrain in the majority of future scenarios for Europe, due to the difference of 5 to 8 % over SI engine, resulting from a fuel efficiency advantage of 15 to 20 % and diesel’s higher cost. The alternative powertrains can be included into four main categories which can be easily developed: hybrids, fuel cell, battery powered, and the compressed natural gas.

The hybrid electric vehicle (HEV) will be the most successful alternative powertrains, but hybrid ones will remain at high costs. The Fuel cells vehicle, in the next 15 years fuel cells vehicle will be in continuous development, due to the high costs and the lack of a hydrogen supply infrastructure.

The battery-powered electric vehicle (BEV) has a low energy storage capacity compared to petrol/diesel engine and has a restricted driving range of BEVs. A battery in a BEV should store up to 30 kWh to afford the vehicle an acceptable range.

The compressed natural gas vehicle (CNGV) Natural gas can be used in all classes of vehicles - motorcycles, cars, vans, trucks, buses, lift trucks, locomotives, even ships and ferries. Natural gas can be used either by converting an existing gasoline or diesel engine, or by using a purpose built natural gas engine. Some benefits of the natural gas can be mentioned: reduced greenhouse gas emissions, reduced particulate and NOx emissions. It can be used in all vehicle classes, derived from renewable sources (biogas), minimal processing or refining requirement, safer than most liquid fuels, noise reductions of as much as 50%, widespread availability of natural gas, lower cost, reduced engine wear all these being now available.

There are currently more than 12 million NGVs worldwide (October 2010) and NGV is thought to increase at least ten-fold, to 50 million vehicles by 2020.[13]

Hydrogen has the merit of being produced from any primary energy source. For hydrogen, as a transportation fuel, all GHG emissions occur in the WTT portion, making it particularly attractive for CO₂ capture and storage [14].

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**Fig.1 Well to wheel (WTW) analysis**
Fig. 2 Comparison of energy density of various energy carriers

There is no need to consider the primary energy efficiency when comparing powertrains using the same energy carrier (petrol or diesel fuel)

When different energy carriers with varying degrees of energy losses during fuel production are compared and distribution is used, primary energy efficiency analysis becomes necessary.

3 Providing security of fuel’s supply by using alternative fuels.

Oil prices have tripled over the last four years. Transport is a key economic sector as nearly all the energy it uses comes from oil. The prospects for alternative fuel are mixed and synfuels and biofuels are used as blending materials. Gas-to-liquid is expected to be profitable technology designed only for reserves in isolated locations where pipeline transport is not feasible. Instead, natural gas usage can be applied only in those regions where pipelines exist or to be developed.

Liquid biofuels, as the only direct substitute for oil in transport, have a justifiably high political priority. Constant growth in the transport sector has not permitted the stabilisation of greenhouse gas emissions, in spite of the efforts undertaken by the industry. Within the transport sector, as they are an expensive way of reducing greenhouse gas emissions, adopting biofuels is one of the measures to be taken to have a reasonable chance of reduction of greenhouse gas emission on a significant scale in the near future.

The European Commission has identified the following main objectives of biofuels policy:

1. Greenhouse Gas Saving. The biofuels directive review argues that since GHG emissions in the transport sector continue to grow whilst those in other sectors are shrinking, future emissions reductions must specifically target the transport sector. Biofuels policy should respect other environmental objectives.

2. Security of Supply. Transport sector is almost completely dependent on imported crude oil. This restricts the potential sources of supply, and makes supply susceptible to political instability. Biofuels should be an alternative to oil product.

3. Employment. Biofuels are claimed to bring economic benefits to EU for they increase employment, mainly in rural areas, and to underdeveloped countries as they open new export markets.

4 Defining a conclusive mobility concept.

Urban mobility is recognised as an important facilitator of growth and employment with a strong impact on sustainable development in the EU.

The Commission therefore has decided to present a Green Paper on urban mobility in order to explore if and how it can add value to action already taken at local level. Several EU policies have already addressed urban transport issues in past years. To be effective, urban mobility policies need to be based on an approach which is as integrated as possible, combining the most appropriate responses to each individual problem: technological innovation, the development of clean, safe and intelligent transport systems, economics incentives and amendments to legislation.

Road transport emissions of air pollutants continue to decline in EEA member countries. None the less, a recent report has shown that they remain the primary source of nitrogen oxides and the second most important source of fine particulates. Throughout Europe, increased traffic in town and city centres leads to chronic congestion, inducing many adverse consequences in terms of delays and pollution. Consequently, the European economy loses nearly 100 billion euros, or 1% of the EU’s GDP per year. Year by year the level of air and noise pollution is increasing. Urban traffic is responsible for 40% of CO₂ emissions and 70% of emissions of other pollutants arising from road transport.

Due to the growing of road traffic, a large number of road traffic accidents in towns and cities is also increasing each year. From the total number of road accidents, one out of three occur in urban areas, whose the main and most vulnerable victims are the pedestrians and cyclists.

Whereas these problems occur at a local level, their impact is felt on a continental scale: climate change/global warming increased health problems, bottlenecks in the logistics chain, etc.

Also, on automobiles in use, controls are exercised on noise from trips at regular cruising speeds As measures against sources which are designed to the magnitude of noise itself generated from the automobiles with improvements in their structure, automobile noise controls are in force on all automobiles and motorized.
bicycles and on nearby exhaust gas noise. Local authorities cannot face all these issues on their own; there is a need for cooperation and coordination at European level. The vital issue of urban mobility needs to be addressed as part of a collective effort at all levels: local, regional, national and European. The European Union must play a leading role in order to focus attention on this issue. To be effective, urban mobility policies need to be based on an approach as integrated as possible, combining the most appropriate responses to each individual problem: technological innovation, the development of clean, safe and intelligent transport systems, economics incentives and amendments to legislation.

Traffic flow control is important to form and maintain smooth and safe traffic flows compatible with local features in the sense of reductions in the air pollution, noise and vibration caused by automobile traffic. The main traffic control measures implemented by authorities for the prevention of road traffic pollution are as follows: reduction of the numbers of starts and stops at intersections, uses of the roundabout, and by dispersing and guiding traffic flows with designated controls are being exercised for the living zones with a combination of various traffic controls, including one-way traffic, off-limits to large-sized automobiles and limits on the maximum speed. The designation of lanes with priority given to buses, the introduction of a park and ride system and other measures, a shift from the use of owned cars to mass public means of transportation is encouraged to strive for curbs on the total volume of automobile traffic. Smoothing of road traffic with development of bypasses and loops contributory to the conservation of the roadside environment in built-up urban areas is needed in modern urban traffic. The adoption of road structure of the kind in which the functions of roads, traffic volume and the utilization of roadside land are taken into account; the elimination of traffic snarls, such as with the construction of overpasses over intersections, the reinforced maintenance and repair of roads and the development of belts of environmental facilities and the replenishment of functions to offer traffic information. The urban mobility policy must cover both passenger and freight transport. Distribution in urban areas requires efficient interfaces between long-haul transport and short distance distribution to the final destination. Smaller, efficient and clean vehicles could be used for local distribution. Negative impacts of long distance freight transport passing through urban areas should be reduced through planning and technical measures[6].

The "service economy" leads to new demands for road space.

Table 1 shows the number of inhabitants exposed at different level \( L_{den} \) [dB] of road traffic noise in Tirgu Mures[7].

![Fig.3 Tirgu Mures’ noise map](image)

Table 1. People noise exposed

<table>
<thead>
<tr>
<th>Noise level (dB)</th>
<th>Population exposed to the during noise day ( L_{den} )</th>
<th>Population exposed to the during noise night ( L_{dn} )</th>
<th>Population exposed to silent facade during entire day ( L_{den} )</th>
<th>Population exposed to silent facade during entire night ( L_{dn} )</th>
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<tbody>
<tr>
<td>(-35)</td>
<td>0</td>
<td>0</td>
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<td>(35-40)</td>
<td>0</td>
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<td>(40-45)</td>
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<td>(45-50)</td>
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<td>(50-55)</td>
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<td>(55-60)</td>
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<td>(70-75)</td>
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<td>(75-80)</td>
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<tr>
<td>(80-85)</td>
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There is evidence that 40\% of all vehicles other than passenger cars are service-related (vehicles for removals, maintenance services, small deliveries, etc.). Courier services often use motor-cycles or mopeds [2,3]. Consolidated distribution in urban areas and zones with access regulations is possible, but requires efficient planning of the routes to avoid empty runs or
unnecessary driving and parking. The development of these solutions requires the involvement of all authorities. Urban freight distribution could be better integrated within local policy-making and institutional settings. Public passenger transport is usually supervised by the competent administrative body. Local authorities need to consider all urban logistics related to passenger and freight transport together as a single logistics system[3,4,5]. In order to attain the objectives of a sustainable road transport, various forms of added value may be applied: promoting the exchange of good practice at all levels (local, regional or national); underpinning the establishment of common standards and the harmonization of standards if necessary; offering financial support to those who are in greatest need of such support; encouraging research the applications of which will make it possible to bring about improvements in mobility safety and environmental; simplifying legislation and, in some cases, repealing existing legislation or adopting new legislation. Walking, cycling, collective transport or the use of the motorbike and scooter, should be made attractive and safe as alternatives to private car use. Authorities should promote co-modality and reallocate space that becomes available after congestion mitigation measures. Intelligent and adaptive traffic management systems have also proven their efficiency in reducing congestion. Citizens should be able to optimize their travel through efficient links between the different modes of transport[8].

Promoting walking and cycling
The attractiveness and safety of walking and cycling should be supported by local and regional authorities by ensuring that these modes are fully integrated into the development and monitoring of urban mobility policies. More attention should be paid to the development of adequate infrastructure. There are innovative ways of involvement of families, children and youngsters in the policy development. Initiatives in cities, companies and schools can promote cycling and walking, e.g. through traffic games, road safety assessments or educational packages.

Optimizing the use of private cars
More sustainable use of the private car should be encouraged e.g., by carpooling, which will lead to roads with fewer cars each of them carrying more people. Other options may also include “virtual mobility”: tele-working, tele-shopping, etc. Parking fees can be used as an economic instrument. Adequate parking policy is also necessary to reduce the use of cars in the centre of the cities. Providing more parking spaces may, at long term, encourage car transport, in particular if they are free of charge. Attractive Park&Ride facilities can provide an incentive for combining private and collective transport. Intelligent transport systems (ITS) can be applied for optimising the trip planning, better traffic management and easier demand management. For reducing the pressure on road space, flexible and multiple use of infrastructure (flexible bus-lanes, flexible loading zones/parking places) should be implemented.

Freight transport
Urban mobility policy must cover both passenger and freight transport and be analyzed as a single logistic system. Distribution in urban areas requires efficient interfaces between long-haul transport and short distance distribution to the final destination. A solution could be the smaller, efficient and clean vehicles used for local distribution. Negative impacts of long distance freight transport passing through urban areas should be reduced through planning and technical measures. It is evident that 40% of all vehicles other than passenger are the service-related cars (vehicles for removals, maintenance services, small deliveries, etc.). Courier services often use motor-cycles or mopeds. It is possible to have a consolidated distribution in urban areas and zones with access regulations, but it also requires efficient planning of the routes to avoid empty runs or unnecessary driving and parking. Urban freight distribution could be better integrated within local policy-making and institutional settings. Public passenger transport is usually supervised by the competent administrative body while freight transport distribution is normally a task to be achieved by the private sector.

5 Reducing chemical and noise pollution
Road traffic causes a number of environmental problems: noise, congestion, and emission of NOx, CO, CO2, and particulate matter. Despite the reduced life road transport exhaust emissions across Europe, there have been no significant improvements in concentrations of PM10 and nitrogen dioxide (NO2). As exhaust emissions decline, tire and brake wear contributes to total road transport emissions of air pollutants. The Euro 5 standard for light and heavy duty vehicles was implemented and the next standard, Euro 6 will be released in 2014 for both categories of vehicles. Particularly, there is a need to further reduce emissions with priority given to diesel vehicles which have significantly increased in recent years.
The Euro 6 proposal, in force in the coming years, lays down common EU rules on heavy motor vehicles and their engines with regard to pollutant emissions. Particularly, the proposal foresees a reduction of 80% in nitrogen oxides (NOx) and of 66% in particulate matter (PM) emissions compared to the Euro5. The NOx emission reduction from Euro 6 will increase the health benefits by approximately 60 – 90% relative to Euro 5. Several new energy-efficient powertrains are currently being investigated by scientists, governments, and car manufacturers to achieve the proposed limits, as:

- GDI and diesel engines;
- Turbo/super charging;
- Highly active intake systems;
- Electronically controlled valve actuation/timing;
- Drive by wire systems;
- Cylinder deactivation;
- EGR;
- Alternative/biofuels;
- Engine start/stop systems;
- Hybrid electric powertrains.

Perhaps the most difficult environmental problem to solve is the expected greenhouse effect, primarily caused by the emission of CO2. Technical innovations, such as the catalytic converter and improved fuels, have decreased the emission of VOC, NOx, SOx, and lead due to road transport during the last 15 years while the limited improvement in vehicle fuel economy has been offset by a growing demand for transportation.

A long-term solution for mitigating CO2 emission in the transport sector would be the use of renewable fuels instead of fossil fuels. Fuels and electricity from renewable sources are, however, still relatively expensive and the supply is limited.

The use of more energy-efficient vehicles is an important step towards a technical solution of improving the local and global impact on environment.
Fig. 8 Influence of HCCI engine load on CO\textsubscript{2} emission

Figures 4 and 5 show the results of the emissions in the case when alcohols as fuel are used and the following figures show the results of changes occurred in diesel engines by using homogenous charge (HCCI). These research results constitute the basis of future improvements of ICE in automotive applications in the coming years [10,11].

6 Conclusions

Strategies of developing road transport by controlling automotives’ emissions to reduce local and global environment impact are influenced by a complex of European, national and local policies, such as:

1) Implementing and reinforcing EU environmental legislations in order to diminish gaseous pollutants, particulates, and noise emissions due to road traffic;
2) Financial policy supporting the replacement of vehicle fleet with new generation one that satisfied latest pollution level;
3) Financial policy supporting development of alternative fuels;
4) Implementing a policy of taxation for second hand vehicle registration and promoting a lower taxation for new vehicles;
5) Investments for infrastructure to result in an improvement of urban road traffic flows, air quality and noise reduction;
6) Introducing alternative mobility means in urban area;
7) Implementing new energy-efficient powertrains.

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