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Transport and its Role in the Society

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ABSTRACT: Non-motorised transport, pedestrian, and bicycle transport are most often considered to be the most environmentally friendly types of personal transport; the railway is considered as environmentally friendly as well. Air transport seems to be a problem and the worst impact on the environment is represented by road transport, mainly individual. Rail transport is considered to be the most environmentally friendly regarding the transportation of goods, on the other hand the most unfavourable is road transport. The evaluation of water transport is ambiguous, because it represents a significant risk in case of accidents and the building of the infrastructure represents a significant interference with the countryside and river ecosystems.

KEY WORDS: Transport, society, means of transport, history.

1 INTRODUCTION

Every country of the world has a different potential and therefore people do not find everything they need for life in their nearest environments. They are forced to transport their goods (raw materials, information) and themselves as well. The globalization of the economic system and growing specialization of individual regions increase this need. Therefore, transport is one of the fundamental pillars of current economics. However, it is among economic restrictive factors as well, since the quality of transport systems limits a number of economic processes. Although the trend of increasing economic demands on transport systems already started in the era of industrialization, it has accelerated since the second half of the 20th century in connection with the gradual transition to the free market and global economics. A lot of economic processes, ranging from commuting to work, through supplying raw materials and energies, up to the distribution of goods to consumers are directly connected with transportation. Transport plays an irreplaceable role in the social sphere as well. It enables people to communicate, meet each other and exchange ideas. Since the time immemorial, transport and habits in using transport, have represented a certain status in the social hierarchy. In modern society, which tries to overcome the social barriers, an equal access to transport is one of the main principles. However, a lot of groups of inhabitants, such as disabled people, elderly people, or low-income inhabitants are access handicapped, which highlights their status on the edge of society. It is necessary to adopt the transport system to their needs so that they can be more integrated in society.

The counterpoint of positive effects of transport is its negative impact on health and the environment. The land use and operation of the transportation network affects landscape, flora and fauna in the environment of transport infrastructure and contributes to the deterioration of the living conditions in cities, where the majority of people are exposed to pollutants with a negative impact on their health. Therefore, transport is currently facing an uneasy task - to find a balance between the inevitable development, economic and social benefits on the one hand, and the protection of health and the environment on the other hand.

2 MODES OF TRANSPORT

Transport occurs in a lot of forms which can be characterized according to various attributes and needs in terms of infrastructure, means of transport, or service transport infrastructure. We could define nodes which provide transport services and which create the transportation network through connection with the infrastructure. Movement of the means of transport in the transportation network is assured technically and organizationally by the transportation infrastructure. Each transport relationship is defined by its origin, i.e. its origin and its destination (Rodrigue et al., 2009; Brinke, 1999).

There are many ways to classify transport. The most common way is to consider the environment (see Figure 1), but there are more parameters which could be considered such as the object of transportation (passenger transport – freight transport), number of people transported (individual – mass), frequency (irregular – regular), access of public (private – public), transport distance (local – regional – long-distance), location of the trip origin and trip destination in relation to geographical units (interurban – interstate – intercontinental), and spatial relation of the origin and destination of the analyzed area (inner – outer – transit). Transportation of the information which is provided by telecommunication services is usually not included in the classification.

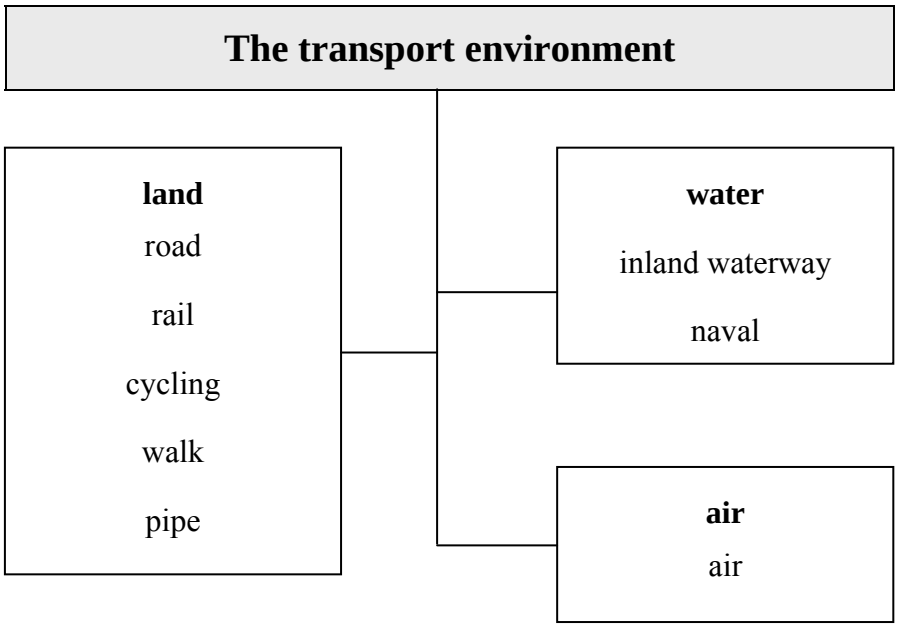

Figure 1: Basic classification of transport.

The transportation networks for individual types of transport are described and classified on the base of various parameters, the most common being the network length, density, shape and configuration of infrastructure, number of the main nodes, route deviation, coherence of the network, and the load of traffic volumes.

3 HISTORICAL DEVELOPMENT OF TRANSPORT

Historical development of society and the history of transport have always been closely related to each other. The quality of transport in various periods reflected the level of society development, but on the other hand, it was transport which gave a boost to society's growth in many time periods. The technical advancement in the production of vehicles allows to follow the technological development of production industries in different time periods.

There had been no forms of motorized transport until the end of the 18th century and the main driving gear of land transport was the traction power of animals, while wind power was used on water. Transport speed was very low, as well as the number of the total quantity of transported goods. Owing to the fact that water transport was more effective, as there was no quality road network, the vast majority of cities grew up near waterways, either on the seacoast or close to big rivers. Obviously, there were some exceptions, such as ancient Rome. Apart from agriculture bound to the fertile lowlands of big rivers like the Nile, the Euphrates or the Indus, the basis for all ancient civilizations was trade. The majority of transport relations occurred only on a local scale, the international trade was marginal and was mainly restricted to luxury goods, such as spices or jewellery.

The Middle Ages were characterized by the growing importance of trade and the progress in the field of sea navigation. The voyages of the Arab and Viking ships were followed by the development of trade in the North and the Baltic Sea, controlled by Hansa, and in the Mediterranean Sea, which was dominated by Italian city states. Their naval traditions were then followed by the Spanish and Portuguese, who gained the upper hand in the world seas at the turn of the 15th and 16th century thanks to the great geographical discoveries. The colonial trade flourished, which brought new kinds of commodities and raw materials to Europe; mainly precious metals and spices became the main import articles. The slave trade flourished as well and a huge amount of European goods found their markets in colonies. In the 17th century the leading role in the naval trade is passed into the hands of the English, Dutch and French. The colonial trade stimulated the further economic development of manufacturing in Europe.

The biggest revolution in transport since the invention of wheel was brought about by the invention of the steam engine in the mid-18th century. During the 19th century it became well established in all kinds of industry and transport. While the steamships started to rule on the world's rivers and oceans, transport overland was quickly mastered by railway. The railway held back all other forms of sea transport, shortened travel times and changed the perception of distance between big towns to figures unimaginable. Steam was later replaced by the combustion engine which allowed the automobile transport advancement and a short time later the birth of air transport as well. After World War I, road and air transport became significant competitors to railway transport, first in the USA, and in Europe a few years after. Thanks to transport, the individual regional economic markets gradually started to become interconnected, creating a world-wide one.

A big development in air transport came after World War II., mainly after the introduction of the jet airplanes, which made regular intercontinental passenger flights possible. This allowed to reach various parts of the world within a few hours. It allowed regional development of regions which had been on the peripheries until then;

namely the industrial countries of East Asia, led by Japan and Korea, and new tourist destinations in the Caribbean Sea, the Pacific, and the Indian Ocean.

Since the 1960s the world's powerful countries have started exploring the space. In spite of the fact that the first "space tourists" have already embarked on an orbit around the Earth, the regular usage of space transport is conditioned by further technological progress. It's goal needs to reach the cost reduction of space devices in such a way that their price would be reduced to a price of similar terrestrial devices. It would also allow the change in the composition of the cargos transported to space because, in comparison with present conditions. We cannot expect a growth in the quantity of transported scientific, communication, or army satellites, therefore only the volume of commercial transportation is to be increased. Another trend which can be expected in the future is further increase in the total volumes of transportation and density of transport networks, unification of transport routes and their concentration in transport corridors. More and more demands are being placed on accelerating and improving transport services.

Approximately 30 years ago the world community asked about the responsibility for the exploitation of non-renewable resources and the condition of the environment. Transport plays a significant role in the consumption of some of the non-renewable resources, mainly oil, and also in increasing air pollution, therefore transport is one of the crucial aspects in the conception of sustainable development. Searching for environmentally friendly forms of transportation has become a necessity which will require gradual renaissance of rail transport and the development of new drives for road transport.

4 INDIVIDUAL MODES OF TRANSPORT

The individual modes of transport are characterized by certain advantages and disadvantages which influence their use on the transport market. The categorization of the individual transport modes in the following text corresponds with the basic categorization of transport mentioned in Figure 1. To see how individual transport modes are used in the transport market, we need to compare the transport performances on various levels, e.g. a national level, local level, transport of certain goods, etc. The individual transport modes usually compete with each other. The competition depends on the aspects of price, speed, availability, frequency, safety, comfort, etc. Multi-modal transport covers only a small part of the market so far.

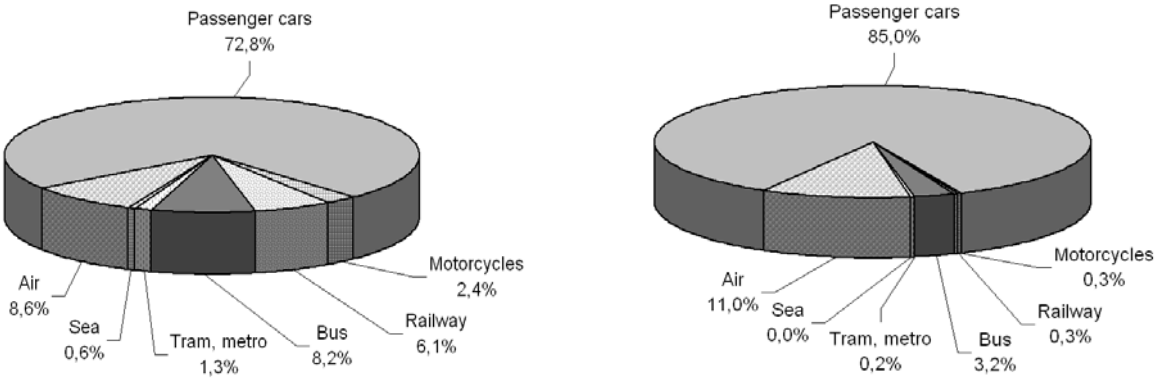

Figure 2: Modal split in passenger transport in 2006 in EU-27 and USA.

A large share of individual automobile transport compared to other modes of transport is characteristic for developed countries regarding the field of passenger transport. In Europe public transport has a proportion of 25 %, compared to 75 % of individual transport, but the difference is even higher in the USA, because individual motoring reaches a proportion of 85 % (see Figure 2). What is typical for the transport system in the USA, compared to Europe, is its minimum use of railways and city transport and a greater use of air transport.

Up until the 1960s railway had dominated in the field of freight transport. Its market proportion has started to decrease significantly in favour of truck transport since that time. The current proportion of rail transport regarding the total overland transport reaches only 16 % (Figure 3). In the countries of Eastern Europe this trend became more obvious after 1990. Railways were unable adapt to the quick social and economic changes in a sufficiently short time, and therefore, over several years, the modal split changed completely in favour of more adaptive and operative truck transport.

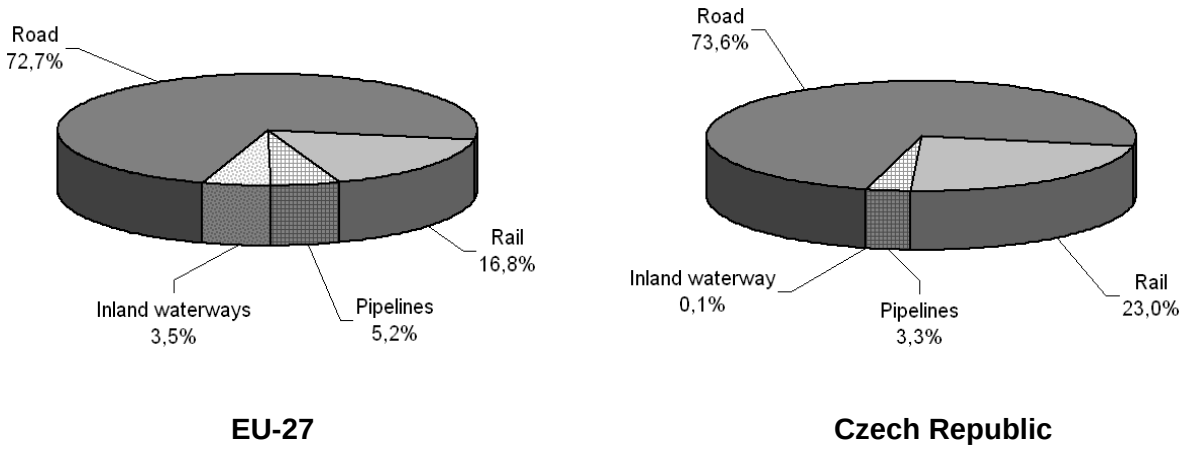

Figure 3: Modal split of freight overland transport in the countries of EU-27 and the Czech Republic in 2006.

4.1 Road transport

Road transport plays a main role in passenger and freight transport nowadays, especially for short and medium distances. Compared to the railways, it has an advantage of higher operability and availability; a disadvantage is a lower degree of organization in its operation, a higher negative influence on the environment, and, above all, low traffic safety.

In spite of this fact, road transport dominates in the transport market in the majority of developed countries, mainly in the freight sector. Its position is still being strengthened thanks to the building of high capacity multi-lane motorways, which create new main axes of the road network. The motorway network is then completed hierarchically with roads classified into categories which are based on their significance in terms of function and technical condition. In the developing countries, on the other hand, an insufficient road network frequently consisting of unpaved roads predominates. The construction of motorways, when considering its size and high terrain demands is demanding in terms of horizontal and vertical alignment, which results in higher land use, amount of necessary building work, as well as the total price.

In the area of the current Czech Republic, a rapid development of motorism occurred in the 1970s. Until that time, there had been a relatively low number of automobiles. Their number started to grow and the trend, which is apparent until today, after a temporary decrease in the 1980s, continued with another boom after 1990 as a consequence of rapid social changes (see Figure 4).
At the same time a significant decrease in the total number of vehicles, classified in the category of single-track vehicles, as well as buses, occurred.

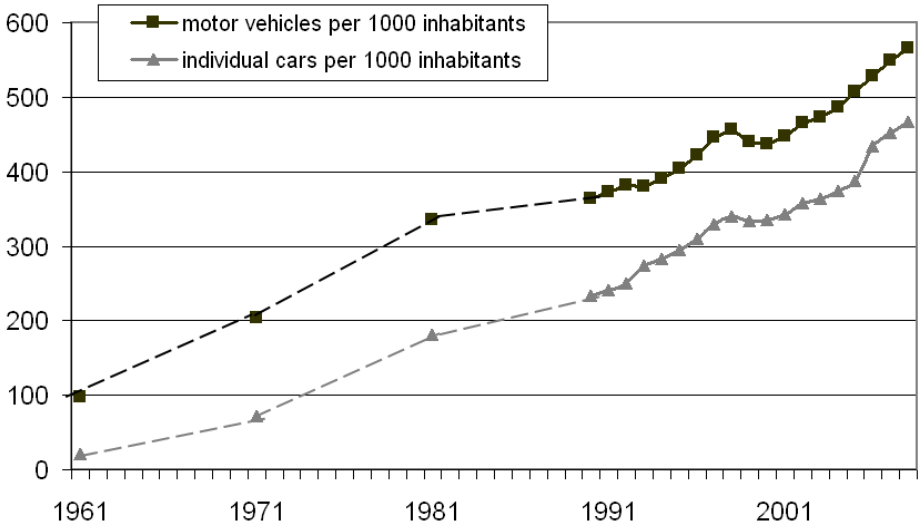

Figure 4: Number of automobiles in the area of the Czech Republic between 1961 and 2008.

The growth of motorization gradually increases the demands on the quality of the road network. The first motorways were first built in the territory of the Czech Republic in 1935, but the construction was later suspended and the finished parts were abandoned (Lídl & Janda, 2006). The construction was restored again at the end of 1960s, and the first motorway section was completed in 1971. On 31 December 2009 the total of 729 km of motorways were in operation in the Czech Republic, which is expected to increase up to 944 km in the future (Brunclík & Vorel, 2009). Attention is currently being paid mainly to the completion of the motorway D8 to Germany towards Dresden, D11 from Prague to Hradec Králové, and a part of D1 from Kroměříž towards Lipník nad Bečvou. With the exception of the cross-border section Bohumín - Polish A1, the motorway D47 is finished and integrated in the transport network as a part of D1. The motorway D3 will connect Praha with České Budějovice and Upper Austria. Its construction is going to be more intensive in the near future.

The construction of new roads and the extension of the existing road capacity is unable to satisfy the current demand, which the current road network is unable to cope with in some sections, which results in congestions. Simple densification of the motorway and road network brings with it the phenomenon of traffic induction, which is an increase in automobile transport as a consequence of the improvement of the qualitative and quantitative parameters of the transport network. This increase occurs, to a certain degree, at the expense of public transport and, partially, as a consequence of generating new traffic which would not otherwise exist at all.

The rapid increase of road transport volumes slowed down with the arrival of the economic crisis, but further growth in road transport on the European as well as national level

is expected with the improvement of the economic situation. To limit the negative consequences affecting health and the environment which will be brought about by this further increase, an application of various measures is necessary.

4.2 Rail transport

Regarding railways we often encounter a broader term rail transport, which besides railway includes tram transport and trolleybus transport. The borderline between rail and tram transport is ambiguous in some cases, as modern transport solutions of operation in large cities prefer the interconnection of individual systems.

Rail transport requires the construction of a transport route based on rails through which the locomotives and railway carriages are moved. In comparison to the road network, the railway network has a higher route deviation, which is given by the lower adhesion of vehicles. Therefore, railway is more affected by geographical conditions of landscape and has a lower ability to overcome the elevation, which brings higher financial costs in the construction of new railways. The greatest advantages of railways are its speed and the high capacity, so it has a valuable role in passenger transport mainly in high-density areas and, concerning freight transport. It is the most effective transport of mass material, like agricultural products, or raw materials, such as wood, coal, iron ore, and building materials.

According to the type of the vehicle drive we differentiate between electric and motor traction. Steam engines, with the exception of some third world countries, are not in regular transport service anymore. Especially the electric traction is considered to be an environmentally friendly type of transport, thanks to its considerably lower energy consumption and lower emissions of pollutants per unit of transported cargo, in comparison to other types of transport. But the indirect consumption of the resources induced by the production of electric energy, with only a small percentage coming from renewable sources, is not negligible.

Nevertheless, the positive effects in terms of health and the environment dominate and, the renaissance of railways is expected. But it has to be adapted to the demands of modern economics and become competitive with road transport, mainly in terms of speed, punctuality, supply patterns of goods, and integration in the multimodal transport systems.

The Czech Republic has a very dense network of railway lines, which is, together with Belgium, the densest in Europe. The first railway arrived in 1839 and by 1870 the whole main network of railway lines was in operation. This network was later complemented with rural side lines. The development of the railway network was finished by World War I., the construction realized after that had to remove the radial arrangement of the main lines towards Vienna and Budapest, inconvenient for the newly formed Czechoslovakia. The most significant railway construction in the area of the Czech Republic realized in the 20th century was the construction of the line Brno - Havlíčkův Brod, opened in 1953. The total operating length of the lines in the Czech Republic reached 9 578 km in 2009; out of which 3 153 km were electrified (MT, 2010). The use of more current systems is a disadvantage which places increasing demands to electric locomotives as the multi-system vehicles have to be used.

The dense railway network of lines gives the Czech Republic great potential for further development of rail transport, but the long-term setback is the high degree of under-investment and the neglected maintenance of some infrastructure. On the other hand, some main lines have been modernized, even up to a speed of 160 km/h, since 1993. These lines are divided into four transit rail corridors (TRC), which cover the crucial transport flows, mainly for international transport. The first two corridors were finished in 2004; the modernization continues on the third and fourth corridor.

The routes of the corridors are mentioned in the following overview:

I.: (Germany -) Děčín – Praha – Č.Třebová – Brno – Břeclav (- Austria)

II.: (Austria -) Břeclav – Přerov – Bohumín (- Poland), connecting line: Přerov – Č. Třebová

III: (Germany -) Cheb – Plzeň – Praha – Č. Třebová – Přerov – Ostrava (– Slovakia)

IV.: (Germany -) Děčín – Praha – Č.Budějovice – Horní Dvořiště (– Austria)

An addition to the above-mentioned corridors, the section from Brno to Přerov, which is included in the priority European projects of the network TEN-T, is planned to be modernized within similar parameters.

The further development of passenger rail transport is expected in urban areas on the main routes from the centres to suburbs. City tramline network may be used by suitable rail vehicles may be used. At medium-range distances, (up to 1000 km), railway will be competitive with air transport on those routes, where high-speed lines, enabling travel speeds over 300 km per hour, will be constructed. In the sector of freight transport, the integration of railway in the combined transport system is its greatest opportunity as it should form the backbone of the overland logistics systems.

4.3 Water transport

Shipping has been used by people since time immemorial, so it is among the oldest modes of transport. It did not need a special infrastructure to be built because water forms natural transport routes, which have become the axes for the transport system in the past. Rivers and lakes were used for this purpose in inland areas and the sea in coastal zones. At the moment, shipping has an irreplaceable role in the freight transport of mass material, like iron ore, coal, or oil. In terms of passenger transport, shipping plays only an additional role nowadays; with the exception of some developing countries, it is mostly used for recreational purposes.

The nodal points of the water transport network are ports. They are large facilities established for ships to be loaded, unloaded, and where ships are taken care of. Ports tend to be connected to the land transport routes through which the goods could be further transported inland. The water infrastructure is formed by rivers, lakes, and man-made constructed canals. A lot of rivers were adjusted for the needs of water transport by canalization, which includes the straightening of the water course, construction of sluice gates, and reinforcement of banks, which bring about dramatic and irreversible changes in river ecosystems.

The Czech Republic is a landlocked country located at the main European water divide between basins of three large European rivers (Labe (the Elbe), Odra (the Oder) and Dunaj (the Danube)) flowing to three different seas (the North, Baltic Sea and Black Sea). That is why it does not have enough of strong water flows, which provide suitable conditions for water transport. The only river which is intensively used for water transport is the Labe, together with the lower flow of the Vltava, with a total length of 303 km. Due to the not very good waterway conditions on the Labe, the regularity of service strongly depends on sufficient water level. The overall length of the navigable waterways, including those only used for recreational purposes, is 664 km.

The overall density of waterways in the Czech Republic is less than 9 km per 1000 km^{-2}., in comparison to 123 km per 1000 km^{-2} in the Netherlands (highest value in Europe) and 51 km per 1000 km^{-2} in Belgium (MT, 2010).

The high financial costs of the construction of new canals do not provide, in the viewpoint of economic profitability, a lot of opportunities for extending the Czech waterway network. The motorways and railways provide alternative sufficient capacity possibilities for transportation, therefore we may expect the maintenance and eventual improvement of the waterway conditions only on the current routes. However, their adjustments need to be undertaken very carefully since valuable and protected water ecosystems could be greatly at risk by the construction works.

4.4 Air transport

The history of the youngest of the commonly used modes of transport is not longer than a century. In the interwar period the zeppelins were an important mean of transportation, but after World War II, heavier-than-air machines were victories in the battle of the use of airspace. Rapid development in air transport came at the end of the 1950s and the beginning of the 1960s.

Aviation has the main role in the fast transporting of passengers over the long-distance routes. Its role in freight transport is not generally important with the exception of hauling the mail and small parcels. The exception are remote regions of Siberia, equatorial and sub-Saharan Africa, and South America, which have a poor system of surface routes and where air transport is the basis of the transport system.

Air transport uses airspace as its transport route, mainly the stratosphere, so it is independent on the construction of overland transport routes and topographical obstacles in landscape. The only exception is the construction of network nodes - airports - which is very difficult in rough terrain. Airport construction (or expansion) is problematic in densely populated areas as well, due to difficulties to meet the required standards concerning noise.

The total number of passengers transported by air is very low but thanks to the long average trip distance, it occupies approximately 10 % of the share of transportation performance worldwide. In spite of the fact that the media regularly report airplane accidents with a lot of casualties, air transport and rail transport are the safest types of passenger transport for their high degree of operating organization. As mentioned above, the air transport is not used for cargo transportation very much, so it only accounts for approximately 0.25 % of the total volume of freight transport.

As far as the area is concerned, the Czech Republic is among smaller countries, so it does not have very suitable conditions for domestic air transport. However, air transport gradually gains a higher importance in international transport. There are five international airports in regular operation in the Czech Republic: Praha-Ruzyně, Ostrava-Mošnov, Brno-Tuřany, Pardubice, and Karlovy Vary-Dvory. In 2008, air transport was used by more than 7 million travellers in the Czech Republic, which, in comparison to 1993, increased more than five-fold (see Figure 5). 95% of the transported passengers go through Praha-Ruzyně airport where the total number of passengers rises significantly every year.

The demand for air transport will probably continue to rise; nevertheless, a lot of airports are on the limit of their capacity so they are unable to handle new services. Low-cost carriers have been more and more active in recent years as an alternative in the continental Europe. Unlike traditional carriers, they use the rural and regional airports more often. But their offer can only address a certain group of customers. On the main routes, the use of giant aircrafts

is expected; this will allow an increase in the number of seats while keeping the number of flights in current level.

The interconnection of the existing independent national air navigation services is important in terms of flight safety to avoid mistakes in communication with the crews of the individual planes.

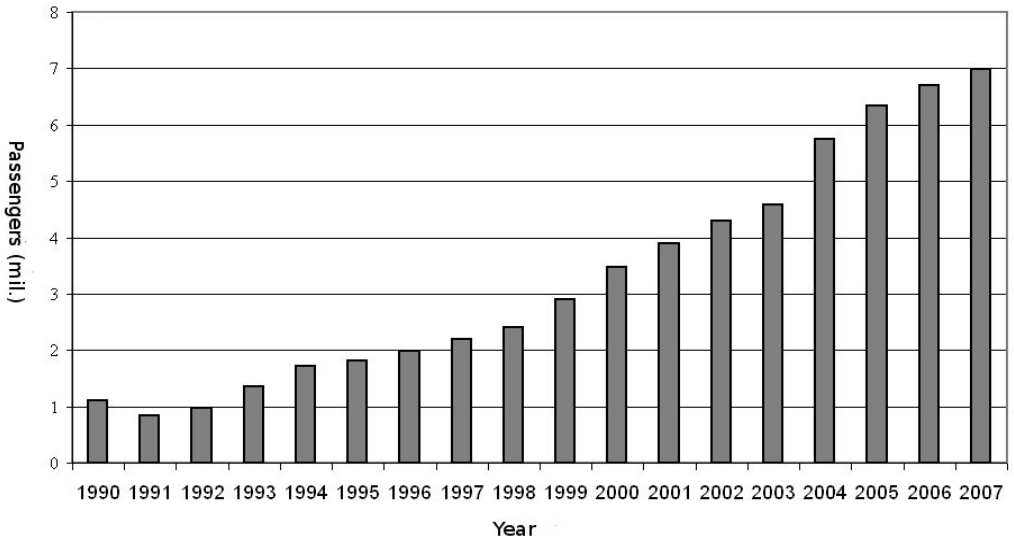

Figure 5: Number of passengers (millions) of air transport with the Czech carriers between 1990 and 2007.

4.5 Cycle and pedestrian transport

The cycling is an effective mode of transportation for short distance trips (up to 5 - 8 km) and could be easily combined with other modes of transport, mainly rail transport or urban public transport in the systems called “bike and ride”. In some countries, like China, the Netherlands, or Denmark, bicycle transport has a big share in the modal split within the local transport. Cycle transport is environmentally friendly and has positive effects on health and physical fitness. It is only a little demanding on non-renewable resources; it does not produce air emissions, or even a distinctive noise. The spatial demands are significantly lower when compared to other types of local transportation, excluding walking. The term cycle transport is often restricted only to a free-time recreational activity in the form of cycling tourism, but in the context of transport sustainability, its importance is to be found in everyday use for urban and suburban commuting. The high vulnerability of cyclists in everyday traffic is a big problem and therefore specialized infrastructure, in the form of bicycle paths, is promoted in localities with the high concentration of cyclists. Another problem is a safe storage of bicycles in places of the most common destinations in urban areas, such as workplaces, shops, authorities, particularly in city centres.

Walking is an everyday part of our lives and its quality is one of the criteria which determine the quality of our lives. It is the healthiest and most environmentally friendly of all transport modes, because it has minimal spatial demands and energy consumption, has positive effects on health, and has an important recreational function. In towns it is related mainly to public places, tourist attractions, public vegetation areas as well as publicity transport. Special infrastructure for pedestrians (pedestrian paths and pedestrian zones) is provided at busy places. These zones are common in the centres of large cities where all

other transport modes are excluded, however, exact conditions vary in different cities. Concerning the environment, the permission of access for cyclists to pedestrian zones is positive; and in many towns, pedestrian zones are accessible to trams as well.

4.6 The multi-modal transport

The basic principle of multimodal transportation is the co-operation between individual modes of transport. Therefore, those transport modes which use at least two modes of transport to get from the origin to the destination are considered to be multimodal. It offers a chance to use the most sustainable mode of transport for each part of the trip, so, in terms of health and the environmental impacts, the most environmentally friendly one. For example, the transportation of goods between logistics centres is realised by railway and the local distribution to the destination is provided by road transport. The significant moment to apply this multi-modal approach in freight transport was the introduction of standardized containers which allow easy transhipment of goods between individual transport systems. The multimodality in passenger transport is particularly used in the creation of integrated transport systems. The idea of co-operation between individual transport modes is relatively new, because, for a long time, the transport market had been strictly segmented and economical competition between different transport modes in freight and passenger transport had been fierce. The introduction of state transport monopolies in rail transport, air transport and public road transport was typical for Europe. In connection with the principles of the free market, which are proclaimed by the EU, these monopolies are gradually removed.

A special case of combined transport is the system of the accompanied intermodal transportation, the so-called Ro-La (Rollende-Landstrasse). It provides transport of road trucks on railway on some routes. Two such lines were operated in the Czech Republic: the first one ran from Lovosice to Dresden in Germany, and the other one from České Budějovice to Villach in Austria. However, due to economic reasons (low use, in the first service mainly due to the removal of duty obligation after the accession of the Czech Republic to the EU in 2004) their operation was discontinued; although such systems are still in operation in other countries.

There are 13 terminals for combined transport in operation in the Czech Republic at the moment. These terminals are linked to motorways and railways. Furthermore, four of them allow transhipment to ships of inland waterway transport (MT, 2010). However, virtually all the existing terminals are privately owned. The transport policy for 2005 – 2013 (MT, 2005) brings a task to build a network of public logistics centres in which the pick-up and delivery of shipments in the neighbouring areas will be realized via road transport and the centres will be interconnected by railway.

5 TRANSPORT IN EUROPEAN CONTEXT

The unified European market and the free movement of labour force are among the basic principles of the EU. In the transport sector, there is an effort to adapt transport to the needs of inhabitants. The fundamental strategic document is White paper - "The European transport policy until 2010: Time to decide" (European Commission, 2001) defining over 60 measures which should help in order to meet targets in the Paper. The main targets are: the increase of railway share in modal split and the interconnection of various modes of transport within multimodal logistics chains.

Unfortunately, the transport systems of individual EU countries have developed separately and therefore there is a considerable fragmentation among them,

either from technical or organizational point of view. This trend is apparent mainly in rail transport, whose development, in relation to its favourable environmental characteristics, is one of the European priorities, mainly in the field of international freight transport. For railways, the organization at the national level is typical. The EU has a task to increase the quality of rail transport by improving the technical and managerial level of individual operators and groups of operators or by increasing the competition on routes to achieve a positive effect on customers. The goal should be the opening of the market in the field of freight transport, both at international and national levels; the liberalization of passenger transport is planned in a longer term perspective. The unified market in rail transport requires the unification of the national technical and organization aspects.

In field of road transport, the whole-European coordination and completion of the road network for long-distance transports is necessary. In some regions, particularly in the newly-acceded members, there is an incomplete network of motorways and highways, or, even non-existent. The motorway network is particularly important for passenger transport; long-distance freight transport should be operated with the use of combined transport.

The quality transport network is one of the European priorities and, therefore, a concept of Trans-European transport networks (TEN-T) was approved in the 1990s. The concept of networks focused on both road transport and high-speed rail transport, as well as on combined transport and inland waterways. The priority projects, which included the elimination of technological limitations in the transport networks, were defined. An example of such a project is the construction of high-speed railways between Paris, London and Brussels, or the construction of a bridge over the Oresund strait, which separates Denmark and Sweden.

The insufficiently developed transport network in the new member states of the EU is their economic disadvantage compared to the original members. The insufficient condition of transport systems in Eastern Europe was caused by overloading, up to their capacity limits, and neglected maintenance over a long time. The consequence was the reduction in their reliability, longer travel times, and the environmental problems. One of the outcomes of the second Pan-European transport conference, which took place in 1994 in Crete, was the agreed routes of corridors linking the most important centres in Central and Eastern Europe. It meant defining the most important transport routes which were necessary to be funded within the period of up to 15 years. In 1997, at the third conference in Helsinki, certain changes were made so that the corridors would meet the needs of the EU after its enlargement. They are therefore sometimes called the "Helsinki" corridors. The routes of the pan-European corridors are perceived as multi-modal usually involving road and rail components, as well as air or water components in some cases.

Out of the total of 10 pan-European corridors, the fourth pan-European corridor and one of the parts of the sixth pan-European corridor touch the territory of the Czech Republic. The main route of the fourth corridor runs from Berlin/Nuremberg to Prague, Bratislava, Budapest and further splits up to Constanta, Thessaloniki, and Istanbul. Regarding the sixth corridor the main route is from Gdansk through Warsaw and Katowice to Žilina (the connection to the pan-European multi-modal corridor number V, Venice - Ľviv). The arm B concerns the Czech area, which runs through the Moravian ravines and is linked to the pan-European multimodal corridor number V in Bratislava, respectively Vienna.

Regarding the Czech road network, the routes of the current or planned motorways and highways: D5, D8, D1, D2, R48, R55 belong to the pan-European corridors. Concerning the rail network, the pan-European corridors contain main arms of the first and second transit rail corridor and a part of the route of the third and fourth transit corridor. The existing Labe waterway could be classified as a part of the fourth pan-European corridor.

The definition of individual corridors allowed to locate places and routes which require foremost attention when reconstructing and improving the transport infrastructure. The inclusion of a transport project in one of the corridors increases the chance when applying for financial support from the funds of the EU.

Figure 6: Pan-European corridors.

6 SUMMARY

The most environmentally-friendly passenger transport mode is often regarded the non-motorized transport, i.e. walking and cycling. Rail transport is also viewed as environmentally friendly. Air transport seems problematic and road transport has the biggest largest impact on the environment, particularly individual road transport. Regarding freight transport, the most environmentally friendly is considered rail transport, road transport is considered to be the most harmful. The assessment of water transport is ambiguous, since there is a high risk in case of an accident and the infrastructure construction is a dramatic intervention in landscape and river ecosystems.

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Transport Requirements for Energy and Resources

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ABSTRACT: This article provides a comprehensive look at the energy and resources required for transport and also at the benefits and disadvantages of replacing conventional energy resources in transport. Besides the issue of replacing fossil fuels, it also describes various trends in alternative drives, which are compared with conventional drives, in terms of energy efficiency and environmental impact.

KEY WORDS: transport, energy, non-renewable resources.

1 INTRODUCTION

The growth of energy needs in transport directly depends on the environment impact, which is further related to the health of population, economic growth of countries, social conditions, etc. The effects of energy consumption on the environment can be divided into two areas. The first area is a steady growth in the consumption of non-renewable fossil energy resources, which is in opposition to the principles of sustainable development. The other area is a growing impact on the environment, particularly by air pollution, due to the continuous increase in the amount of the consumed fuel. Emissions of carbon dioxides (CO_2), one of the most important greenhouse gases produced by transport, are directly based on fuel consumption, i.e. energy, in comparison with other emissions.

The primary used fuel in transport, and therefore the source of energy in transportation, is petrol and diesel fuel, which is produced from crude oil. Nowadays, the consumption in the transportation sector reaches approximately 40% of the global oil consumption. This proportion of the transport sector in oil consumption is estimated to grow steadily, in theory even up to 90% in 2050 (Birky et al., 2001). Whereas oil consumption in energy, residential, and commercial sectors will decline, the trend in transportation will be quite opposite. A huge growth in oil consumption in the transport sector will increase significantly due to the considerable growth of the global number of vehicles which is expected particularly in the developing countries. For example, 8.5 vehicles per 1000 inhabitants were registered in China in 1998, which corresponds with statistics of vehicle ownership in the USA in 1912. 112.63 vehicles per 1000 inhabitants were registered in 2006, respectively 39.43 passenger cars. Another reason for growing energy consumption in transport is the higher mileage of vehicles. Whereas in 2000 the share of transport in oil consumption was 30 million barrels of oil a day of the global daily consumption of 75 million barrels of oil (1 barrel = 159 litres), it is assumed that in 2050the global oil consumption

will rise to 186 million barrels a day, out of which 170 million will be consumed by transport (Birky et al., 2001). In contrast to stable gradual increase in energy consumption in developed countries, a rapid increase in energy consumption by transport in developing countries is expected, which will certainly have a global impact on the environment of the whole planet.

2 ENERGY CONSUMPTION BY TRANSPORT

The increase in the number of vehicles and in the mileage of vehicles goes hand in hand with the growth of energy consumption, which from 1993 to 2005 increased by almost 75% in the transport sector. The most significant growth in energy consumption occurred in individual car transport, road freight transport, and aviation. On the other hand, consumed energy significantly decreased in water transport and rail transport, which was caused by the consumer preference for road freight transport. The energy consumption is directly related to the consumption of fuel, whose sale almost doubled in the Czech Republic from 1993 to 2005. The most considerable growth was observed in diesel fuel, which is connected both to a significant increase in freight transport in the Czech Republic and the growing popularity of diesel fuel cars in individual car transport.

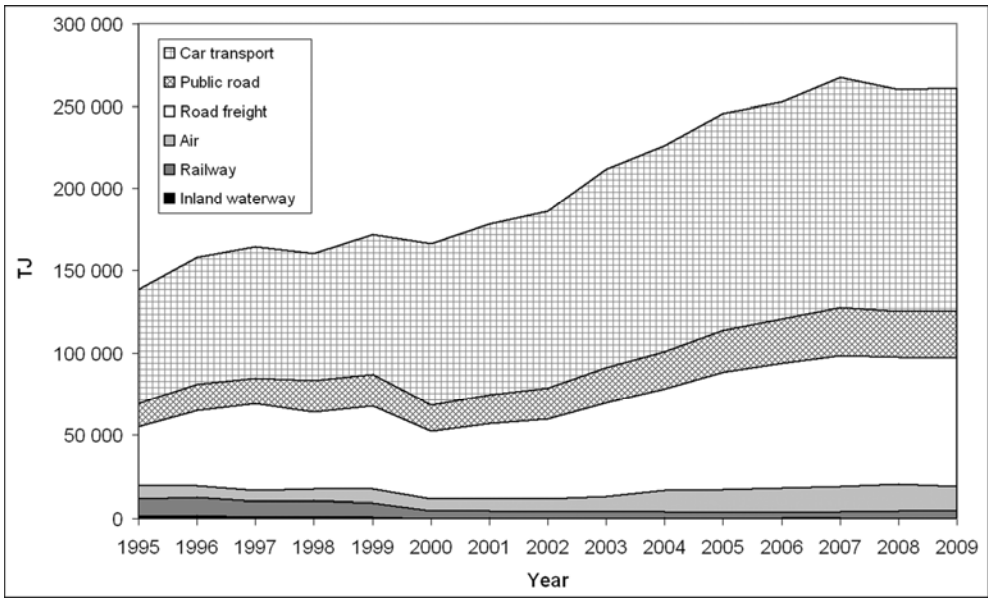

Figure 1: Energy consumption by transport in the Czech Republic.

3 CURRENT ALTERNATIVES TO CONVENTIONAL ENERGY RESOURCES

Virtually nobody can imagine nowadays that within a very short period of time the automobile petrol and diesel fuel may be replaced by new fuel or by an utterly new drive of the vehicle. On the other hand, hardly anybody is aware of the non-renewability of these fuels as well as the real threat of the future shortage of this energy resource, which should be used much more efficiently. Oil is raw fossil material found in underground layers and extracted in so-called oilfields. The majority of the largest oilfields, called "super giants", are found in the Far East. The world's oil reserve estimates are regularly revised and provide information about the development in the world of oilfields. The estimates of world's oil reserves depend on a lot of limited information, such as the depth of extractable oil, rock formation, and many others. The oil reserves should not

only be associated with the development of oil production; it is just one of the factors on whose basis the development of global oil production is estimated. Other factors are, for example, the history of a given oilfield production, local geographical conditions, available technologies, oil price on the world market, etc.

In connection with the exhaustibility of world's oil reserves, we speak about "the world production oil peak". After discovering an oilfield, oil production at that site grows, until the production peak has been reached. After reaching the peak, the remaining oil reserves are extracted with declining production characteristics. In some cases the oil production decreases very slowly, but reaching the peak production is no longer possible. The lifetime of an oilfield is counted in decades and the production peak is usually reached after about a decade after the discovery of the oilfield. When considering all world's oil reserves, then we refer to the world's oil peak, i.e. reaching the maximum world's oil production, not to the exhausting of oil reserves. The world's oil peak has already been a subject of discussion for a long time since the beginning of the modern oil era, dating back to the mid-19th century. Even now, after acquiring new knowledge about oil technology, the estimates of an oil peak are still only a speculation with high degree of uncertainty.

The world experts on oil also differ in their estimates on reaching the world's oil peak. Some of them expect a new oil peak to come in a very short time, others place arguments for the abundant amount of oil for a time period longer than a decade. The arrival of the oil peak by 2010 was predicted by e.g. C. Skrebowski, editor of Petroleum Journal, as well as the non-government world organization World Energy Council. De Almeida & Silva (2009) also expect to reach the global oil peak around the end of the first decade of the 21st century. The Energy Information Administration, CERA (energy consultants of the USA), as well as the company Shell, predict the arrival of a new oil peak after 2020. The American company EIA (Energy Information Administration) produced an extensive study of scenarios on the exhaustion of world's oil reserves. On the basis of the assumption of a 2% yearly increase in the global demand for oil, the production oil peak is to be expected in 2037 (Wood et al., 2004) with the demand for oil reaching 53.2 billion barrels a year.

Table 1: The conventional fuel savings when using the driving systems of the vehicles.

Fuel	Efficiency potential	Exhaust emissions	Date of the market launch	Cost increase	Other
More efficient conventional	Mild	Gradually decreasing	Present or short-term (0 – 5 years)	Minimum (5%)	Favourable for customers, depends on oil
Hybrid	Important	Nearly zero	Short-term (2 – 7 years)	Significant (10% – 20%)	Growing interest, accepted by producers
Fuel cells	Very high	Very low, nearly zero	Middle-term (5 – 12 years)	Very high (>20%)	Potential oil independence
Electric	Very high	Zero	Short-term (2 – 7 years)	Very high (>20%)	Capacity of accumulators

With both the continually growing demand for oil with a yearly increase of 2% and reaching the production oil peak, the effect of jaws opening will appear when the demand for oil grows and the world oil production decreases. This phenomenon is called by experts the "oil gap" and it deals with the energy difference between the demand for oil and limited oil supplies. The oil gap, however, cannot be considered to be an energy crisis, as it has been

indicated in some cases, due to several times larger resources of fossil fuels used in the energy industry (coal, natural gas, etc.) in comparison with oil reserves. The most serious effect of the oil shortage threatens the transportation sector. Therefore, it is necessary now to address the issue of how to fill the oil gap.

One of the ways to achieve energy supplies after reaching the world oil peak is to extract energy from unconventional fossil resources, whose world reserves are enormous – it is estimated that the energy reserves of unconventional fossil resources are a hundred times bigger than the total energy resources of the conventional fossil resources. The unconventional oil resources are the oil-bearing sands, shale gas, and heavy oil, whose processing is economically and technologically too demanding so far. The other option is the production of synthetic motor fuels from natural gas, GTL technology (Gas to Liquids) with the use of the technology of obtaining natural gas from methane hydrates. Hydrates and the technology for their production are in the early stages of research.

Another way to assure the energy in the transport sector is the development of new, andan improvement of the existing, driving systems of vehicles (hybrid and electric drive, fuel cells, etc.) while developing new alternative fuels (bio-fuels, natural gas, hydrogen, etc.).

Table 2: Comparing the potential of transport fuels.

Fuel	Renewability	Status of the technology	Needs of the infrastructure / costs	Other obstacles
Oil	Final	Developed	No	Continuing huge carbon emissions
Unconventional oil	Final, but huge reserves	Short-term even mid-term availability (5 – 10 years)	Minimal	High extraction costs
Methane hydrates	Final, but huge reserves	Long-term availability (7 – 12 years)	Mild	Unknown technology
Bio-ethanol	Renewable resource, limitation by the area	Short-term availability (0 – 15 years)	Minimal	High production costs
Biodiesel	Renewable resource, limitation by the area	Short-term availability (0 – 5 years)	Minimal	High production costs
Methanol	Final	Developed	Mild	Toxicity
Natural gas	Final	Developed	Significant	Storage, growing price
Biogas	Renewable resource, limitation by the area	Short-term availability (0 – 15 years)	Significant	Distribution, storage
Electricity	Depends on primary source	Developed	Significant	Storage
Hydrogen	Potentially huge, depends on the resource	Short-term even long-term availability (5 – 12 years)	Very high	Storage security

3.1 Bio-fuels

At present we are almost unable to find a daily or specialized press which does not mention the replacement of fossil fuels with bio-fuels, which are, in the case of motor fuels, produced from biomass. These are mainly biodiesel, bio-ethanol, and biogas. The replacement of the part of fossil fuels by renewable resources is also one of the strategic goals of the European Community whose partial goals are to reduce the dependency on oil imports, reduction of the transport impact on the environment, new jobs in agricultural, etc. The requirements for the use of bio-fuels are determined in the White Paper, in "European Strategy for Sustainable Development" (European Commission, 2001) and particularly in the European Directive 2009/28/EC (European Commission, 2009), which is implemented in the Czech legislation with the amendment of the Act on air protection, in which the obligatory mixtures of bio-components in petrol and diesel are specified. Since June 2010 the share of bio-components has reached 4.1% for petrol and 6.0% for diesel.

The technical term biodiesel means 100% pure fatty acid methyl esters (FAME), which are made by reesterification of plant or animal oils and methanol. The oilseed rape, from which methyl esters of the fatty acids of seed oil are produced, is the most important raw material for the production of biodiesel in the Czech Republic, and foreign production of FAME comes from soya, palm oil, and other oil products. The fatty acid methyl esters are fuel which is approved by the announcement of the Ministry of Industry and Trade, which specifies the requirements for fuels for road traffic; and the method of monitoring their quality and their parameters are defined by the standard ČSN EN 14214 (656507) Automotive fuels – Fatty acid methyl esters (FAME) for diesel engines – Requirements and test methods. The offer of car fuels include 100% pure methylester fatty acids as well as mixed motor fuel composed of diesel and biodiesel additives, usually of 20% (mainly abroad) and 30%.

By operating vehicles using biodiesel the impact on the environment is reduced, in comparison with the vehicles using diesel. The results of studies which measured the emissions during biodiesel combustion have demonstrated the influence of the quantity of added biodiesel into conventional fuel, in relation to the quantity of the emitted air pollutants. The declining dependency of the quantity of the emitted particulate matter (PM), carbon oxide (CO), hydrocarbons (HC) on the growing content of the mixed biodiesel is demonstrated. On the contrary, due to the physical-chemical properties of the fuel, the emissions of nitrogen oxide (NO_x) proportionally grow with the increasing quantity of the mixed biodiesel (U.S. Environmental Protection Agency, 2002). In the past, the vehicles running on biodiesel needed adjustments of the fuel systems considering their aggressive effects on the rubber parts. Nowadays, several car manufacturers have already approved biodiesel or mixed motor fuel for operation in mass-produced vehicles.

In the Czech Republic bio-ethanol is an alcohol fuel made from sugar-beet or cereals, from maize;, sugar cane, and potatoes abroad. We distinguish two types in this fuel, fuel for petrol engines, and fuel for diesel engines. For petrol engines mixed motor fuels are used, the fuel with a low content of bio-ethanol (it is currently possible to add 5 % of alcohol to petrol), and fuel with a high content of bio-ethanol (so-called E85) composed of a mixture of 85 % waterless bio-ethanol and 15 % petrol. However, fuel E85 cannot be used in the mass- produced vehicles running on automobile petrol. Special vehicles called "flexi fuels" were constructed for this fuel, for which, on the basis of the evaluation of the type of fuel mixture, the optimum conditions of combustion are set. These flexi fuel vehicles can be run on an arbitrary mixture of bio-ethanol and automobile petrol, with a content of bio-ethanol ranging from 0% up to 85%. As an example of European producers of flexi fuel vehicles, the companies Ford, Renault, Saab, Volvo and Škoda could

be mentioned. The company Saab introduced a flexi fuel vehicle model which could run on 100% pure bio-ethanol. The "alcohol-fuelled" vehicles are characterized by lower emissions of some pollutants during their operation and then by reduced CO_2 emissions, which is a consequence of the renewability of ethanol and thus by the circulation of carbon in the ecosystem. However, the results of foreign studies differ in opinions over the efficiency of production and the use of bio-ethanol in transport and the environmental impact of vehicles running on these fuels (Patzek, 2006).

For diesel engines of trucks the fuel marked E95 is used; it is composed of waterless ethanol and additives. The most important European country in terms of the operation of ethanol buses is Sweden, where SCANIA buses running on bio-ethanol are operated. The ethanol buses are able to meet the current emission limit of EURO V. The disadvantage of these vehicles is their high consumption which is in urban areas nearly 45% (Capaccioli, 2009) or even 70% (Matějovský, 2005) higher than the consumption of diesel buses, and expenses for their maintenance are higher by approximately 50% (Matějovský et al., 2006). The ethanol buses in the Czech Republic are being used in a pilot project, but are expected to be supplied to the Czech market together with the infrastructure development.

Table 3: Effects of emission factors of mixed fuels of used passenger cars.

Fuel - used passenger car (Euro 3)	Emission of the pollutants			
	CO ($g \cdot km^{-1}$)	**NO_x** ($g \cdot km^{-1}$)	**HC** ($g \cdot km^{-1}$)	**PM** ($g \cdot km^{-1}$)
Limits EURO 3 – diesel	0.640	0.500	-	0.050
Diesel	0.697	0.770	0.107	0.024
Diesel + 5 % FAME	0.587	0.784	0.121	0.025
Diesel + 31 % FAME	0.734	0.442	0.120	0.017
Limits EURO 3 – petrol	2.300	0.150	0.200	-
Petrol	0.828	0.455	0.127	-
E85	0.145	0.012	0.026	-

When mentioning the use of bio-fuels, particularly in terms of the technological and raw materials requirements, it is necessary to take into consideration the negative local effects, as well as global environmental effects, The global negative aspect is the high demand for agricultural raw materials for bio-fuel production, which is also linked to economic subsidies to the growers of these crops. This high demand and support for the cultivation of bio-fuel feedstock are most recently linked to the high demand for agricultural land for cultivating sugar-cane and soya in Brazil, which have an unambiguous influence on the increase in the deforestation of Brazilian rainforests, whose rate is approximately 3 million hectares a year. Another example of the negative impact of growing crops for bio-fuels is a huge increase in maize prices in the world market, which is reflected in situations in Mexico, where maize products are the traditional food components. A somewhat local, but still inadequately solved, problem of bio-fuel production is the energy analysis of the whole production life cycle, the so-called “well-to-wheel” analysis, which means processing of the energy balance including the production of synthetic fertilizers, agriculture cultivation, harvest and processing of agricultural products, production of bio-fuels, transportation to fuel filling stations, and eventually the combustion of the fuel in the vehicle engine. In contrast to the positive energy balance of the life cycle of bio-fuel production in the majority of published studies, recently, studies were published with the “well-to-wheel”

analysis with a negative energy balance, which demonstrate that for the production of bio-fuels a higher amount of energy was needed than the amount gained.

The energy balance of the bio-fuel production depends on the standard and use of the agricultural technology in a given locality, climatic and agricultural conditions and on a number of other factors. Based on the above mentioned reasons, it is clear that it is necessary to perform the life cycle analysis (LCA) of bio-fuels for each country in which the plants are grown for bio-fuel production, and fuels are directly produced. Another issue of the current bio-fuel production is the "humane nature" of these technologies, particularly the production of car fuels from nutrition commodity. Therefore, the most important fuel companies engaged in the production as well as the distribution of the bio-fuels stop the development of these technologies and focus their research potential on the production research of so-called second generation bio-fuels. This is mainly the bio-ethanol production from lignocelluloses biomass, i.e. the extraction from wooden chips, fast-growing energy plants, straw, pressed sugar beet, etc.

This technology has already been mastered technically, but the commercial production is still very expensive and the commercial use of the second generation of bio-fuels is expected to occur within 10 to 15 years. The process of bio-ethanol production from lignocelluloses biomass is, compared to the conventional production from cereals or sugarcane, more difficult in the technological process of hydrolysis of the cellulose biomass into monomeric sugar.

3.2 Compressed natural gas (CNG)

Natural gas is a fossil fuel whose main component is methane (minimum 85%), and, in contrast to oil, its reserves are estimated to last for up to 150 years. Natural gas as a fuel in transportation could be gradually replaced by renewable biogas in the future, as is currently being done in Sweden, and thus we can speak about CNG in the context of fuel renewability. At the end of 2009, more than 11.3 million vehicles were in operation in the world powered by compressed natural gas, and the number of filling stations was estimated to be approximately 17 000. 1.3 million vehicles and approximately 3490 filling stations are operated in Europe. Italy has the leading position in the use of CNG in Europe with the number of vehicles reaching more than 677 800, followed by Germany with approximately 84 850 vehicles. There were approximately 1 960 vehicles powered by compressed natural gas registered in the Czech Republic an the end of 2009, out of which there were approximately 270 buses and 20 commercial vehicles. The disadvantage, in comparison to European countries, is the insufficient infrastructure of filling stations, which are gradually being built, and in the early 2010 there were 22 public filling stations operating in the Czech Republic.

On 1 January 2007, the amendment Act 355/2003 Sb., on excise duties came into force in which exempts compressed natural gas from excise duty. The excise duty will be increased in the future in order to reach the value 3 335 $CZK \cdot t^{-1}$ in 2020. Support of natural gas in transportation in the Czech Republic is guaranteed by the government resolution no. 563 within the Programme for the support of alternative fuels, and furthermore a voluntary agreement between the state and gas companies (ČPS, 2006) leading to the use of natural gas as an alternative fuel in the transportation.

The gas companies and the state, among other things, committed to:

- Gas companies will build filling stations for CNG at the place where the local authorities make a decision to transform the vehicle fleet of the urban and suburban transport (or its parts) into the fleet running on natural gas and where it would be

allowed by the local technical conditions of the gas network. The condition for building a filling station is the minimum number of 4 buses or vehicles with similar natural gas consumption, approximately 100 thousand m^3 in the first year. The minimum annual consumption will reach 400 thousand m^3 within 4 years from its implementation.

- By 2020, in relation to the targets according to the government resolution no. 563/2005 Sb., on the transport share of natural gas consumption amounting to 10%, gas companies will build a CNG filling station network in the total extent of 100 filling stations.

- As a marketing support of regional and urban public transport, gas companies will provide a subsidy of CZK 200 000 for a newly acquired bus running on compressed natural gas, up to a maximum amount of CZK 10 million per year, and they will be offered a bus advertising space at the appropriate extent for the further project presentation of the project.

- The government will support the use of natural gas in transport as one of the priorities of the National programme of economic use of energy and renewable and secondary resources for 2006 – 2009.

Although compressed natural gas is currently not a renewable energy resource, its significant benefit in terms of quality for the environment, as well as human health, is the lower production of pollutants during operation in contrast to diesel and petrol vehicles. Although it is possible to convert passenger cars to run on this fuel, the expected trend is to purchase new manufactured CNG vehicles, rather than mass vehicle conversion, which does not significantly contribute to the quality of the environment.

In the Czech Republic, only a limited range of passenger and commercial vehicles powered by this fuel is currently available (e.g. the makes Fiat, Opel, Mercedes-Benz, Volkswagen and Iveco).

Table 4: Comparison of emission factors of gas vehicles, CNG conversion of used cars and CNG vehicles directly from manufacturer.

Pollutant ($g \cdot kWh^{-1}$)	**Petrol**	**CNG conversion**	**CNG from manufacturer**
CO	0.828	15.413	0.090
NO_x	0.455	0.052	0.081
HC	0.127	1.735	0.058

The Czech Republic is an important producer of CNG buses even in global perspective. There are several manufacturers including SOR Libchavy, and Tedom. The other foreign manufacturers supply CNG buses to the local market – Irisbus, Mercedes-Benz, Solaris, and Volvo. With the use of CNG buses, the emissions of pollutants produced by urban public transport in urban agglomerations can be reduced significantly, especially NO_x and PM emissions. CNG buses meet the emission limit EURO V and emission limits of enhanced environmentally friendly vehicle (EEV).

The European Community also introduced a support for the development of petrol engines reaching the designed emission limit EURO VI, which focuses considerably on

the reduction of exhaust emissions of NO_x and PM. This was introduced within R&D programme of the 7th Framework Programme.

Table 5: Comparison of emission factors of CNG bus engines.

Pollutant ($g \cdot kWh^{-1}$)	**Limits of ETC test (since 2008)**	**EKOBUS [1)]**	**ŠKODA LIAZ 637 NGS [2)]**	**IVECO CNG [3)]**
CO	4.00	0.012	0.26	2.09
NMHC	0.55	0	0.08	0.07
CH_4	1.10	0.25	0.09	0.20
NO_x	2.00	2.08	0.17	0.25
PM	0.03			

[1)] according to Ekobus (2009)
[2)] according to Laurin & Bartoníček (2003)
[3)] according to Kalousek (2010)

3.3 Hybrid drives

Hybrid drives combining a combustion engine with an electric motor, which works as a generator of electricity for charging the battery (source of electricity for the electric motor) during braking, can be divided into three functional classes: Micro, Mild and Strong.

Micro hybrid drive system is equipped with the system Start/Stop. In urban traffic, vehicles often stop at junctions or in traffic jams. The start/stop system automatically turns off the engine in these cases. When the vehicle can move on, the system quickly restarts the engine after pressing the clutch. With the use of the start/stop system, up to 8% of the fuel can be saved (Bosch, 2007). With the use of the hybrid system Strong, the consumption of fuel can be reduced by 30 or more percent. The system usually has an electric engine with performance around 50 kW, which guarantees sufficient acceleration during overtaking and furthermore, it allows a trip for shorter distances using only the electric drive. The electric engine can work as a generator as well, and the produced electricity supplies the electrical appliances of the onboard network.

The Japanese automobile factories Toyota/Lexus and Honda are the main global producers of hybrid passenger cars. Whereas Toyota vehicles rely on Strong system of hybrid drives and their vehicles are equipped with 50 kW electromotors, electric motors of lower performance operating in Mild system are used for Honda vehicles. The majority of European leading producers are also going to offer various types of passenger cars with hybrid drives. As far as cargo vans are concerned, the leading companies are Daimler and Iveco. Regarding heavy goods vehicles, the use of hybrid drives is in the stage of conceptual development and developing projects. For example, Volvo group introduced efficient hybrid drive for heavy vehicles which brings fuel savings up to 35%. Hybrid technology has already been used successfully for several years on a worldwide basis in bus drive systems. European producers have been performing extensive tests of the new technology and solutions have led in some cases (such as Mercedes-Benz, MAN, Solaris, and Volvo) to the stage of mass production. On the basis of long-term tests manufacturers have reported a reduction in fuel consumption by 25–35 percent.

4 ENERGY FOR TRANSPORT IN THE FUTURE

What kind of fuel will we use in the next 50 years? Will our society come to a stage of oil shortage? Will there be sufficient technologies for energy replacement in transport, caused by oil shortage? These are the issues which experts deal with in almost every science-research institution, engaged in relationship between transport and energy consumption. There is no clear way known to guarantee energy supplies, but the use of combined energy resources, depending on raw materials and the energy possibilities of individual countries, can be expected. Furthermore, in the distant future we can expect the use of biomass for fuel production, which concerns GTL technologies (Gas to liquid) on the basis of synthetic oil production from natural gas via Fischer-Tropsch synthesis. Whereas this technology has been technically mastered since the Second World War, the BTL technology (Biomass to liquid) is in the stage of intensive research and pilot projects. BTL technology is a multi-step process. The first step is the gasification of the biomass. In the next steps the acquired synthesis gas is, converted into an automobile fuel using GTL technologies. Great hopes are currently placed on hydrogen technologies and the electrical drives are up again, having experienced a decline in recent years.

4.1 Electric drives

Greater and greater hopes are being placed on electric drives of vehicles, so-called "electromobiles", which were not perspective in the past due to the insufficient capacity of accumulators. Design concepts of electromobiles have undergone certain changes in connection with the technological progress over the recent years. The most significant change is the trend in the installation of electric motors as the vehicle drive as a part of wheel discs, rather than differentials . Another important step is the development of high capacity accumulators. In the past, lead accumulators were gradually replaced with nickel-cadmium and nickel-metal-hydride accumulators, and currently with lithium based accumulators. The development in this field has not finished yet, latest research and development have dealt with the possibilities of using ultra-capacitors, which are special electrolytic condensers with a high capacity up to thousands of Farad and their properties are comparable to electrochemical resources.

The most important technological development in electromobiles was in the USA in the 1990s when the California Air Resources Board institution issued a regulation which required the sale of 2 % of new vehicles meeting the requirement for zero-emission vehicles powered by electricity or alternative fuels (for example hydrogen) in 1998. In 2003 the regulation required the sale of these vehicles to reach 10 % of new vehicles on the market. The extensive programmes of development of electric vehicles in American automobile companies, including foreign manufacturers, such as Ford (Ranger EV), Honda (Honda EV Plus), Toyota (RAV4-EV), Nissan (Altra EV) and others, began with this regulation. These electric vehicles were based on the concept of classic vehicles with a petrol engine. General Motors (GM) took a different course and created an entirely new and unique prototype of an electromobile, EV1, which used the latest technologies in the automotive industry. The availability of the vehicles on the market was aqn interesting decision, because all vehicles were only rented to the customers.

The first EV1 with lead accumulators was launched on the market in 1996. By 2000, 650 examples of EV1 were rented, and between the 2001 and 2002, a number of them were modernized by equipping them with nickel-metal hydride batteries, which enabled an operating range from 120 km up to 240 km. Some of the examples of technological perfection of EV1vehicles are the aluminium construction of the frame, antilock braking systems, heat pump, keyless control, regenerative braking set, very low

resistance coefficient (Cd~0.19, CdA~0.36 m²), low-rolling resistance tyres, automated tyre pressure loss warning system, etc. In 2002, the GM decided not to continue with the EV1project.

The vehicles were gradually withdrawn from the users and, with some exceptions, gradually scrapped. The main reason for stopping the project was the limited development of high capacity accumulators. Another reason might have been the change of the California Air Resources Board directive in 2003, when the earlier requirement regarding the market share of electric vehicles with zero emissions was mitigated to the distribution of hybrid vehicles or vehicles with fuel cells. At present, the development of electric vehicles is experiencing a renaissance and, apart from small innovative companies like Tesla, Venturi, Think, etc., some large automobile manufacturers are starting to specialize in this type of drive. An advantage of the electromobiles is zero emissions of pollutants and a low environmental impact throughout the whole life cycle, which is specified in Table 6, where the different types of drives are compared.

Table 6: Comparison of different types of drives.

Technology	**Vehicle**	**Consumption** [2] (l/100 km)	**Energy efficiency over the whole life cycle** [3] ($MJ \cdot km^{-1}$)	**CO_2 emissions over the whole life cycle** [3] ($g \cdot km^{-1}$)
Petrol engine (V12)	Ferrari 599 GTB	17.9	6.49	431.26
Petrol engine (V10)	Lamborghini Gallardo	14.4	5.22	349.43
Petrol engine (V8)	Ferrari California	13.1	4.75	319.04
Petrol engine (V6 Turbo)	Porsche 911 Turbo	11.6	4.21	283.97
Petrol engine (V6)	Porsche 911	10.3	3.74	253.57
Petrol engine (V4)	VW Golf	6.4	2.32	162.39
Petrol engine (V4 Turbo)	VW Golf	5.2	1.89	134.34
Diesel engine (V4 Turbo)	VW Golf	4.5	1.88	134.94
CNG engine (V4 Turbo)	VW Passat	4.6 kg/100 km	1.97	135.01
Hybrid (V4/electromotor)	Toyota Auris	3.8	1.38	101.60
Fuel cell	Honda FCX	0,98 kg/100 km	2.01 / 5.46 [1]	98.08 / 208.00
Electric drive	EVC R7	12 kWh/100 km	1.24	126.09

[1] hydrogen production via steam reforming of natural gas / electrolysis of water

[2] data from manufacturers

[3] calculated using Edwards et al. (2007)

4.2 Hydrogen technologies

Great hopes are being placed on hydrogen technologies nowadays, because they should replace fossil liquid fuels in transport in the distant future. However, due to the currently slow progress in hydrogen technologies, its high energy intensity of production, and the high production costs of hydrogen production itself as well as the drive technologies, we cannot expect significant use of this fuel in transport by 2030. One of the most significant research workplaces in the field of hydrogen technologies in transport is the company Daimler Chrysler, which, within the project CUTE, constructed thirty-two hydrogen buses, Mercedes Citaro, which have already driven more than million kilometres in ten European cities (HyFLEET:CUTE, 2007).

The vehicles were equipped with fuel cells, which in principle performed the energy conversion of hydrogen and oxygen into electricity, water, and heat via catalytic reactions on the electrodes of the fuel cells. Other hydrogen projects are being dealt with by automobile manufacturers, such as BMW, GM, Honda, Mercedes-Benz, etc. These vehicles are the outcome of long-term research projects and so far they are still not commercially available for the end users. However, an exception exists; Honda launched a limited production of a model FCX Clarity and BMW rented 100 vehicels of the model Hydrogen7.

On the other hand, it is still unclear how the hydrogen will be produced. The most probable three ways of hydrogen production are seen in steam reforming (hydrogen production from natural gas), in water electrolysis (renewable source of hydrogen), or in the thermo-chemical water decomposition with the use of the 4^{th} generation of nuclear reactors (Janík, Doucek, & Dlouhý, 2010). At a conference "International Hydrogen Day", the company Linde introduced their vision of creating an infrastructure of hydrogen filling stations on German motorways (Linde, 2005). In the first phase, the network would connect German major cities and consist of filling stations located on German motorways within the distance of about 50 km. The extension of the infrastructure to connect the most important European cities is expected by 2020.

5 SUMMARY

As mentioned above, the replacement of non-renewable fossil fuels used in transport will have a positive impact on the environment, under condition that the global policy is in accordance with the principles of sustainability, particularly regarding bio-fuel production. However, the price of alternative fuel is higher than the price of conventional energy resources, which is one of the reasons for the slow development of alternative fuels. Other reasons are the insufficient car fleet and infrastructure for distribution and fuelling. Regarding the current development of alternative fuels and drives, it is possible to realise that future development is not clear at all, and we will surely see distinctive changes, both in technological fuel production and automotive systems.

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Economic Aspects of Transportation

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ABSTRACT: Economic tools lead to the elimination of all unfavourable environmental externalities of economic activity. This provides a solution to the issue of property rights and the full application of the principle " the contaminator pays", with the goal that prices would reflect all costs, including the externalities. The individual economic tools have diffrent forms, such as various payment systems, and recently the even more stressed environmental tax reform. Market-compatible tools are gradually being applied as well. A definite requirement is the cancellation of environmentally harmful subsidies, which still exist in practically all countries in the field of energy and transport.

KEY WORDS: transport, economical tools, taxation, road toll, external costs.

1 INTRODUCTION

Regarding transport, health and the environment are very important economic aspects, since the transport costs are among the most significant factors affecting behaviour of people in transport, choice of means of transport for travelling, and subsequently the emission as well as noise production. Nevertheless, some costs are not included in the price of transportation, and in that case we refer to the so-called externalities (external costs of transportation) which are described in this chapter in more detail. The transport economy, which not only deals with costs, but also with the benefits of transportation, has been developing since the beginning of the 20th century; some of the concepts used are even older. In the beginning, the major attention of transport economists was paid to the regulation of rail transport and its effective use; approximately from the middle of the 20th century the issue of resource allocation (distribution) was explored comprehensively in transport. The demand and supply research was developed - particulalry the cost and production theory and the customer demand theory, and also the issues of charging and the efficiency of transport investments, effects of regulation on the behaviour of the operators and on the transport development.

Transport is special for the fact that its outcome (product) is the transport of certain goods or passengers from their origin to their destination within a certain time period. The basic units which express the transport production are person-kilometres and tonne-kilometres. the time period of transport is of high importance as well: the highest demand for transport

(mainly passenger) is usually in the morning and afternoon hours of week days and at the beginning and at the end of holidays. However, other transport quality parameters have a great impact on the demand of both the quality of the traffic routes, the reliability, and comfort of the means of transport.

Another typical feature of transport is the high degree of statutory regulation which includes prices, access, and the operation of the majority of transport modes. The justification of this regulation is based on the fact that the government usually funds a considerable part of the transportation costs, such as the necessary infrastructure; and in addition it guarantees its maintenance, transport serviceability for public, and enforces the traffic regulations. However, the resources allocated for the funding of traffic safety policies and activities are not unlimited. Therefore, their effective use should be decided on. In this way, the investments in new projects should be beneficial.

2 PRIVATE AND SOCIAL COSTS AND BENEFITS

Transport, as well as any other human activity, is linked to certain costs and benefits. Some costs are obvious, while we usually do not realize about others. Fuel, used by means of transport, is among the obvious costs. However, the costs caused by the exhaust gas emissions are usually not included in our decision-making process and we would have difficulties to estimate them; this concerns with the external costs of transport. Who bears the costs is of high significance as well. It could be a consumer (a passenger buys a train ticket), the government, and, through taxes, the whole society (the government decides about a new motorway construction), or some other person (an owner of the house by a noisy road who invests in the insulation of windows due to excessive noise). It is necessary for effective market functioning that prices truly reflect all costs. If it does not happen, we refer to market failures.

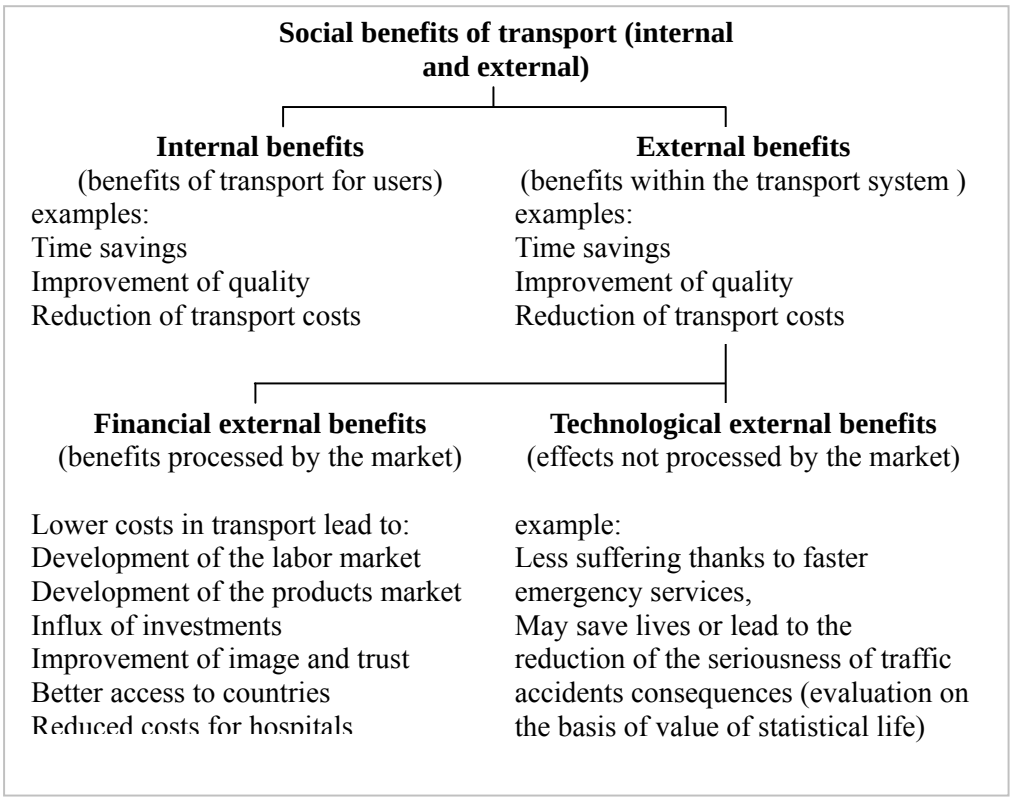

Figure 1: Social benefits of transport (OECD, 2001).

The transport benefits and costs could be divided into private and social ones. The private benefits are the benefits for those who use transport specifically; these benefits include time savings, and the better availability of goods. The private costs are resources spent by the users of transport - either on the car operation or on its maintenance, or a ticket for city public transport. The social benefits of transport are the benefits for all subjects within the society, i.e. altogether for the transported subjects and for those not using a specific transport service. The definition of the positive external effects of transport is much more problematic. Generally, transport has a whole range of benefits, however, the majority of these benefits are "individualized", i.e. the social benefits are equal to individual benefits, in contrast to the social costs, which are higher than the individual costs in transport. Therefore, it is not the case of typical positive externalities but a consumer surplus (example.g. travel time saving, higher comfort of travelling thanks to the higher quality of the transport infrastructure, etc.).

3 EXTERNALITIES AND THEIR POSSIBLE INTERNALIZATION

The concept of externalities is widely known and used in economics, yet there is no complete agreement about its exact definition and interpretation. It is generally accepted that externalities represent an example of market failures, which concern costs transferred by the given subject to other subjects without receiving any compensation, or benefits which the given subject brings to others without receiving any compensation. The existence of externalities is usually related to the absence of property rights, which particulaly applies for various environmental components, such as air, the ozone layer, water, and wild animals. In case the externalities increase benefits for others, we call them positive externalities or external benefits. The negative externalities decrease benefits for involved parties. These external effects have a considerable impact on the environment quality (Verhoef, 1994). In the transport sector, the negative externalities appear very often, the most serious being traffic accidents and the emissions of exhaust gases from road motorised traffic. Traffic accidents cause the loss of human life and damage to human life; material damage occurs as well. Among others, the air pollution by emissions causes damage to human health, damage to material properties (faster corrosion, lower life span of plasters, etc.), damage to forests, and agricultural production damage (see Table 1). These all bring about additional costs. The socially effective solution to the issue of externalities is not the total prevention of their existence, as it may seem in relation to the production of emissions of harmful gases, but the incorporation of external costs into market prices, which would reflect the social costs in the future (Holman, 2002). We speak about the internalization of externalities in this case. However, the primary prerequisite for the internalization of externalities is their evaluation. It is the evaluation of goods and services of the environment that are among the most discussed issues of environmental economics; and the evaluation methods of the total service and goods value of the environment are not yet fully developed and accepted (Rothengatter, 2003).

There is a range of approaches for internalizing the externalities which all count on public interference at some degree. Probably the most often mentioned approach in the neoclassical economics is the Pigovian tax approach. This tax is imposed on an externality producer amounting to the difference between social and private costs, which leads to reducing the production of the externality to a socially optimum, level. Hypothetically, Pigovian taxes are ideal taxes, but, because of the difficulties in their determination (i.e. determination of the amount of an externality and its producer), monitoring, and checking, their implementation in the real world is difficult.

The community of liberal economists, mentions Coase´s theorem (Coase, 1960) very often. According to the American economist R. Coase, under the condition of negotiating with zero costs, it is possible to reach an effective solution to the dispute via negotiations between the pollution producer and its receiver. The necessary assumption of this negotiation is the fact that one of them has property rights to certain property and reaching the agreement is not based on any transactional costs. The whole situation can be shown in an example. My neighbour's fruit tree interferes with our garden, where it casts a shadow (this is a negative externality for us). Doing so limits our ownership property rights, and therefore we can visit our neighbour and come to an agreement. For example, the neighbour could share the harvest with us, offer us a financial compensation, or, in the most extreme case, chop the tree down, and in one of these ways internalize the caused the externality. However, in the case of externalities caused by transport, the negotiations are, considering the huge number of producers and the damage, virtually impossible, and there are no zero transactional costs.

Table 1: Overview of externalities in transport.

Field	Externalities
Traffic accidents	Injury*, death*, permanent effects*, psychological damage to relatives*, material property damage*, costs for emergency services*, fire brigade*, police*, environmental damage caused by accidents*, loss of production*, payments to widow, orphan pensions and other costs. – see Figure 2
Air pollution	Effects on health – respiratory and cardiovascular diseases, damage to agricultural production, forest ecosystems, more intensive corrosion
Greenhouses gases (climate change)	Effects on health, agricultural production, ecosystems; water stress, desertification, rising sea and ocean levels, etc.
Higher noise level	Discomfort of the population, health damage – hearing disorders, increased risk of heart attacks and cardiovascular diseases, sleeping disorders, effects on the performance of people
Congestion	Time losses*, increased emissions of vehicles in queues
Building of transport infrastructure	Fragmentation of landscape (impact on biodiversity), decrease in the number of animals, land-use, pollution of surface water, threat to ground water

Note: * the mentioned effects are not always and complete externalities

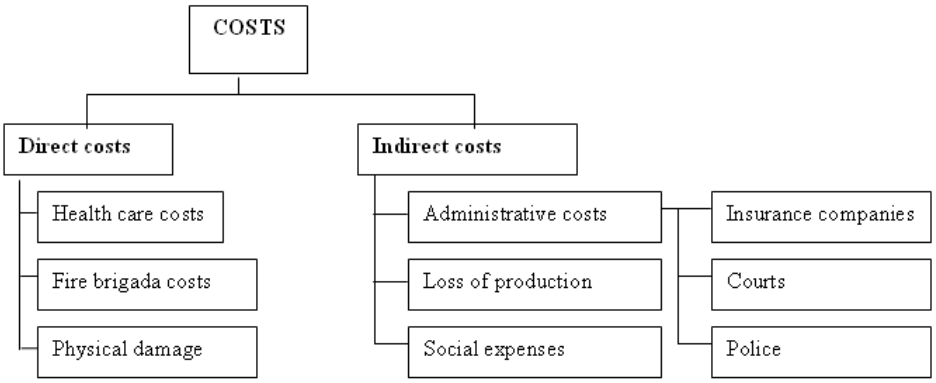

Figure 2: Overview of costs and losses caused by traffic accidents.

Although there is general agreement about the fact that in terms of social efficiency it is necessary to internalize external costs, the open issue is whether to internalize the marginal or average external costs. Marginal costs are costs which are caused by additional means of transport (vehicle, train, boat, airplane) when using the transport infrastructure. The scientific discussion in European strategy documents is reflected in the effort to charge transport in the form of short run marginal social costs. These are costs that are covered by the society and are applied to every additional driven kilometre or another journey. They include infrastructure costs and costs which were caused by a vehicle to other road users and the rest of the society (mainly the costs of damage caused by emissions, noise, accidents, etc.). This charging ensures that the capacity of the transport network is maintained at a socially optimum level. But there are some technical problems related to marginal costs, and they concern the method for their determination and selection for each individual vehicle due to excessive variability and growth coming with another vehicle.

4 ECONOMIC TOOLS

There is currently no unified classification of transport regulation tools and it is often possible to find a different division among various authors dealing with this topic. Basically, the generally accepted basic classification divides the used tools into market-conforming tools (economic) - which are tools of fiscal policy (taxes and fees), tradeable permits, and others (e.g. bails or insurance) – and normative tools, which are based on prohibition and orders, limits, standards, and prescribed administrative procedures (Kubátová & Vítek, 1997). The economic tools change the relative prices of products and services (i.e. changes in prices to one another), or they change the household and company incomes which leads to the change of consumers' and producers' behaviour. Compared to normative tools, the economic tools offer a range of advantages - they usually allow for higher flexibility to achieve the goal, motivate for a faster introduction of new technologies, tend to be less administratively expensive, and may bring additional income to public budgets.

4.1 Fees and taxes

Fees and taxes are basic economic tools of all countries; they are a decisive component of income of state budgets. In contrast to taxes, which are defined as mandatory, payments of irretrievable and non-equivalent nature specified by law, fees are related to a certain reciprocal service or another counter-value. However, in practice these terms are often confused, which may cause a situation where the fee for the release of polluting sunstances in the air is an environmental tax. Taxes and fees concerning road transport are mentioned in Table 2.

Table 2: Overview of taxes and fees in transportr (Kubátová & Vítek, 1997).

Fees	Taxes
Motorway stickers	Vehicle registration tax
Toll fee	Circulating taxes from vehicles
Exceptional load fees	Fuel excise tax
Parking fees	
City centre traffic, or other locality, fees	

With the exception of vehicle registration tax and the exceptional load fee, all the above-mentioned types of taxes and fees are used in the Czech Republic. In the case of other (non-road) transport modes, a smaller range of economic tools is usually used, with the most common being fuel excise duties, infrastructure access fees (e.g. the use of railways), but there could be other reasons as well (example.g. charging the noise in air transport).

4.2 Excise duty and road tax

Excise duty and road tax are among taxes linked to the environment because their tax basis has a special relationship with the environment, in spite of the fact that they are primarily collected for different purposes than the protection of the environment. It is related to indirect taxes, which are taxes imposed on goods and services. The subjects of the excise duty on mineral oils are not only mineral oils, but also all products used for engine drives and an defined list of products, as well as their mixtures, used for the production of heat.

Mineral oils used as fuel for air transport (with the exception of recreational flying), some waste oils, pure bio-fuels, and some other products are exempt from taxation. The current tax rate for unleaded petrol is CZK 11.84 per litre, CZK 9.95 per litre for diesel (medium oils and heavy gas oils), and CZK 0.472 per kilogram for heavy heating oils. The total income of the excise duty regarding mineral oils is less than CZK 70 billion a year. A part of this yield is allocated into the State Transport Infrastructure Fund (SFDI). Previously, it used to be 20%, since 2005 this share has decreased to 9.1% (in absolute terms of the income got reduced by CZK 7.4 billion). The reason for this reduction was an administration transfer of the second and third class roads to regions which were also given corresponding financial resources. Within the EU some rules concerning the taxation of energies are harmonized; and the minimum level of taxation for the main types of energy products, depending on their usage, and conditions for rate exemption or a reduction for the selected energy products (e.g. bio-fuels) or specific uses, (e.g. aviation) are determined. In the following table a comparison of the excise duty rates for unleaded petrol in individual member states is shown.

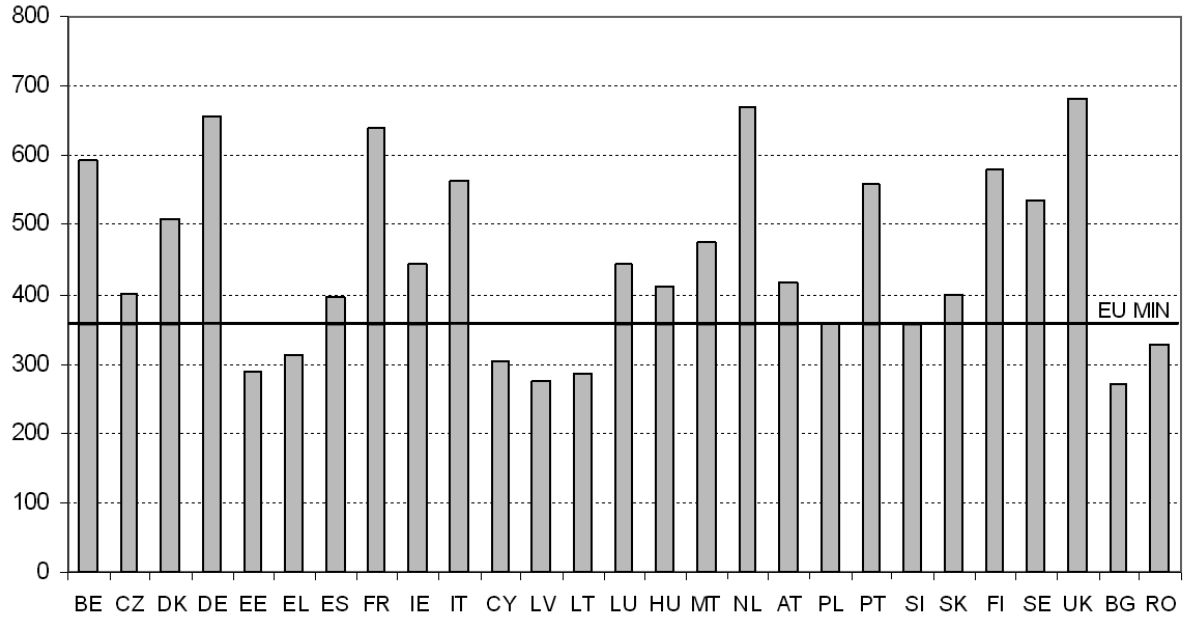

Figure 3: Taxation of unleaded petrol (excluding VAT) in the countries of EU-27- in €. 1000 l^{-1} (European Comission, 2007).

Another tax which is related to the environment is the road tax, which is imposed on trucks and passenger cars used for business purposes. The yearly rate of road tax for passenger cars ranges from CZK 1200 – 4200 according to the engine displacement. The road tax for trucks depends on the vehicle weight and the number of axles, and may even amount to CZK 50 400 a year (3 axles, weight over 36 tons). Vehicles providing domestic passenger transport and vehicles with electric drives are among those which are tax exempted. The total yield of the road tax was CZK 5.51 billion in 2004.

Regardng the road tax, there is a partial harmonization within the EU, which only concerns trucks, for which the minimal tax rates are determined depending on the number of axles and total weight. A proposal for the harmonization for the taxation of passenger cars, which should reflect the volume of emissions of the main greenhouse gas - carbon dioxide, is currently being discussed in the EU.

4.3 Charging the transport infrastructure

As it has been repeatedly mentioned, transport infrastructure charging tools should reflect the extent and period of its use. In road transport there are two approaches to charging which are currently widespread – time, and since January 2007 performance as well,. Whereas the time charging only reflects the period of use of certain infrastructure, performance charging enables the calculation of not only the period of use, but also the number of driven kilometres. In the Czech Republic, both systems are used for charging toll on selected roads - time charging ("motorway sticker") for motor vehicles with their weight under 12 tons and a performance charging - toll for vehicles over 12 tons.

Rates of the time fees are determined according to weight, whereas in case of the toll, the rates are determined according to emission classes and number of axles. Three versions of validity are set for the time charging (yearly, monthly, 7 days). The yearly rate in 2007 was set to CZK 900 for vehicles up to 3.5 tons and CZK 7000 for vehicles from 3.5 to 12 tons. The toll rates are set according to the number of axles and emission classes of vehicles, from CZK 1.7/km, for vehicles EURO 3 and higher with 2 axles, up to CZK 5.4/km, for vehicles EURO 2 and lower with 4 and more axles (the individual rates are shown in table 3). Revenues from the sale of motorway stickers and from the toll collection are the income for the State Transport Infrastructure Fund, which funds the development, construction, and modernization of roads and highways, railways, and inland waterways.

Table 3: Toll rates in 2007.

Emission of class EURO 2 and older			**emission of class EURO 3 and newer**		
Number of axles					
2	3	4 and more	2	3	4 and more
Rate of toll (CZK/km)					
2.30	3.70	5.40	1.70	2.90	4.20

Source: Ministry of Transport

The toll is either paid in advance through a subscription ticket before entering the charged road, or after the use of the road in regular billing cycles, which are based on the agreement between the electronic toll operator and the vehicle operator. Both fixed and mobile control devices continuously check the toll payments. The vehicles for which the toll was not required, or was required in the wrong way, are automatically identified and handed over to mobile control. The customs administration officers of the Czech Republic, who are legally authorized to stop vehicles, check the discrepancies in toll charging, and impose a fine or start an administrative action, or even impound the vehicle. All motorways and dual

carriageways, with the exception of some sections, in the Czech Republic are charged. There is currently a plan to extend the charged infrastructure with I. class roads or with the whole road network, and charging the vehicle category of 3.5-12 tons and passenger cars is being taken into consideration as well.

In rail transport, the obligation is to pay for the assignation of the capacity of the railway, for its use, for providing the operation of the railways, and for other provided services.

4.4 Subsidies

A subsidy is considered to be a measure which maintains the consumer prices under the market level or the production prices above the market level. A special category of subsidies are the environmentally harmful subsidies; they provide financial or different benefits for certain products, procedures, or areas in contrast to environmentally more friendly alternatives.

One of the most common forms of subsidies is state support. These are selectively provided resources from the government or public administration which provide the recipient with a benefit which would otherwise be out of reach for them. It results in an interference in the market environment; the conditions for competition have changed. In transport sector, the typical examples of the state support are the tax-reliefs or support of public transport. For example, in 2005, Czech Railways were covered a contribution for the economic loss from the passenger rail transport operation in the amount of CZK 2.12 billion. Similarly, regions cover demonstrable loss to operators who operate public bus transport to ensure the transport service within a certain area.

The government also provide subsidies for the purchase of vehicles for public transport and city public transport; special emphasis is put on supporting vehicles using environmentally friendly drives. The support is available for operators who provide transport services within an area or operate city public transport. The amount of subsidies for the renewal of bus fleet is provided in fix amounts which can reach up to 30% of the acquisition cost of buses.

Regarding the amount of provided resources, the state budget grants for the construction of the transport infrastructure are the most important. They are usually provided by the State Transport Infrastructure Fund (SFDI). The construction of motorways and railway corridors are among the most important investment projects of recent years. The costs for the construction of the first and second transit railway corridor were to be equal according to the original plan, CZK 36 500 million for each corridor. The State support was to amount CZK 14 810 million for first corridor, andCZK 18 870 million for the second corridor. Providing the state guarantee for the majority of loans related to the construction of the above mentioned corridors may also be considered as a form of the state support.

One of the types of sustainable transport support measures may be the price assignment of the services of public passenger transport into the reduced rate of VAT. In the Czech Republic, prices of public passenger transport and luggage, including passenger road and rail transport, other passenger transport and underground transport apply for the reduced VAT rate. The reduced VAT rate is further applied for the prices of water and air passenger transport and luggage. Whereas in case of the rail transport it is the support of an environmentally friendly mode of transport, in case of air transport, which causes a higher environmental impact, their inclusion in the reduced VAT rate is environmentally harmful. The situation is similar with international air transport, where VAT is not applied at all in some cases, on the basis of international agreements.

Another example of environmentally harmful subsidies is the different taxation of petrol and diesel. This difference is an example of a relic from the past and has purely economic

reasons. Diesel was mainly used by trucks and its lower taxation should have increased the competitiveness of transport operation in international transport competition.

4.5 Tradable permits

Tradable permits are most commonly used for the reduction of emissions to a preset level which corresponds with the quantity of issued permits. This is different from environmental taxes where the tax rate is known in advance, but the volume of the emission reduction is unknown; in the case of tradable permits the situation works the other way round – the volume of the emission reduction is known but the price is unknown.

The trading system with the permits for CO_2 emissions has been in operation in the EU since 2005 and only concerns the stationary sources of pollution. However, at the end of 2006 the European Commission presented a proposal according to which domestic and intra-community flights which land or take off from airports within the EU would be included in the emission permits trading scheme in 2011.

4.6 Insurance

Insurance is an economic tool which has a specific significance in the transport sector because through the compulsory insurance contract the issue of responsibility for damage caused by the vehicle operation in road transport is dealt with. The corresponding Act also determines, among other things, the minimum insurance limits for the compensation of damage to health or death, material damage, lost profit and costs for claiming compensation Similarly, there is a mandatory liability insurance for rail transport, as well as for air transport with certain specifications.

5 SUMMARY

Economic tools seek to eliminate all unfavourable environmental externalities of economic activities (Moldan et al., 1997). This mainly concerns the solution of the property rights issue and the full application of the principle "the polluter pays", so that the prices reflect all costs, including the externalities. The individual economic tools have various forms, such as various payment systems, and the recently more and more emphasized environmental tax reform. Market-compatible tools, such as tradable permits, are gradually applied as well.

The definite requirement is the cancellation of all environmentally harmful subsidies which still exist in virtually all countries in the fields of energy and transport.

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The Social Aspects of Transport

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ABSTRACT: Spatial mobility is a very broad term in social sciences, and it can take various forms when we consider the mobility of people and things, the mobility of "pictures" or virtual mobility, much like the levels from the global to the international and even up to the micro-level of everyday life. From the mentioned range of topics, which definitely need not be considered exhaustive, it is apparent that transport should not be considered only a technical phenomenon and mobility only a geographical phenomenon. Both terms have a connection with a lot of social phenomena, they are influenced and they influence a range of social processes and structures, as far as the social stratification, change of social relations, social exclusion, or changes in urban spatial patterns is concerned. Transport systems should be developed and operated in such way that they would also support viable economic and a moral society, in which all individuals are alowed to develop their potential and enjoy the everyday quality of life. Additionally, these goals have to be met without the unfavorable influence on the artificial and natural environment in which the society exists.

KEY WORDS: Mobility, transport behavior, demand for transport.

1 INTRODUCTION

Every field of human activity, transport included, brings with it certain social aspects. From an objective point of view, transport itself as a whole is value-neutral and is of a purely purposeful nature. However, at every specific manifestation of transport it is possible to identify both positive and negative social features. In this respect, transport could help to form a bridge between various cultures or social groups, but on the other hand, it is one of the instances which creates barriers to mutual communication and beneficial co-existence.

In terms of transport, the guarantee of equal access for all groups of the population and an extension of lifestyle focused on consumption, which depends on the use of cars, are the most important social aspects. Additionally, attention is paid to the social view of demand for transport and its prediction as well.

2 EQUAL ACCESS TO TRANSPORT

Movement and mobility have become the fundamental features of modern society; and their influence on a lot of aspects of life of the society has a growing tendency in connection with the globalization processes. However, not every citizen in the society has equal access to the same possibilities of transport as others. Although the freedom of movement is embedded in the "Charter of Fundamental Rights and Basic Freedoms" and the principle of equal access also follows other important European documents, mainly the European Social Charter, there are considerable discrepancies in the access to transport in society, which causes some social groups to be handicapped. It is up to the government to help overcome these barriers to equal access, because sustainable transport the transport which not only does not damage the environment, but also the transport which serves to all and does not handicap anyone.

2.1 The handicapped groups

In spite of the widely conceived definition of equal access to transport, it is apparent that it has a particular importance mainly for the so-called handicapped groups. Not only does it deal with the underprivileged, but also with the people who are physically or mentally handicapped, children, seniors, pregnant women, and parents with children or travellers with large luggage as well. It is estimated that all these groups together form almost half of the entire population and they are the majority users of public transport. It is necessary to classify women, who are often omitted in the planning and designing of transport projects, among these specific groups, taking into consideration the differentiation of their needs, Therefore, the public transport services, means of transport, and traffic space should be designed so as to allow the sufficient comfort for people from these handicapped groups as well. Meeting these demands is one of the most important criteria for the evaluation of equal access to transport.

There are, therefore, targeted and organized efforts to deal with the needs of the handicapped groups in the Czech Republic at the national, regional and local levels. One example is the "National Development Programme Mobility for All", within which the methodological handbook for the elimination of barriers within the transport systems was published (Šindelářová, 2002). There is a wide range of smaller regional and urban programs and projects which also try to contribute to guarantee equal access to transport (example.g. "Through Brno without barriers", "Barrier-free Olomouc", "Uničov - a city without barriers").

2.2 Transport integration of remote areas

Currently, a huge problem in rural areas, and one of the main causes for their depopulation, is the insufficient transport service for smaller towns, villages, or settlements and hamlets in remote regions, which are considerably distant from metropolitan zones. In terms of the Czech Republic, the compact and dense structure of settlements virtually in the whole area of the country, and the great tradition in transport serviceability in rural areas by public transport, is a huge advantage. Nevertheless, after 1990, in connection with a gradual, and sometimes very fierce, restriction in the services of regional public transport, this problem started to occur in some regions of the Czech Republic as well. People in a lot of small villages without their own car are practically completely cut-off from the world, including the insufficient availability of medical and social services and offices. The poor level of transport service, together with a general lack of work opportunities in rural areas, then caused an increase in the urbanization processes, when mainly the young generation

moves to larger urban areas for work, and typically older people stay in rural areas, which complicates the issue of the ageing population even more.

2.3 Ageing of population

The ageing of the population is another of a range of important issues which our society will have to deal with in a short time. The mobility of the elderly is characterized by many specifications which have to be taken into consideration. Older people are much more often dependent on public transport, which is, however, in many places replaced by individual transport at the expense of public transport. The stress and risks, which come with the ever increasing traffic volume on roads, mainly in urban areas, place increased demands on older drivers, who do errors more often. Therefore, transport has to be adapted to the trend of an ageing of the population, which will intensify even more in the following years, since population ages not only in the Czech Republic, but also throughout the whole world. Therefore, an initiative at the level of the UN was established, on whose basis the Czech Republic produced the "National Programme of Preparation for Ageing for the period of 2003 - 2007", approved by the Government of the Czech Republic in 2002.

It states two points related to transport:

1. "Within the transport policy, it is necessary to apply the specific demands laid on transport systems, considering the needs of the elderly and people with disabilities, mainly in terms of safety, availability, and stability. It is necessary to make the transport network accessible to all people, in terms of their mobility and without safety risks".

2. "On the basis of an all-society agreement, it is necessary to follow and meet the conditions for the transportation of the elderly via transport systems and conditions for the elderly in the field of telecommunication".

Considering the transport preferences of the elderly, it is necessary to focus on the creation of a barrier-free environment in public transport, and besides offering low- floor services also provide easy access to stops and railway stations, and to limit the construction of complicated overpasses and underpasses which the elderly and immobile people find rather difficult handle.

2.4 Social exclusion

Everyday mobility is a part of common social practice, which contributes to the creation of a social structure. By following normal social practice, in this case through using mobility services, people show their membership in the society and participate in reproducing the social order. There are many reasons why a lot of people cannot attain their social commitments due to their inability to maintain their everyday mobility. The problems with transport could form a significant barrier for the integration of individuals or whole groups into the society. The fact that people do not have access to various services is a consequence of social exclusion. For example, they are not able to use transport due to their low income, or the routes of the public transport do not lead to the right places. Age and disability are other common reasons which participate in the restriction of mobility.

The problems with providing of transport and the location of services may intensify the exclusion. They prevent people from accessing key local services and activities, e.g. to work, school, healthcare, the purchase of food, or free time activities. The problems may vary according to locality (rural – urban areas) or among various groups of people,

and this burning issue concerns mostly the poor, the disabled, elderly, and families with children. So it comes down to the socio-economic spatial exclusion of some groups as an effect of the relations between social duties and the commitments of people, their individual resources (mainly time and financial opportunities), and the available transport infrastructure. This triangle of relations shapes the long-term patterns of transport behaviour of households, in which the choice of the means of transport or the planning of routes is not a matter of short-term calculation, but concerns long-term commitments and duties as well. The place of residence itself and the possibility of use of certain types of transport determine travel behaviour, e.g. the choice of certain schools, shops, or the choice of occupation.

3 LIFESTYLE AND MOBILITY

The degree and method of realized mobility is a reflection of the lifestyle of each individual up to a certain extent. Whereas this lifestyle is not unified for the whole population, it differs in various social groups. The technological progress, particulalry symbolized by the car, allowed the extension of the consuming lifestyle for middle and lower classes proportionally to the growth of availability of car ownership, tough tourism based on travelling by car, freight transport and related negative impacts of transport.

The lifestyle of higher classes has always been characterized by relatively high mobility. This can be traced back in history, where mainly higher classes of the society were those who travelled much more than others. This trend is still apparent, in spite of the mass growth of motoring; e.g. in the degree of the use of air transport, as one of the typical features of globalization. Thanks to transport, the limitations given by space and distance are disappearing, as they are easily surmountable, either virtually or in real life. Therefore, we can say that higher social classes live a global lifestyle. In contrast, lower social classes are characterized by low mobility and local lifestyle (Bauman, 1999). Whereas, the "globalists" have the freedom to travel almost anywhere and anytime, the "localists" are tied to the place of their life involuntarily, because they simply do not have enough resources to be able to afford costly travel. The local lifestyle predominates mainly in poor regions and developing countries.

The current society and the lifestyle which dominates is characterized by the strong position of the automobile culture, whose extreme form manifests as the dependence on cars. This phenomenon, known mainly from the USA, is characterized by a total permeation of the human environment, people's thoughts and lives, by cars, so that they could not imagine everyday life without them. This is aided not only by the efficient advertising of the automotive industry, but also by the adapting of the infrastructure in cities for cars at the expense of other types of transport; in doing so, the dependence on cars is becoming a forced and difficult-to-change fact. The dependence on cars has been an accompanying phenomenon of suburban processes, characteristic for surroundings of big cities, since the Second World War, first of all in the USA, and gradually in the countries of Western Europe, and then after 1989 in the Czech Republic as well (Havlíček & Dostál, 2010). A new type of settlement occurs with suburbanization, and is characterized by the concentration of high income groups of the population in newly-built "ghettos", as only these groups could afford the new housing. Their lifestyle, strongly dependent on commuting by car to work, school, services, and culture, new localities are developed which are accessible only by car as it is not economical to introduce alternative types of transport there. The intensive use of cars leads to the creation of regular all-day and all-week congestions along access routes to these locations. The development of suburban colonies of family houses brings about hidden social segregation, as, in contrast to densely

inhabited districts, they strain local and government budgets more for the maintenance of road infrastructure, lighting, power distribution, waste water systems, gas, because in low density population areas the expenses for these services are considerably higher.

A similar trend could be also found in the case of the commercial suburbanization, when newly developed huge commercial centres, appearing in suburban zones on green meadows in the vicinity of main road are only constructed in such a way that would be easily accessible by car. This is in contrast with other modes of transport which are largely neglected by investors of these centres.

Various alternative subcultures within the movement for the rights of pedestrians and cyclists try to fight against the increasing influence of motoring. This activity is often a part of an environmentally oriented non-governmental non-profit organization. A typical feature tends to be actions whose goal is to draw attention to certain problems and attract such a number of people which would allow to start to change the system. A known example from Czech cities is, for example, bike rides, which draw attention to the insufficient space dedicated to bicycle transport.

4 DEMAND FOR TRANSPORT AND ITS PREDICTION

The amount, time variation and spatial pattern of the demand for transport depend on a lot of characteristics, such as demographic, economic and social aspects, or the land-use. The following text is mainly focused on the problems of transport in urban agglomerations, which form the varied pattern of diversified economic and social relations and groups. Nevertheless, most of the facts could also be referred to on a regional or mesoregional level.

4.1 Transport behaviour of inhabitants

Various groups of inhabitants are also characterized by different transport behaviour which is influenced by their lifestyle, not only in terms of the absolute number of trips, but also in terms of the choice of destinations, or also the mode of transport used. The knowledge of the basic transport needs of various groups is a necessary prerequisite for the process of prediction of demand for transport.

There is a variety of different types of trips in everyday life of inhabitants in the city in relation to specific types of human activities and to the spatial location of these activities. Each type of land-use is characterised by origins and destinations for certain types of trips dependent on the factors of regularity, financial costs, types of housing, density and technological level of the given area (Ramadier et al., 2005). The trips which are forced are mostly given by regular activities, such as everyday commuting to work, while voluntary trips, whose realization depends only on the decision of the person who undergoes this journey. These two categories can be clearly differentiated and examples of such trips are noted in Table 1.

Another view of the evaluation of trips in cities is to find the purpose for which they are executed. The most common types are trips:

- shuttle- they usually contain routine journeys between the place of residence and the place of occupation, they have a high degree of regularity and repetition, and, therefore, they are well predictable, both in time and space;

- work- trips executed for jobs mainly containing activities such as meetings or business meetings, which take place largely during working hours and, in terms of space, most often tend to be bound to places of occupation;

- personal- these are mostly arranged as voluntary trips and tend to be related to commercial activities, shopping and recreation;

- tourist- these mainly occur at places of historical or recreational importance, with accommodation facilities and restaurants; they are often of seasonal nature, or are linked to periods of special events, such as sports matches, congresses, or various festivals;

- logistic- a distribution of goods to satisfy the demand of both the consumers and producers; in terms of space, they are linked to areas of warehouses, distribution centres and retail areas.

Table 1: Classification of various types of trips in cities, depending on time and space.

Level of spontaneity of journey		**In space**		
		regular	Irregular, planned	immediate
In time	regular	**routine** *"I am at my workplace daily from 8 am to 4:30 pm"*	**fixed time, agreed place** *"We have our Friday's beer today in the new restaurant U Kořínků"*	**fixed time flexible place** *"It is 10 o'clock - time for my everyday morning coffee. I've to stop at the nearest coffee house"*
	irregular, planned	**agreed time, fixed place** *"We'll meet tonight in our favourite squash club at 6:30 pm"*	**planned in advance** *"We are going to see that new movie at the cinema Svět on Tuesday at 7 pm."*	**agreed time, flexible place** *"Today after six I shall call my mother-in-law. I need to find a phone box"*
	immediate	**flexible time, fixed place** *"Sometime this week I will have to stop at my mother's and mow the lawn in her garden"*	**flexible time, agreed place** *"As I'm driving past the office in Husova street, I'll call by and pick up working papers"*	**impulsive** *"Sale of clothes with 50% off. I must go there there immediately!"*

A common inhabitant of a city makes 3-4 various trips daily on average, however, this figure may vary considerably according to individuals (Rodrigue et al., 2006). The number of trips. which start or end at a given locality and are made by a specific means of transport is some of the crucial information for transport planning.

4.2 The choice of a means of transport

The choice of a transport mode by which each individual trip will be executed depends on a lot of factors, particularly on financial costs, out of which public transport costs considerably predominate over individual transport. However, there is also the viewpoint of the aspect of time and freedom of movement, which makes public transport increasingly uninteresting for certain groups of passengers (Dostál & Dufek, 2007).

Therefore, the majority of users of public transport to not have a sufficient freedom of choice of the means of transport, particularly if they do not own a car. So millions of people cannot participate in the automobile transport; nevertheless, they share its social and environmental negative impacts. As an example, we can mention the vicinity of busy roads, where low-income groups of population live, as the rents are cheaper due to the noise and pollution. People with higher income prefer to move to more peaceful suburbs, from where they commute to centres by car and in doing so, they increase traffic volume, whose consequences are predominantly faced by others.

In this association the division of people between the so-called "choice riders" and "captive riders" is appropriate. The first group consists of people who have an opportunity to choose a beneficial and comfortable mean of transport for themselves – typically, economically active men travelling are rated in this group. The “captive riders” are those who do not have a choice in the selecting the means of transport, or are dependent on choices between less advantageous and less comfortable means of transport, which, according to the context, might be regarded public transport, bicycles, walking, etc. (Rutherford & Wekerle, 1988). This group often consists of children, elderly people, the disabled, but women as well. This disadvantage in mobility is mainly produced by the unequal access to ownership of cars, which is a direct consequence of different income between various groups in the population.

4.3 Modelling of demand for transport

To forecast transport demand means to predict by different modelling techniques the changes, which will probably occur in traffic after a realization of an infrastructure construction or after a strategy measure will come into force. These changes have a direct impact on the quality of the environment, mainly the pollution and noise level. Both road traffic volumes as well as the number of passengers by public transport can be predicted. Road traffic volumes are affected by road engineering measures, such as the construction or reconstruction of roads, road closures, entry restrictions, speed redcution, etc.; whereas the number of people transported by public transport is changed through the influence of measures such as a new service in the urban public transport system, construction of a underground line, reconstruction of railway hubs, etc.

The entry data for modelling could be divided into three categories:

- socio-economic data: (number and socio-economical pattern of the population, number of jobs and schools, land-use),
- transport system data: (number of lanes, length of road section, average speed, etc.),
- special mathematic functions, which are used for traffic intensity in the network.

The outcomes of modelling are:

- corresponding traffic volumes (number of passing vehicles or passengers on all sections of the network),
- travel time for all trips (this reflects delays at junctions and in congestions),
- emission flow of a given pollutant.

These results are calculated for each section of the modelled transport network and it is common that the model area of a larger city or region consists of even several thousand of sections. Therefore, modelling cannot be performed without a specialized computing software. Some examples of good quality software which is used worldwide are EMME/3, PTV (VISUM, VISEM), TRIPS, TRANSCAD, PARAMICS.

Modelling is performed through a set of several dozens of different scenarios. The basic scenario always reflects the current state, from which the modelling of other scenarios evolves, representing different versions of the area development, versions of the realization of construction projects, or the application of individual measures.

The first step in the creation of a basic scenario is to divide a model area into traffic zones, which are homogeneous from the viewpoint of trips origin and destination. If the modelled area is a city, each zone can represent, for example, a housing estate, the centre, a shopping centre, or an industrial site; while when modelling a larger region, the individual cities and villages represent the zones. The second step is the creation of a transport network graph of nodes and links, which usually represents a partially general transport network of the real area. Then follows the modelling itself, which consists of two basic parts:

1. Modelling of the transport demand gives answers to the questions: where from, where to , by which means of transport, and how many people are transported over a given period of time (e.g. hour, day, morning peak hour, etc.) and the resulting numbers of transported people are mathematically expressed in the form of the so-called “matrix of the transported relations”,

2. Assignment, where the answer for the question "which way" is searched for, i.e. by which route, and, or by which services of public transport, are people transported.

The evaluation of the environmental impacts could be followed by the calculation of emissions with the help of transport volumes assigned in road network and the emission factors of various types of vehicles.

The prediction of transport demand in the future is prepared with the help of a perspective scenario, which differs from the basic scenario by taking into account the measures, which are considered for the implementation. The model transport network will be completed with planned roads and their parameters. The predictions for the development of the monitored socio-economic and demographic characteristics or changes in land-use in the individual zones are considered as well. If we model the measures of a financial nature, which could be, e.g. charging for use of the infrastructure or parking, it is necessary to complete the calculation of the functions with a parameter of costs. For example: in the scenario for evaluating the Park and Ride system, the approach of "intermediate zones" is used where extra zones representing localities considered for construction of parking facilities with good possibility of change to urban public transport are defined. This system helps to choose the optimum number and localization of such car parks in cities. Furthermore,

the loading of the perspective network by the current matrix follows, which allows the perspective trafic volumes to be calculated on all sections of the modelled network.

The efficiency of individual measures tends to be evaluated as a difference between an appropriate future scenario with the current state. It could be the difference, both in absolute number of vehicles, as, e.g. the calculated reduction of emissions and the average time travelled by different means of transport.

5 SUMMARY

Spatial mobility is a very broad term in social sciences, and it can take various forms when we consider the mobility of people and things, the mobility of "images" or virtual mobility, as well as levels from the global and the international and up to the micro-level of everyday life. From the mentioned range of topics, which definitely need not be considered exhaustive, it is apparent that transport should not be considered only as a technical phenomenon and mobility only as a geographical phenomenon. Both terms are related to a lot of social phenomena, they are influenced and they influence a range of social processes and structures, be it the social stratification, change of social relations, social exclusion, or changes in urban spatial patterns. Transport systems should be developed and operated in such way that they would also support viable economics and a fair society, in which all individuals would be able to develop their potential and enjoy the everyday quality of life. Additionally, these goals have to be met without the unfavourable influence on the artificial and natural environment in which the society exists.

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The Unfavorable Influence of Transport on the Environment

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ABSTRACT: Transport has become an important factor in the development of the society, both in a positive (transport of people, raw materials, products, information) and a negative sense (traffic accidents, emissions). The rapid growth of transport capacity and the quantity of passenger and freight vehicles is reflected in the increasing environmental burden. Hence compounds emitted from all transport modes occur in all environmental components. These compounds often have adverse effects on ecosystems, animals, plants, and human health, and thus it is important to observe their occurrence in the environment.

KEY WORDS: transport, emissions, pollution, air, soil, water

1 INTRODUCTION

Air pollution is mostly spoken about when discussing the increasing environmental burden due to transport; however, the share of other components in the pollution of the environment, such as surface and ground water, soil, and biota, is central as well. The land use for the transport infrastructure and fragmentation of the countryside influences the migration of animals and bio-diversity and cannot be omitted. The production of vehicles and the considerable quantity of waste produced when they are scraped, containing a whole range of dangerous substances, represent a considerable impact on the environment. Whereas the above-mentioned consequences are long-term negative effects, the increasing mobility bring about a rise in the number of cases of acute pollution, mainly during traffic accidents. The accidents may have far-reaching consequences for the environment, particularly during the transportation of dangerous goods. In this respect, the issue of transport in relation to the environment and health of people has become more important in recent times.

2 AIR POLLUTION

One of the most important issues for transport is air pollution by emissions, mainly as a consequence of the significant risk they have in affecting human health. Recently,

the share of automobile transport in air pollution has been rising significantly, which is particularly reflected in urban areas with high traffic volume. The source of emission of pollutants from vehicle engines into free air are exhaust gases formed during the combustion of fuel. They are complex mixtures containing hundreds of chemical compounds in various concentrations, contributing to long term warming of the atmosphere, the so-called "greenhouse effect", and often contain toxic, mutagen, and carcinogenic properties for humans. The most significant harmful pollutants contaminating the air from traffic can be divided into the limited compounds and unlimited compounds to which the emission limits refer. Carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NM VOC), and particulate matter for diesel vehicles (particulate matter - PM) are rated as the limited pollutants. With the exception of PM in new vehicles, they have decreased as a consequence of stricter limits required by EURO standards, but considering the increasing volume of traffic, principally freight traffic, the total amount of emissions has grown nonetheless. The graphs depicting the development of the limited pollutant production by the individual modes of transport are shown in Figure 1 (Adamec, Dufek, 2002).

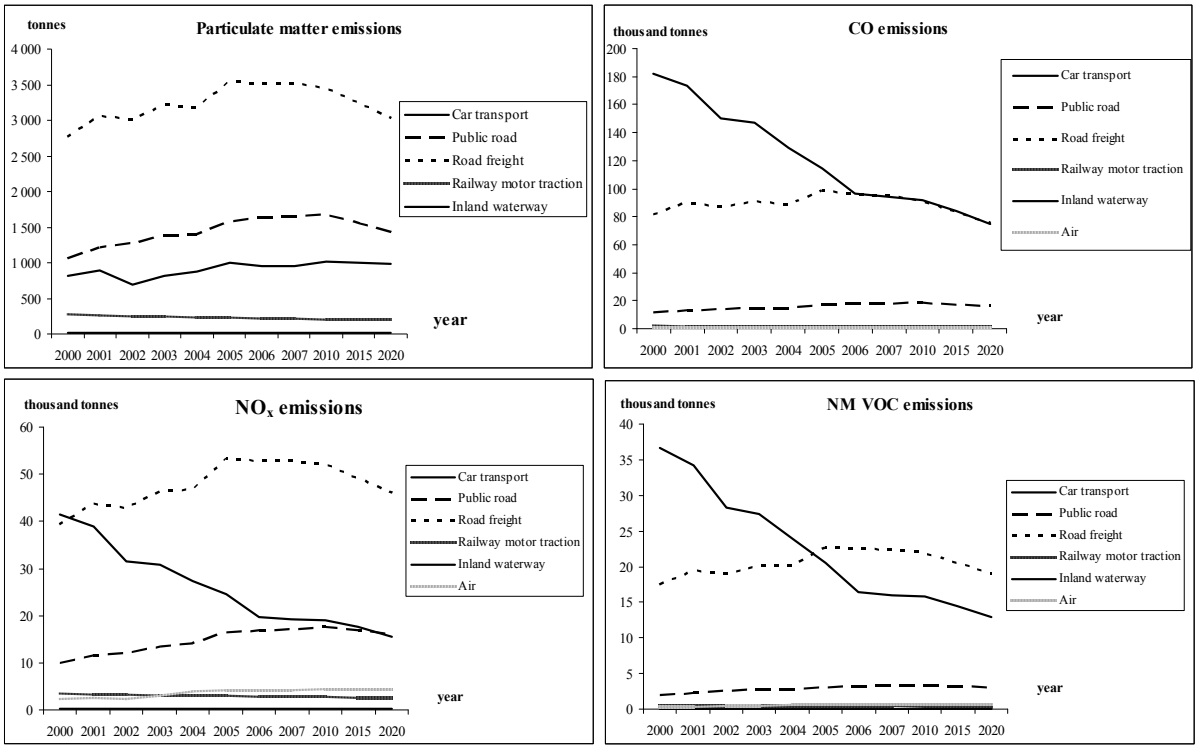

Figure 1: Production of limited pollutants by individual modes of transport.

The unlimited pollutants often have more serious effects on human health, but, currently, due to the lack of information about the compounds and far higher demands on the measuring technology, their production is not monitored. Within this group of pollutants we rate compounds contributing to long-term warming of the atmosphere, i.e. carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The other pollutants dangerous to human health, mainly produced during the imperfect combustion of fuel, are poly-aromatic hydrocarbons (PAH), phenols, ketones, tar, 1,3- butadiene and benzene, toluene, and xylenes (BTX). When fuel is burned polychlorinated dibenzo-p-dioxins/furans (PCDD/F) and polychlorinated biphenyls (PCB) could also be produced, in case of chlorine being present in the combustion system. The highest increase is recorded for the emissions of greenhouse gases, CO_2 and N_2O,

where newer vehicles show higher measured values than older types. The reason, in the case of CO_2, is higher fuel consumption as a consequence of transport performance increase; in case of N_2O emissions, the increase is caused by the introduction of catalytic converters. Some organic pollutants (PAH) emitted by traffic which are dangerous mainly due to their toxic, genotoxic, and mutagen effects show a similar increasing trend. On the other hand, CH_4 emissions are still decreasing because new vehicles have to meet stricter EURO limits. The Pb and SO_2 emissions which depend on the quality of burnt fuel and their production by traffic is virtually negligible due to the legislative introduction of unleaded fuels on the market since 2001, and the gradual regulation of sulphur content in fuels since 2000. As it is apparent from Table 1, the share of transport on the total air pollution of CO is 37 %, of NO_x approximately 30 %, and of volatile organic compounds 24 %. In comparison to 1993, there is an important increase in emissions of almost all monitored pollutants, predominantly PM which is based on the growth of transport performance.

Table 1: Transport share of the total air pollution (Jedlička et al., 2009).

Pollutant	Year												
[%]	**1990**	**1995**	**1997**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
CO_2	6.05	8.07	9.16	10.94	9.53	10.17	11.08	12.24	13.14	15.33	14.97	15.33	15.76
CO	22.67	34.87	39.64	45.04	43.58	43.60	47.10	45.21	41.76	47.33	44.12	40.20	43.06
NO_x	19.54	28.91	35.13	38.12	30.87	30.94	29.72	30.67	29.91	35.09	34.62	33.41	34.87
N_2O	2.70	4.76	5.72	5.90	6.20	5.46	6.35	8.07	8.41	10.01	10.48	10.37	9.60
CH_4	0.20	0.32	0.36	0.39	0.37	0.34	0.32	0.35	0.35	0.33	0.30	0.31	0.30
VOC	12.93	23.87	27.18	28.08	25.47	26.10	25.17	25.36	24.12	26.57	23.62	22.61	21.07
SO_2	0.18	0.31	0.58	1.58	0.67	0.79	0.87	1.04	1.16	0.28	0.30	0.30	0.37
PM	0.68	1.77	3.43	6.49	9.08	8.03	9.38	7.57	7.85	10.35	9.42	9.80	9.86
Pb	80.03	78.35	77.38	74.47	63.28	19.23	17.41	12.88	4.54	2.21	2.39	1.68	2.39

In the effort to reduce dangerous exhaust gasses produced by burning fuel, catalytic convertors, used for the modification of automobile exhaust gases, were introduced in the first half of the 1990s. They are devices located in the exhaust pipe-line with a metal carrier which is covered by a catalytic substance on a highly porous layer. This substance allows to speed up the oxidation of the produced CO and hydrocarbons, and to reduce NO_x. So-called three-way controlled catalytic convertors are currently used the most; they use a mixture of platinum metals – platinum (Pt), rhodium (Rh) and palladium (Pd) are contained as catalytically effective substances. Considering the fact that catalytic convertors are exposed to high temperature differences, the platinum metals are released into the environment (Farago et al., 1996, Gómez et al., 2001) which may have a negative influence on human health (Barefoot, 1997).

The above mentioned issue concerns the pollutants produced by the combustion processes of the so-called burning emissions. However, the release of other pollutants, especially PM, is connected with other processes as well, such as the abrasion of various exposed components (brake and clutch lining) when copper (Cu), antimony (Sb), barium (Ba), iron (Fe), aluminium (Al), zinc (Zn), molybdenum (Mo), manganese (Mn), magnesium (Mg), cadmium (Cd), and others are released into the air (Lamoree, Turner, 1999). The abrasion of tyres containing various types of rubber is a source of zinc; other metals like calcium

(Ca) and iron (Fe), and elementary carbon are released as well. The whole range of metals also gets into the environment during the mechanical separation from the rusting automobile body-shell and street accessories (litter bins, road signs, lighting, crash barriers, etc.) (Janssen et al., 1997). The problem of resuspension of PM deposited on the roadway and in its near surroundings, initiated by passing vehicles or by the wind flow poses a significant burden to the air quality (Nicholson, 1988). The dust on the road pavement contains particles of bigger fractions which are composed of both metals of a geological origin from the surrounding soil (Al, Si, Ca, Mg) and the above-mentioned metals from the operation of automobiles (Janssen et al., 1997, Vallius, 2005). The particles of chemical (salt) and inert material (sand, gravel, slag) also play an indispensable role in the road maintenance during the winter period, as well as falling-off dirt from vehicles and falling-off parts of transported material. We speak of the non-combustible emissions in this case. The brief overview of the pollutants produced by traffic, including their potential creation, is mentioned in the following Table 2.

Table 2: Sources and characteristics of selected air pollutants in connection with traffic (Adamec et al., 2005).

Harmful compound	Production in traffic
Carbon dioxide (CO2)	Fuel combustion containing carbon. Petrol passenger cars produce 3 183 g of this pollutant by combusting 1 kg of fuel, the same for diesel engines and freight.
Carbon monoxide (CO)	Fuel combustion containing carbon with the insufficient access of air or at high temperatures. Petrol passenger cars produce 18 – 168 g of this pollutant per kg of fuel, diesel 2.5 to 9 $g.kg^{-1}$ of fuel. Trucks 7 to 221 $g.kg^{-1}$ of fuel. It is always dependent on the observation of the EURO limits.
Sulfur dioxide (SO_2)	Fuel combustion containing sulphur, however, the production is currently minimum due to quality fuels.
Nitrogen oxides (NO_x)	Combustion of fuel and air mixture, oxidation of the atmospheric nitrogen at high temperatures. Petrol passenger cars produce 1 to 45 g of this pollutant per kg of fuel, diesel 4.3 to 18.3 $g.kg^{-1}$, trucks 10 to 93,3 $g.kg^{-1}$ of fuel.
Nitrous oxide (N_2O)	Reaction of atmospheric nitrogen with atmospheric hydrogen mainly in presence of catalytic convertors from the group of platinum metals. Petrol passenger cars produce 0.3 to 1.1 g of this pollutant per kg of fuel, diesel 0.1 to 0.3 $g.kg^{-1}$ and the same holds for trucks.
Ammonia (NH_3)	Reaction of atmospheric nitrogen with hydrogen contained in the fuel. Petrol passenger cars produce even 1.4 g of this pollutant per kg of fuel, diesel and trucks then approximately hundredths $g.kg^{-1}$ of fuel.
Ozone (O_3)	Secondary chain radical reactions in the earthbound layers of the atmosphere from the molecular hydrogen in the presence of the exhaust gases components, nitrogen oxides and liquid hydrocarbons under the influence of solar radiation.
Lead (Pb)	In the past, mainly combustion of leaded petrol in which it was present as tetraethyl-lead. Anti-knocks have not been used since 2001 on its basis. Its sources are currently balancing weights of the tyres, grease, oils, and particles produced by wearing out of bearings.

Harmful compound	Production in traffic
Cadmium (Cd)	Wear out of various car components.
Nickel (Ni)	Abrasion of brake pads and various stressed joints.
Chrome (Cr)	Mechanical separation from rotating parts of the engine parts and the brake pads.
Platinum metals (platinum Pt, rhodium -Rh, palladium - Pd)	Released from car catalytic convertors.
Polycyclical aromatic hydrocarbons (PAH)	Imperfect fuel combustion, or, abrasion of the road pavement surface. Diesel and trucks produce hundredths of grams of this pollutant group out of 1 kg of fuel by its combusting, in case of gas, approximately thousandths of $g.kg^{-1}$ of fuel.
Methane (CH_4)	Imperfect fuel combustion. Petrol passenger cars produce 0.1 to 0.9 g of this pollutant per kg of fuel, diesel hundredths of grams and trucks from 0.1 to 0.6 $g.kg^{-1}$ of fuel.
Volatile organic compounds (NM VOC)	Fuels combustion and evaporation from the cars. Petrol passenger cars produce 1.3 to 40 g of this pollutant per kg of fuel, diesel 0.6 to 2.3 $g.kg^{-1}$, trucks 3 to 42 $g.kg^{-1}$ of fuel.
Benzene (C_6H_6)	Fuel combustion and evaporation during their manipulation, distribution and storage. In Europe it is present in automobile petrol in share of around 5 %, sometimes even more than 10 %.
Toluene (C_6H_5-CH_3)	Combustion of fuel containing mixtures with benzene and xylene used as an additive to increase the octane rating of petrol.
Styrene (C_6H_5-CH=CH_2)	Imperfect combustion processes.
Formaldehyde (H_2C=O)	Imperfect fuel combustion.
1,3-butadiene (CH_2=CH-CH=CH_2)	Imperfect fuel combustion mainly with high content of olefins.
Particulate matter (PM)	$PM_{2.5-10}$ (large fraction) – predominantly swirling dust from road pavements, abrasion of tyres, and in the combustion processes. It stays in the close proximity of the source. $PM_{2.5}$ (fine fraction) – as a consequence of chemical reactions in the combustion of fuels. $PM_{0.02}$ (ultra-fine fraction) – from gas emissions during combustion processes. It could be transferred by air even on long distances.. $PM_{0.01}$ (nano-particles) – fuel combustion, mainly in petrol engines. Diesel passenger cars produce 0.3 to 4.8 g of this pollutant per kg of fuel, freight then 0. up to 6.3 $g.kg^{-1}$ fuel, depending on observing the EURO limit.
Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F)	Oxidation of carbon particles in burnt gases at the temperatures of 250 – 350°C in the presence of hydrogen, water vapour and chlorine.
Polychlorinated biphenyls (PCB)	Synthesis of particles of carbon, hydrogen, water vapour in the presence of chlorine.

Particulate matter (PM) have come into the spotlight lately, due to their negative influence on human health and their increasing content in the air, mainly in urban areas. Therefore, greater attention is paid to PM in this chapter.

PM contains particles of solid and liquid material of a size from 1nm up to 100 mm staying in the air for a certain period of time. We can see them in the atmosphere in the form of a complicated heterogeneous mixture, in terms of particle size and their chemical composition. PM are characterized by their specific physical (form, size, electric charge, surface of the particles, and solubility) and chemical properties (inorganic and organic components) which depend on their source, mechanism of origin and other conditions which influence their occurrence (distance from resources, meteorological conditions). Out of the physical properties a representation of individual size fractions of the particles is principally critical for the emitted particles, which contain ultra fine, fine, and large fractions as well. Out of the total quantity of the total suspended particulate matter (TSP) in the air, 60-65 % are formed by fraction of PM_{10} particles, which are particles of a diameter lower than 10μm. 72 % PM_{10} fraction is formed by particles of a aerodynamic diameter lower than 2.5 μm (fraction $PM_{2.5}$) and smaller particles in the $PM_{1.0}$ fraction (aerodynamic diameter under 1μm) make 52 % (Harrison et al., 2003). In Figure 2 there are photos of PM taken with the use of a scanning electron microscope (SEM).

The possible effects on human health, and the possible health risks which they may have on the exposed population, are connected with the size of particles and their composition (Weijer et al., 2001). The dangers of PM do not lie only in their mechanical properties but mainly in the hazardous organic content (particularly PAH) or in a whole range of inorganic pollutants, such as molybdenum, copper, nickel, cadmium, platinum (Adamec et al., 2004, Krzyzanowsky et al., 2005, Adamec et al., 2006).

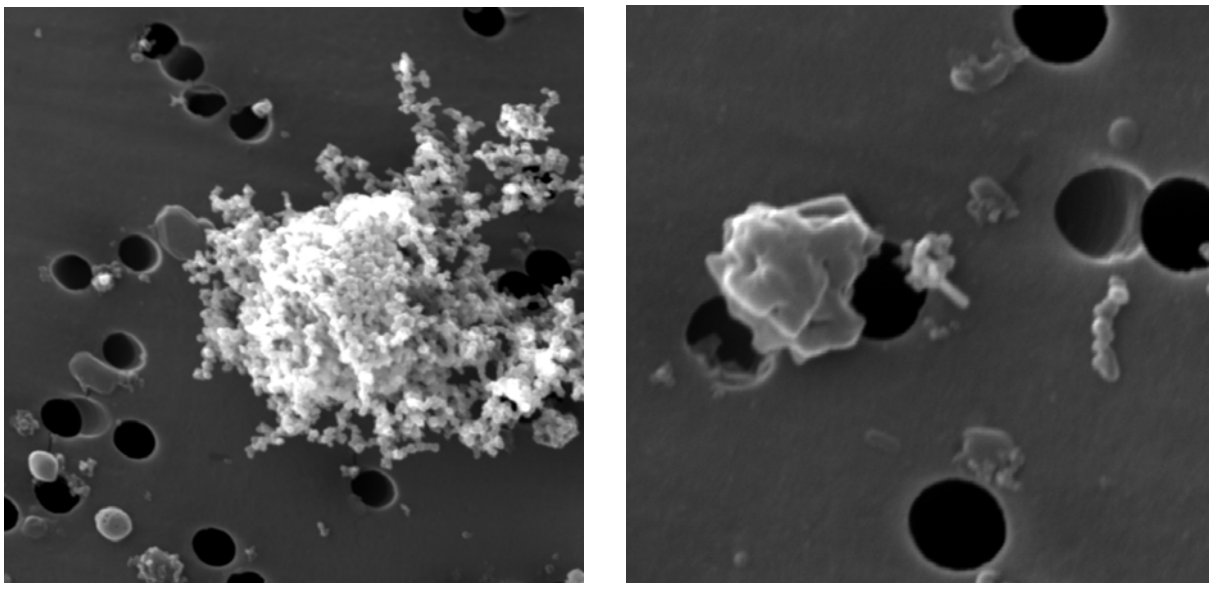

Figure 2: Left photo - PM produced from fuel combustion (amplification 30 thousand), right photo - PM produced by mechanical separation (amplification 70 thousand).

The total content of particles in the air, apart from the particles emitted directly from the primary resources (traffic, industry), is contributed by the solid particles in a very significant way. This process significantly contributes to their content increase in the air

and according to various studies, it could be a source of even 60 % of particles of PM_{10} fraction (Braaten et al., 1990). Blowing the sedimentation particles as a consequence of passing cars depends on specific local conditions, on road surface quality, vehicle speed, vehicle weight, and air humidity. The dangers of the re-suspended particles lie mainly in the sorption of other pollutants onto their surface in case of their longer stay on the road or in its surroundings.

PM can be removed from the air by wet deposition during rain, when there is a "washout" of mainly large particles with aerodynamic diameter over 5 μm, or by the change of the air masses, when "clean" air comes to the given area. Another mechanism for eliminating the particles from the air in urban areas is their deposition when dissociation of the particles from the air appears as a consequence of their contact with a solid or liquid surface. The presence of vegetation which greatly enhances the circulation of air in the lowest layer of the terrain surface, supports this deposition considerably. In densely built-up urban areas, grass areas, which are often the only alternative for permanent particle deposition in these places, play an important role in the particle catching. We can generally conclude that particles of smaller dimensions (under 1μm) are caught more easily, whereas particles larger than 5 μm, tend to be reflected by the surface.

Currently, the research in the field of nano-particles, which are particles with dimensions under 100 nm and have some special properties, like bio-persistence, adsorption, or diffusion, and are the subject matter for a range of world research institutes, is developing very quickly. Nano-particles are produced by both natural processes (erosion) and the anthropogenic activities of people (fossil fuel burning, mining, production of nano-materials, etc.) and they are released into the environment. Then they are exposed to various biological, chemical, and physical changes and get in contact with living organisms (Dreher et al., 2003). Currently, the concentrations of ultra-fine particles in the air of large urben areas are monitored and analyzed only at some stations in Europe due to very expensive equipment.

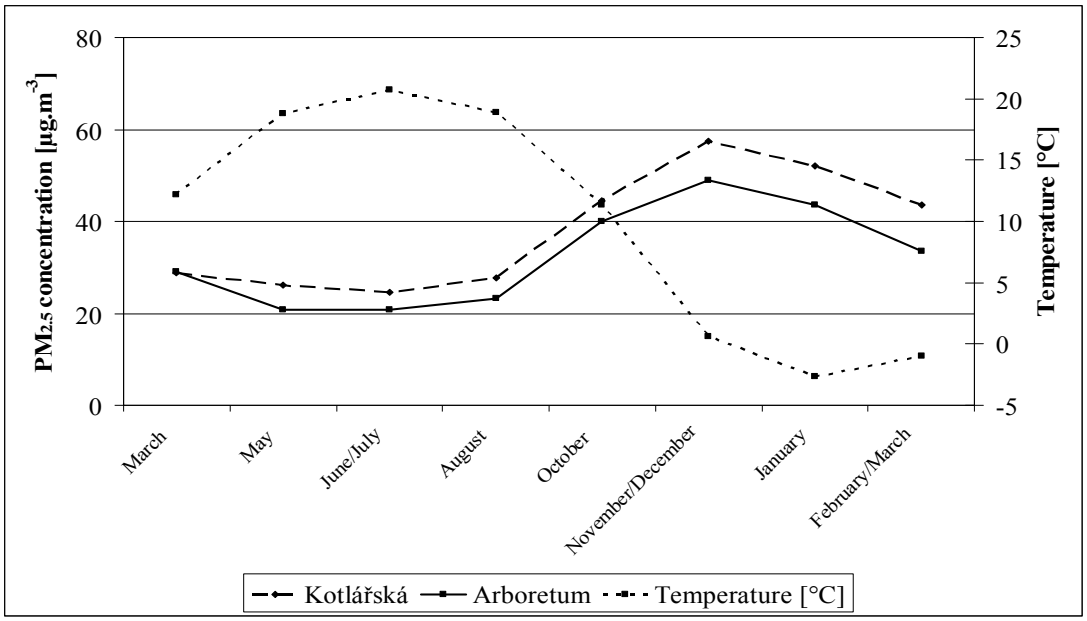

Figure 3: Development of $PM_{2.5}$ concentration and temperatures (Adamec et al., 2007).

The evaluation of the level of air pollution comes from the monitoring of the polluting compound concentration in the atmosphere ground layer in the network of measuring stations.

The evaluation of air pollution is based on the relation of measured imission values to corresponding imission limits and target imission limits. In 2006, the government resolution No. 597/2006 Sb., came into force following the Act on air (Act No. 86/2002 Sb.), which determines the imission limits which are in accordance with the requirements of the EU directives on the environment quality. The regular measurements of particulate matter (mainly fractions of PM_{10}) take place in the Czech Republic in connection with this legislative framework; in 2006 the measurements were executed in 148 localities. These places represent various fields in terms of landscape morphology, presence of residential areas, industrial enterprises, etc. The background localities which are of highest numbers are located mostly in the residential zones of the cities, in rural, and natural areas. Industry is considered to be a dominant source of particulate matter in 12 localities. 33 localities are directly influenced by traffic. In these cases, the measuring devices are close to roads and junctions with high traffic volumes. The primary sources of particulate matter are processes related to traffic in these places, mainly fossil fuel combustion in car engines, and the mechanical production of the particles by tyre abrasion, brake pads, and tarmac surface of roads. The monitoring network stations are operated by The Czech Hydrometeorological Institute, Health Institutes of the given areas, or municipal authorities of the urban areas where the measurements take place. Measured data are then freely available on the websites of the Czech Hydrometeorological Institute ČHMÚ.

As is clear from certain long-term measurements (Adamec et al., 2005, Adamec et al., 2007) of concentrations of $PM_{2.5}$ fine fraction, the determined annual average concentrations (38.07 μg. m^{-3} resp. 32.49 $\mu g.m^{-3}$) are significantly higher than limit concentrations for this pollutant (25 μg. m^{-3}) proposed in the prepared EU directive for air quality. The results also show the significant seasonal dependence of $PM_{2.5}$ concentrations, (Figure 3) when in the lowest measured temperatures the highest concentrations were determined, this also worked vice versa. This difference could have been caused by the loss of volatile components of PM (e.g. ammonium salts) in summer months; these components coagulate and could be caught by filters in periods of low temperatures. However, the above-described trend could have a connection with other aspects as well, mainly with vertical atmosphere stability. Thanks to better ventilation, the particles are better dispersed during hot periods (convection), whereas during colder months (inversion) the ventilation is limited, so PM "accumulation" in the lower layers of the atmosphere occurs near the place of their origin. Some local sources, such as fireplaces and other sources of heating, could also significantly participate in the presence of particles in winter.

The knowledge of distribution of the individual size fractions of PM, i.e. the representation of individual particles in the range of sizes 2.5 to 10 μm, 1 to 2.5 μm, and 0 to 1 μm in the total particle content smaller than 10 μm, is very important for understanding PM behaviour, and, mainly, for an estimation of the health risks. The share of the individual fractions in PM_{10} during the summer period is shown in Figure 4, during autumn at the turn of November and December in Figure 4. The share of finer PM2.5 fractions in the total concentration of PM_{10} is higher during cold periods when these particles make 92.9 % of PM_{10}, whereas during hot periods of year, this share was only 59 % (Adamec et al., 2007). The annual average concentrations of PM_{10} (50.24 $\mu g.m^{-3}$ resp. 35.56 $\mu g.m^{-3}$) determined within long-term measurements are in accordance with similar towns and cities in Europe, where the concentrations reach values between 44.4 $\mu g.m^{-3}$ – 53.8 $\mu g.m^{-3}$ (Martuzzi et al., 2002). The following concentrations of PAH in the chosen risk elements - cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), Mo, Pb, linked to their surface, correspond to values determined in the environment with medium traffic volume or industry in a number of European cities, such as Manchester, London (Harrison

et al., 2003), Birmingham (Harrison et al., 1996), Helsinki (Yli-Tuomi et al., 2005), and Budapest (Salma, Maenhaut, 2006).

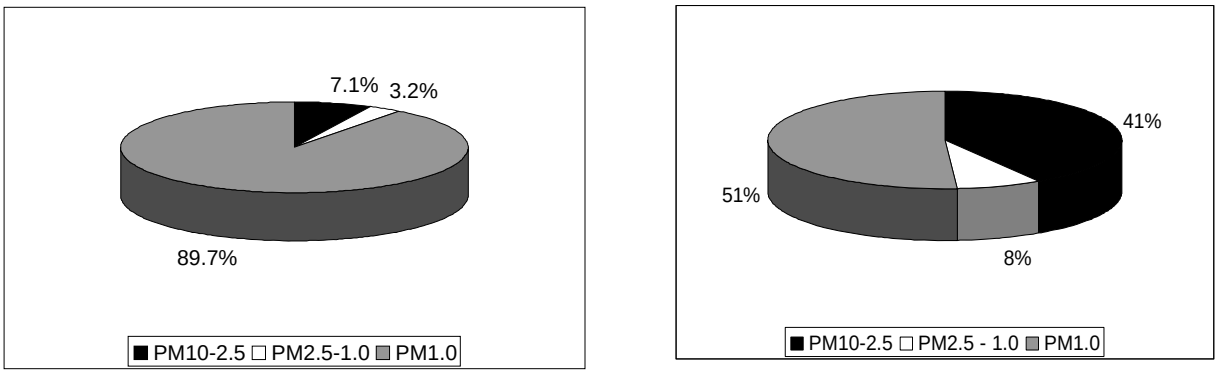

Figure 4: The share of the individual PM10 fractions during the period 25 June – 5 July 2007 (left graph) and during the period 28 November – 5 December 2007 (right graph).

As has already been mentioned, the evaluation of air pollution monitors the relationship of air pollution and the relevant limit values (Table 3), which are determined in connection with the Clean Air Act in the Czech Republic (Act No. 86/2002, Sb.) by the government resolution No. 597/2006, Sb., as amended. The pollution limits are in accordance with the requirements of the EU directives on the environment air quality valid in all EU member states (Act No. 86/2002, Sb.).

The overall air pollution is evaluated by emission balances which compare the production of selected harmful compounds from all sources. The basis for the national emission balance is a Register of Emissions and Air Polluters (REZZO), which has been methodically conducted and operated by The Czech Hydrometeorological Institute (ČHMÚ) since 2003. The pollution sources are recorded in four categories - large, medium, small, and mobile – in the REZZO database.

Table 3: Values of pollution limits valid in the Czech Republic for selected pollutants (government resolution No. 597/2006, Sb.).

Pollutant	Valid imission limit in the Czech Republic
PM_{10}	Annual average concentration of 40 $\mu g.m^{-3}$ maximum 24-hours concentration of 50 $\mu g.m^{-3}$ (maximum number of exceeded values per year 35)
NO_2	Annual average concentration of 40 $\mu g.m^{-3}$ maximum 1 hour concentration of 200 $\mu g.m^{-3}$ (maximum number of exceeded values per year 18)
NO_x	Annual average concentration of 30 $\mu g.m^{-3}$ (to protect vegetation)
CO	maximum daily 8-hour concentration of 10 $mg.m^{-3}$
Benzene	Annual average concentration of 5 $\mu g.m^{-3}$
Benzo(a)pyrene	Annual average concentration of 1 $ng.m^{-3}$
Lead	Annual average concentration of 0.5 $\mu g.m^{-3}$

The emissions from traffic, together with emissions from agriculture, forestry, civil engineering industry, and the military, are a part of the mobile sources balance. These emissions are calculated as a product of the so-called active data and emission factors. The active data are expressed as consumption of fuel per a kilometre of a given category of means of transport. The emission factor is an emission quantity of a given pollutant which refers to a weight unit of a given fuel or driven distance unit. The CDV methodology (Dufek et al., 2001) based on the calculations of emissions from the consumption of fuels, is used for the determination of emissions on the national and regional levels. The program MEFA, which calculates the emission factors by referring to 1 km of the driven distance (Šebor et al., 2002), is used at the local level.

In Table 4, there is an overview of the emission factors of selected pollutants concerning petrol and diesel passenger cars which meet the EURO 3 limits, e.g. Škoda Fabia, produced between 2001 and 2005. The emission factor for heavy vehicles is also mentioned here as a comparison from the same production date. The emission PM factors for petrol passenger cars are not determined, considering the fact that these types of engines produce very fine, or even ultra-fine, particles, whose production is not currently monitored due to high costs of the measuring equipment.

Table 4: Emission factors for various types of vehicles.

Emission factors [g.kg^{-1} fuel]	**limited pollutants**				**unlimited pollutants**				
EURO 3	**PM**	**CO**	**NO_x**	**NM VOC**	**CO**	**N_2O**	**CH_4**	**PAH**	**NH_3**
Petrol passenger car	X	18.21	1.07	1.27	3.183	1.10	0.10	0.002256	1.333
Diesel passenger car	0.28	2.42	4.25	0.57	3.138	0.25	0.08	0.020832	0.016
Heavy vehicles	0.41	7.33	10.26	2.71	3.138	0.25	0.15	0.0016	0.012

Legend: X = not determined

3 WATER POLLUTION

The surface and ground water form an important component of the environment and are one of the fundamental raw material sources necessary for maintaing life on Earth. However, human influence gradually leads to its quality reduction, when one of the negative factors affecting its quality are various modes of transport. The seas and oceans may be contaminated by ships, mainly as a consequence of huge tankers accidents when considerable amount of oil leaks into water which brings with it extensive pollution with serious environmental effects. The cases of the tankers Exxon Valdez (1989) and Prestige (2002) are among the most infamous accidents. A source of long-term pollution may also come from large ports through handling with transported material or during vessel repairs.

In connection with the pollution of water, both surface and groundwater, the issue of rail transport come into consideration. The pollution sources are, in this case, rail transport, power supply, and switching stations, places for the washing of rail cars, fuel stations; and in the case of diesel traction, the railway vehicles themselves, and their accidents on the rail tracks. The pollution by road transport could also have a random character in the form of car accidents with a leakage of fuel, motor oils, operating liquids, and other pollutants, but also through long-term impact of exhaust gases, abrasions

of the tyres and road pavement surface, and fuel dripping. The indicators of the maximum permissible level of surface and ground water pollution are evaluated by the government resolution No. 61/2003, Sb.,as amended, and the the guidelines of the Ministry of the Environment of the Czech Republic, Appendix of the Bulletin of the Ministry of the Environment, No. 8, year 6, 1996.

3.1. Surface water

The pollution of surface water is caused by rain water drained from the road surface with a high traffic volume, mainly motorways and dual carriageways. The pollution is highly dependent on the amount of rain falling on motorway surface where the concentrations of the pollutants in the "first drain" are the highest after rainfalls and after a over time it rapidly decreases, whereas, the pollution is directly reflected behind the drain where the drained water is not sufficiently diluted yet. The whole range of pollutants, including metal elements and suspended solid particles produced from the operation of traffic, mainly through the abrasion of road pavement surfaces and tyres, was identified in the surface drainage outlet, (Sansalone, Buchberger, 1995). The pollutants could also come from the materials used for road maintenance, lay-bys, and car parks mainly during winter, when the contamination could be connected with the application of defrosting agents and antifreeze mixtures. A key source of pollutants are also the leaks and spills of fuel when, besides the whole range of organic pollutants like PAH, hydrocarbons and metals are released into the environment (Shinya et al., 2000). Another important risk of possible environmental contamination is represented by filling stations, in whose proximity and on the adjacent car parks the highest concentrations of PAH were found (Smith et al, 2000). The motorways are, according to a range of studies, also the main source of chlorides which do not drain away through the watercourse, but they mainly soak into the soil and rock environments where, under certain conditions, their accumulation and subsequent gradual washout occurs (Runge et al., 1989).

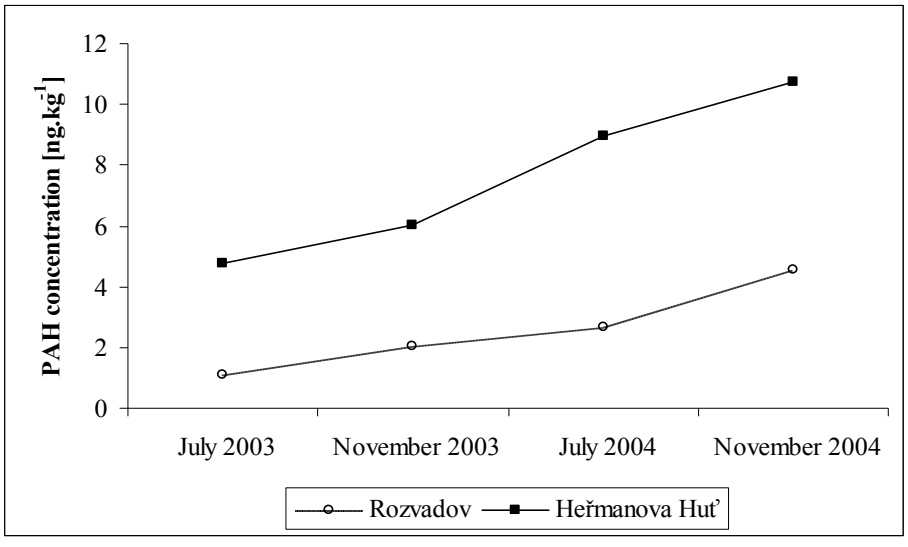

Figure 5: Development of PAH concentrations.

In order to monitor the pollution of the drained water, a method of passive sampling with the help of semi-permeable membranes (SPMD) is often used. This method simulates

the diffusion process via bio-membranes, which are considered to be crucial in the bio-concentration of the pollutants in living organisms. This method was also used for the monitoring of the pollution level of the water drained from motorway D5 into retention tanks. From the graph in Figure 5, the growth of the PAH concentration within the monitored period is easily apparent (Adamec et al., 2005), nevertheless, the set contents are lower than figures recorded in some foreign studies, and so far they do not exceed the limit concentrations set by the government Directive No. 61/2003 (NV, 2003), as amended.

3.2. Ground water

A similar problem, although not that urgent, is the contamination of the ground water by pollutants from materials used for road building. During the construction a whole range of materials, which met the technical construction requirements at that time, was used in the past; however, currently, as a consequence of stricter measures (limits), they could have a negative influence on the environment components and human health (Legret et al., 2005). Especially the migrant water in the roadway, drained by drainage systems, could be contaminated by pollutants released from the construction materials. However, this process depends on a lot of factors, like the subgrade type and the surrounding terrain characteristics, ground water management, capillary rise of ground water level, and the amount of precipitation which could penetrate the roadway, mainly as a consequence of damage to its surface layer (cracks, fissures). In the Czech Republic, the construction of asphalt roads uses unmodified and modified road asphalts made of raw materials which influence their final properties, i.e. influence a release of hazardous substances to the environment as well. These could form a basic part of the produced binder (e.g. PAHs, hydrocarbons) or could be added to modify and prepare better asphalt properties, e.g. the reduction of plastic deformations. For these purposes, e.g. elementary sulphur, polyethylene, polypropylene, powder polyvinyl chloride, and others are used. The permeating of some PAHs and metals from the sample asphalt surface and other construction materials are shown in some foreign studies and their results are in correlation with the results of Czech researches (Ličbinský et al., 2007). The release of pollutants from the used materials could currently be considered low, depending on the pollutant properties and on the primary content of the organic and inorganic pollutants in the given material. The major source of pollution lately, due to the increasing traffic volume, are traffic accidents with a leakage of fuel, motor oils, operating liquids, and transported dangerous goods, such as acids, lyes, and other chemicals.

4 SOIL POLLUTION

As in the case of water pollution, the threat to soil quality in the road surroundings occurs basically by three sorces: by long-term pollution, caused by everyday road traffic, by seasonal pollution, mainly through the influence of road winter maintenance, and by traffic accidents, when the leaking of environmentally harmful materials occurs.

Long-term soil contamination in the surroundings of roads is connected mainly with the pollutant drainage from the road surface and the splashing of water caused by passing cars to the surroundings. Thus, the soil could be contaminated by PAH and its derivatives, particularly nitrated ones (nitro-PAH), hydrocarbons, and some metals as well. Its contamination may also occur through using abrasive winter maintenance materials and chemical defrosting materials. For this purpose sodium chloride, calcium chloride, and their mixtures, as of spreading, sprays or dampers (sprinkling salt), are used; however,

during their application it is not possible to prevent dispersion around the road and thus contamination with chlorides. Subsequently, their presence causes the corrosion of metal elements of the road equipment and the increased release of pollutants from their protective coating, which could lead to subsequent pollution by heavy metals. The issue of soil contamination is also closely related to pollutants permeating from roadways when under the influence of water soaking in the road body, their permeating and subsequent transport to the environment occurs. The soil contamination is particularly problematic in large urban areas with a high volume of car transport. Metals from the platinum group (PGE) like platinum (Pt), palladium (Pd), and rhodium (Rh), which are among materials worth mentioning, are classified as toxic metals, and their increasing concentrations could represent a serious risk nowadays. The concentration of Pt emitted from car catalytic converters at sites with high traffic volumes in the Czech Republic, ranges from 9.20 – 21.57 $\mu g.kg^{-1}$ and is comparable with the levels of other European cities (Zereini et al., 1997). At these sites, higher contents of PAH, higher even than in the close proximity of motorways, were found (Tuháčková et al., 2001).

Table 5: Land use as a consequence of road construction (Jedlička et al., 2009).

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008
Středočeský	12.74	71.31	89.75	61.10	142.62	317.41	110.18	85.68	14.51
Jihočeský	18.08	52.21	28.55	11.02	84.94	4.07	42.49	50.54	9.51
Plzeňský	40.03	24.23	31.95	28.18	0.00	10.30	1.22	88.42	9.00
Karlovarský	0.00	18.98	36.64	0.00	31.90	2.00	26.00	0.00	33.39
Ústecký	15.73	112.18	17.20	5.16	107.21	114.10	0.00	0.00	0.00
Liberecký	0.00	0.00	0.00	10.16	4.97	26.88	10.32	2.29	39.10
Královohradecký	x	x	8.06	14.18	86.21	0.04	x	3.23	x
Pardubický	0.30	0.00	14.20	0.00	93.83	0.00	70.00	9.14	0.00
Vysočina	0.00	2.65	33.50	46.23	0.88	28.39	15.58	32.78	0.47
Jihomoravský	1.03	0.94	139.15	10.48	0.01	0.46	11.61	16.12	1.62
Zlinský	167.93	198.10	52.62	62.79	55.97	45.70	12.62	0.00	0.00
Olomoucký	10.92	0.00	0.00	107.49	100.89	3.05	135.32	4.66	171.30
Moravsko-Slezský	0.00	79.23	40.61	112.01	117.22	280.84	205.20	141.85	34.26
In total	266.76	559.84	492.24	468.80	826.66	833.23	640.54	434.71	313.16

Legend: x= information is not available

The negative impact of traffic on soil is not only reflected in the chemical pollution of the road infrastructure surroundings, but also in the construction of roads and the whole transport network. As far as the land designated for construction is concerned, its original function has to be removed. Such land is converted into areas designated for construction, so, from the viewpoint of the Nature, it results in their degradation. The arable and forest land use figures clearly show (Table 5) that in 2004 almost 988 hectares were designated for road construction, which represented almost a fifth of the capital city's area, Prague.

The road alignment of important roads (nowadays mainly motorways) is considerably conditioned by terrain obstacles. It is easier to build such motorways mainly in the lowlands and valleys along important rivers; however, at these places there is often soil, which is highly valuable for agriculture. The motorways are commonly built in four lanes with a central reserve, i.e. that only the motorway itself and its adjacent strip will require the land use of an area of approximately 3 hectares per 1 km of motorway length. Apart

from the motorway itself, other accompanying constructions are also included in the land use – ditches and embankments compensating the road alignment, grade-separated junctions, petrol stations, and other commercial activities linked to providing services to passengers, as well as constructions used to mitigate the negative impacts of traffic, like anti-noise screens or retention tanks for drain water.

5 FLORA AND FAUNA

Currently, due to transport development and increasing building activity, a debated topic is the impact on biological diversity, i.e. the number of flora and fauna species. Biodiversity is not only threatened by the reduced size of ecosystems or by the hunting of endangered species of animals, but also by the fragmentation of localities.

This fragmentation is understood as a division of natural localities into smaller and more isolated units, and therefore the survival of some species is threatened. One of the main reasons for locality fragmentations is, apart from agriculture and urbanization, mainly the construction and the use of transport infrastructure. The transport network divides the natural localities into smaller, isolated segments which are often smaller than some species need for their survival. The road then acts as a physical barrier for animals and is particularly restrictive for those species which need large areas for their living. This does not only include smaller animals, like amphibians, reptiles and small mammals, but also larger ones, like deer or wild boar, which are very often hit by vehicles. The pollution of the road environment by chemical pollutants influences the amount and species diversity of the soil micro flora and fauna (Tuháčková et al., 2001).

6 LANDSCAPE PATTERN

Quality and fast transport means shortening of the "perceived distance", because the destinations are much easier to be reached than years ago; therefore the de-concentration occurs for a lot of human activities, which were before concentrated in the cities. Currently, the process of suburbanization is the most typical demonstration; this is characterized by spatial urban growth in the outskirts, which is enabled by easily available individual car transport and which sometimes even develops into its uncontrolled form called “urban sprawl”. This process is currently not occurring in a coordinated manner, because the role of land use planning is not powerful enough to ensure positive city development in terms of traffic and land use. The everyday problem of urban areas is the large number of cars, which the current city road network system is unable to accommodate anymore. In the case of huge cities, the move of residential areas and extensive commercial activities from the centres to the outskirts is apparent, without the appropriate connections to other urban areas, This causes increased demands on traffic, particularly individual road traffic, because these zones are usually designed to be predominantly available by personal vehicles, and public transport is usually not designed for these areas at all or only in a limited extent.

The landscape is very negatively influenced by the media advertisements, billboards, placed in the proximity of roads, particularly the busiest motorway sections, where the traffic flow exceeds 15 000 vehicles per 24 hours. The advertisement messages are seen daily by tens of thousands of people, and, therefore, these places are very attractive for the advertising industry. The placement of legally constructed billboards, for which their owners signed the proper contracts, passed through the approval procedure of the administrative bodies, and, therefore, they are usually not located in inappropriate

places. The Act No. 114/1992, Sb.,on the environment and landscape protection, states that it is not possible to place an advertising facility in places where it could have an impact on some important landscape features or some protected areas.

As a regulation complementing this Act, the Agency for the protection of the environment and landscape (AOPK) produced the "Methodology for the Evaluation of the Scenic Landscape" in 1999, which further specifies the terms such as natural, cultural, and historical characteristics of landscape, aesthetic value of the scenic landscape, natural value of landscape, cultural dominant features of landscape, etc.

However, besides legal advertising areas, there are a large amount of advertising facilities placed without the proper permits which are very often located in places unsuitable for these advertisements. It is a recent effort of the Road and Motorway Directorate of the Czech Republic, as a road administrator, to deal with this problem and restrict the number of billboards in road environment by up to 80 %. However, the owners of mega-boards, visible from over a long distance, are not too threatened by this effort, because their facilities are often located outside the designated safe area of roads and are often on private land. The assessment of the disturbance of landscape character has a big disadvantage due to the subjective assessments of specific situations. Therefore, there are unified rules for the determination of places where the advertising facility considerably affects landscape and where it should not be palced. An example of how a huge advertising panel could aesthetically violate the landscape is shown in a photo from the D1 motorway (see Figure 9 in the Appendix), which is, for comparison, supplemented with a computer photo-mounting where the advertising panel was removed.

7 ACCIDENTS

Dangerous chemical substances and chemical products (toxic, flammable, explosive), which can have a negative impact on human health and the environment, are handled with in everyday activities, including industry, trade, or during their transport.

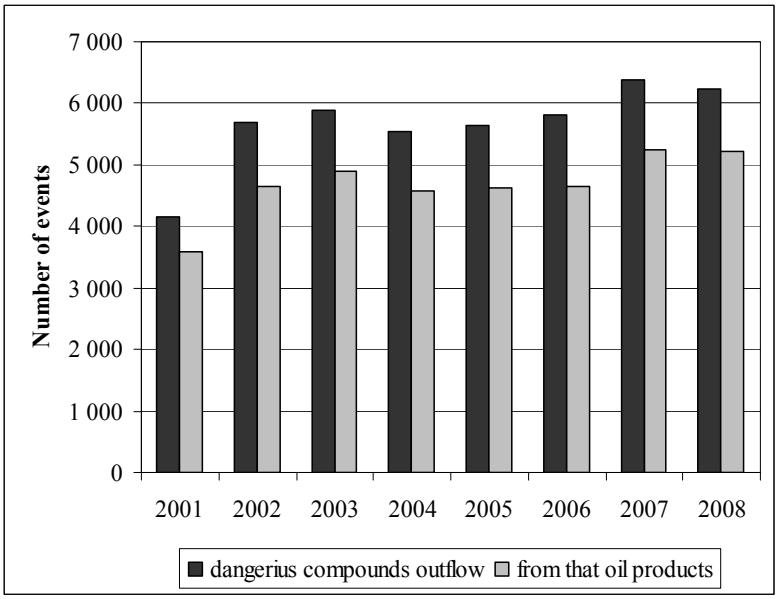

Figure 6: Number of releases of hazardous substances (HZS ČR, 2006).

Due to the increasing traffic volume, there is more and more contamination of surface and ground water and the rock environment through vehicle accidents on roads. Their consequences are the leakage of dangerous materials – mainly fuel, motor oils, operating liquids, and also transported dangerous items, e.g. sulphuric acids. Currently, the majority of regulations concerning this issue have been cancelled and replaced by new regulations, or, they have been amended. Currently, Act No. 59/2006, Sb., on prevention of serious accidents, is mandatory, which is reflected in the development of the EU legislation, and, when it became effective, the earlier legislation regulations were superseded.

Transport of chemical, toxic, flammable, and explosive materials requires great attention, considering the risks of traffic accidents and the subsequent leakage of these materials during transport. All hazardous substances have their specific properties, and, consequently, they acquire different degrees of danger under different conditions, which is particularly important during their transportation and handling. The international road transport of hazardous goods complies with the The European Agreement concerning the International Carriage of Dangerous Goods by Road – ADR (Accord Dangerousness Route), which the Czech Republic also complies with. The International Carriage of Dangerous Goods Regulations is valid for the International Railway Transport of Dangerous Goods Regulation (RID) as a supplement to the unified legal regulations concerning the Agreement for the Carriage of Goods by Rail (CIM). Air transport of dangerous cargo follows regulations issued by the ICAO (International Civil Aviation Organization) and the regulations of the IATA (International Air Transport Association). The maritime transport of dangerous goods follows The International Maritime Dangerous Goods (IMDG Code).

Traffic accidents with oil products leakage of dangerous substances have the highest share in the creation of environmental accidents and crashes in transport. The following graph in Figure 6 shows the number of leakages of dangerous substances including oil products, with the intervention of fire brigade units between 2001 and 2005. The graph clearly shows the steady trend of leakage of dangerous chemical materials and oil products.

Each accident which causes the deterioration of environmental conditions needs to be assessed as an environmental accident which could cause the instability of the ecosystem (Kvarčák et al., 2000). The principles determined in the above-mentioned international regulations are the first step for the reduction of the number of collisions of vehicles transporting hazardous substances. But despite the observance of the regulations, there is still a risk of vehicle accidents, which could be increased, e.g. by aggravated climatic conditions, an increase in road traffic volume and consequent congestions. In order to avoid traffic accidents and subsequent environmental accidents, it is necessary to search for other ways to maintain safe traffic, which will lead to the minimization of environmental accidents.

8 WASTE FROM TRANSPORT

The production of huge amount of waste in the form of car wrecks is becoming one of the priority issues of every developed society. Car wrecks consist of up to 80% of recyclable materials, usable as secondary raw materials, e.g. metals or plastic. However, dangerous types of waste, such as leaded accumulators, oil filters, braking and anti-freeze liquids, components containing mercury or PCB, or brake pads containing asbestos, could have a negative effect on the environment through improper handling or leakage. In the Czech Republic, this issue is dealt with by Act No. 185/2001, Sb., which defines a car wreck as any complete or incomplete motor vehicle intended for the use on roads to transport people, animals, or goods which has become waste. Everyone who gets rid of waste is obliged to hand it over only to people who operate the devices for the re-use,

removal, collection, and repurchase of car wrecks. The fundamental document which modifies the handling of this waste in the EU is the directive of the European Parliament and Council 2000/53/EC on vehicles with expired lifespan, and its appendices issued in the form of Decisions of the Commission of European Communities which are integrated in the Czech legislation in the form of the Waste Act (No. 185/2001, Sb.), as amended by the Implementation Programme of the Czech Republic No. 4. The goal of all legal measures is to complete and improve the existing system of handling car wrecks, which could be an important source of secondary raw materials and energies.

The handling of car wrecks concerns several target groups on various legislative levels. These target groups are public (origin), local authorities, regional authorities (as an authority which issues licenses to facility operators for handling with this waste), and business entities (the authorized operators). The system of deregistration and environmental handling with scrapped passenger cars consists of the following steps. The principle is to hand the vehicle over to the collection network, then the gradual disassembly of the car wreck is executed so that the individual parts could be obtained separately, which individually are of higher value. Apart from this, it is possible to separate other waste containing hazardous substances, and thus reduce the total amount of dangerous waste. The crushing the vehicle body itself allows to gain pure steel scrap; this step could be alo replaced by cutting and pressing, which are less demanding in terms of operation and investments costs. Consistent sorting is an required for the higher level of metallurgical processing for non-ferrous metal components. Approximately 160 thousand cars are decommissioned yearly from operation in the Czech Republic, and up to 9 million vehicles in the whole EU (Božek et al., 2003, Šooš, 2006). Their material structure depends on a range of properties, such as the size and type of the vehicle, vehicle producer, model year, the age of the vehicle, or the efficiency of the processing and sorting technologies. In terms of quantity and recycling, ferrous metals (steel and cast-iron) are the most important components, which form around 62-68%, then non-ferrous metals (for example aluminium, magnesium, copper) and their alloys at 3.5-6%, other components such as paints, leather, wood, and paperboard make 5-15% of the car wreck weight. The proportion changes of individual components in the material structure are given by the technological development of the vehicles, where the share of plastic and the so-called light metals is currently increasing. An overview of the average material weight composition is shown in the following Figure 7.

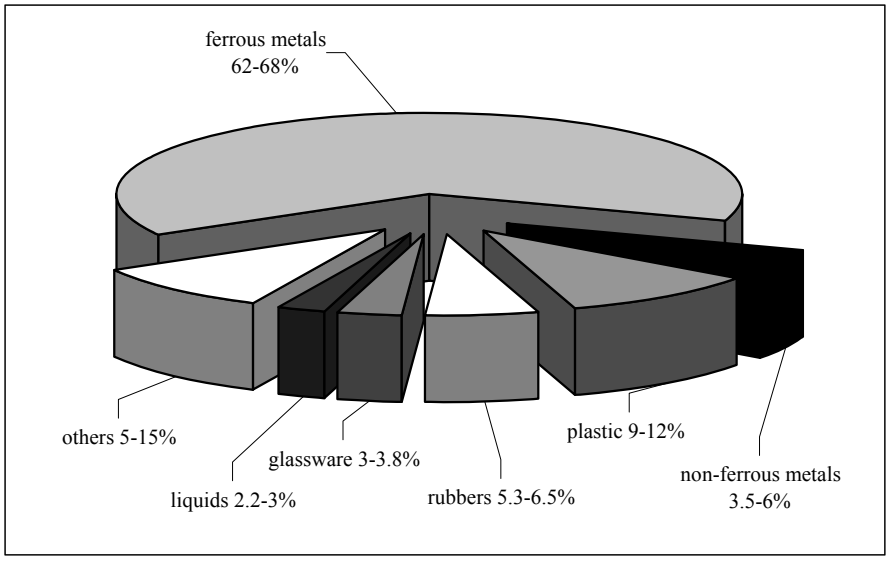

Figure 7: The average material vehicle weight composition (Polívka, 2004).

In the EU countries, the total expenses for car disassembling are between € 150 and 450, and, with the use of waste crushers, which are mostly used in Germany, France, and Great Britain, between € 50 and 70 per vehicle. Currently, approximately 80 collection points and 8 facilities for car wreck processing (disassembling devices + crushers) are in the Czech Republic. For the environmental processing of passenger cars with expired lifespan a fee amounting to CZK 1200 is charged. The costs for environmental car wreck processing range around CZK 3000, out of which approximately one third of the costs is used for the transport and handling, the other costs include the car wreck processing and the removal of the remaining parts, which include hazardous waste (Sýkora, 2005).

The waste produced by transport is currently a very topical issue, mainly due to the increase in the number of registered vehicles and their average age, which is currently 13.5 years. As far as the vehicle handling of future generations is concerned, waste production will still be on the rise, which has a range of negative effects. Therefore, the prevention and minimization of waste, which will lead to less harmful impact on the environmental, are very important issues concerning waste handling. There is also a connection with vehicle construction, which should, in the production stage, be focused on more effective use of secondary raw materials and energies, the share of materials with dangerous or toxic properties should be reduced in the maximum degree, so that new vehicles would be more environmentally friendly and have a higher potential for prevention, re-use, and material and energetic use (Adamec et al., 2006).

9 SUMMARY

Several thousands of various chemical compounds, often with mutagenic and carcinogenic effects, have been identified in the environment, out of which a considerable number comes from traffic (e.g. the combustion of fuel, abrasion of exposed parts of vehicles and the road surface). The concentrations of a some of them are regularly monitored and the Czech Republic has to reduce their amount according to its commitments within the EU membership. Nevertheless, the amount of the harmful compounds released to the environment by human activity is increasing rapidly. This unfavourable situation is apparent mainly in big cities with high traffic intensity where the considerable deterioration of air quality occurs, which influences the health of their citizens, mainly children and the elderly. In this respect, it is necessary to pay attention to this issue, which means to care more about the destination of the pollutants produced by traffic, and the associated potential health and environmental risks.

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Technical Notes on Usable Information to the Segments of Development of Economic Environment influencing Demand on Transport Market

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ABSTRACT

Transport sector is heavy influnced by all fluctuations on the market with goods traffic services and passenger services concerning demand - the only “stored” potential to cover unpredicted growth of traffic are free “mobile” capacities of vehicles, and in some extent capacities of transport infrastructure.

Findings in the below quated article analyse effects of large balance sheet adjustments in corporate sector as a result of economic crisis; they prooved the impact of greater adjustments on the level of GDP, that could be transmit into the sectoral structure of demand for transport.

These adjustments could refine medium term forecasting of renewal of traffic on the initial level, under normal market condition, without help from outside.

KEY WORDS: forecasting of growth of traffic.

FURTHER POSSIBILITY TO ELABORATE EFFECTS OF EPISODES OF ECONOMIC GROWTH INFLUENCING TRAFFIC

ADJUSTMENTS OF THE BALANCE SHEETS OF COMPANIES

Focus “Balanced sheet adjustment in the corporate sector” in Quaterly Report on the Euro Area, volume 9, No 3 (2010) describes results of analyses of sample of 31 episodes of large balance sheet adjustments in corporates of states with advanced economies, with some extensions to the EU27 and the achievements that proved sizeable macroeconomic consequences. The episodes are events disturbing developments of economies of corporates that touched total development of GDP exceeding 2% GDP.

The negative consequences of large balance sheet adjustment in the period of financial and economic crises reflect losses in GDP growth and strong falls in investment, lasting on average more than 8 years.

Balance sheets adjustments bring weaker growth of wage bills, which in turn weighs on domestic demand and economic growth.

Case studies from Japan and Germany together with an econometric analysis show that the adjustment episodes can be triggered by corporate over-indebtedness, stock market declines, business cycle downturns and negative shocks in GDP growth. Prolonged adjustments could come from deterioration of financial intermediation and changes in the tax system. As a lecture from the crisis fixing banks´balance sheets and frontloading growth reforms under the Europe iniciative will lessen the negative consequences of the adjustment.

The structure of balance sheets of corporations responds to changing economical and financial conditions, including prospects of growth of asset prices, taxation and interest rates. In normal times, changes in balance sheets of individual firms have little effects on the economy, but in case of larger shocks the macroeonomic consequences are significant.

Under very strict assumption (perfect capital markets, no bankruptcy costs and neutral tax system) changes in structure of balance sheets should leave the value of the firm nad output decsions unaffected. Without such assumptions the structure of balance sheets depends on economic conditions and firms´ financial decisions can no more be separated from their output decisions. Modern finance theory has enphasised the possible interactions between balance sheet structure and the non-financial side of the economy when capital markets and information are imperfect.

Not to deepen indebtedness there could be cuts in costs of wages either by decreased employment or lesser level of wages with impact on rate on employment, social assistance, but through these changed indicators of passenger traffic too- either in lesser commuting, or lesser costly trips for leisure. Both above mentioned items influenced corporate net lending or borrowing (NLB).There is posible to derive delayed investments and their influence in losses in traffic demands during investments and later- untill the opening of traffic operations – in volumes of traffic.

The moves of NLB indicates the role of sector either as a net provider or recipient of finance for the rest of economy. In euro area there were oscilations in range of 0,5% to 4.5 % of GDP. As it has been mentioned above, for counting balanced sheet as an event of adjustment worth consideration there was taken balanced sheet adjustment NLB with the effect more than 2% GDP with lasts more than one year.

FINDINGS FOR POSSIBLE PREDICTABILITY FOR BOTH CORPORATIONS AND TRANSPORT OPERATORS

The sample of balance sheet adjustnents gathered from all 27 Member States of EU and US were oriented mostly on the states of euro area and other high developed countries with advanced economy. There were during about thirty last years 31 episodes lasting on average 8,3 years with standard deviation of more than 5 years. Such very high standard deviation needs farther analysis concerning the secondary divission of factors with decisive impact. The calculations effects of balance sheet adjustments on economic growth were oriented to the 4^{th} year after the beginning of adjustment- it means to the 5^{th} year. Relatively long time periods for adjustments in above mentioned episodes need in modes of transport with high participation of SMEPs very prudent measures to assure satisfaction of higher volumes of traffic, with not too high overhang of capacities after peaks periods´during decreased demands. Refused requirements could hamper the development of economies, influence possibilities for growing employment etc.There could be very simplyfied choice how to react in the most efficient way on peak demand – to have reserves in drivers´capacities in all cases where could be either the possibility to use capacities of operated vehicles in more shifts or prolonged shifts with farther drivers instead of more expensive free capacities of vehicles and unemployed drivers.

LITERATURE

Focus: Balance sheet adjustment in corporate sector . In Quartely Report on the Euro Area, Volume 9, No 3 (2010), pp. 9 - 19.

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