Energetics, Security and Sustainable Development of Cities

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Abstract: The life in cities and its quality increasingly depends on transport means and on the energy used for their propulsion. The much discussed reason for the substitution of classical energy sources is also the energetic security; the second reason is the decreasing energetic returnability of oil. The paper draws attention to some aspects, connected with accessibility to the passenger transport in the city system. It is emphasized that the solution of the mentioned problems comprehends many factors not only from the field of transportation. These factors have been influencing one another. Therefore it is necessary to find ways how to harmonize these factors for achieving the sustainable development of the city system. The sustainable city development is conditioned by the bearable development of the transport system so that the access to various transport modes is ensured for all city inhabitants and so the sustainable mobility of city inhabitants is ensured.

Key words: Energetics, security, sustainable development, city, urban transport, quality

1 Introduction

The transportation has been during the whole history basic driver of the human society form. It determinated not only the location of towns, but also their internal form and last but not least it was the basic element of the economic development as the inevitable presumption of the goods barter. Its role in the 21st century will not be other and the question is rather in which form we will use the transport further. The trend of a few last decades (esp. the acceleration of the car transport) has shown that one has to solve above all the problem of the transport in cities, that fight the lack of space and then also the problem of the energy re-source for the transport (or the substitution of oil by another resource) whatever the reasons will be - environmental ones (lowering of transport emissions), strategic ones (connected above all with the oil and gas supply security from the countries where they are won) or another ones (above all the discussed oil exhaustion during the next 50-100 years).

The environmental impacts of the car transport furthest concern the cities, where the most people live. The quality urban mass transport and the solution of the propulsion of transport means in the sense of lower emissions can thus significantly contribute to the sustainable development of cities and to the higher life quality.

Figure 1: Revenues of the Prague urban transport in the 20th century (real price level 2009, gross estimation 1938-1962), source (Baroch, 2011).

The urban transport were developing yet at the break of the 19th and 20th century in a idyllic way – the urban mass transport had been gradually rising without serious competition which the individual car transport became as late as in the course of the 20th century. The European cities have been fumbling with the lack of space, because their centres were not designed for this type of transport. Besides that it brought a big underflow of...
revenues for the urban transport companies, as shown in the figure 1.

The graph shows that (except the period 1938-1962) the revenue maximum of the Prague urban transport was won in the thirties of the 20th century and the revenue was decreasing during its second half except two price rises in 1970 and 1991.

2 City, system, transport

The city as a system consists of a number of elements, among which linkages and interactions rise. These elements can be described as follows:

1. Activities: products, services, trade, education, culture, travel and other activities
2. Infrastructure: office buildings, residential housing, schools, plants, shops, transport infrastructure—roads, railways, airports etc.
3. Land used for various purposes
4. Mobile elements: people, goods, transport means
5. Political and social structure: plans, goals, decisions

In the city system on the one hand population activities have been functioning and on another one the economic structure has been being created. The action of these two structures is given by several levels: the national, regional and urban one. Both structures then create the urban space, where the human activities take place, from the viewpoint of the population these activities can be classified into four categories or factors: work opportunities, production activity and services, the infrastructure use and the land use. These activities are connected by communication (in a general conception of communication) and the transport system is an implicit component.

This static conception has to be added by the dynamic approach, because the development of the city system has been changing in time both quantitatively and qualitatively. The dynamics of changes can relate to central parts of a city when decentralization of activities from this region happens as a consequence of technology changes and criterion economic choice. Outside of this region new residential and office objects appear, new infrastructure comes up. The technical development in the field of transport and communication technologies functions on the city system by two effects. The first one creates more homogenous land use than in the case of the centralization of activities in the city centre. The second effect makes cities more attractive than small town systems by building of big commercial, financial and office centres in big cities.

The economic base has moved from the city centre to suburban regions and this decentralization phenomenon is supported mainly by the development of the car industry and higher incomes of the inhabitants. Easier access to cars helps then to the higher mobility of the labour force and so to the further growth of suburban regions. The transport and telecommunication network amplifies the decentralization in the city space.

The big growth of car number allows on one hand the high mobility of city inhabitants, but on other hand it strongly influences the city environment and life quality. In spite of many approaches trying to harmonize the individual city transport the problems still keep open. The question of making the public transport more attractive has still failed to the transport strategy and planning. The proposals for the public transport support have been eliminated on the other hand by the construction of additional parking areas (land use management), especially by the construction of underground garages in the city centre. This is what one of the approaches to the city system factor integration is connected with. It is the city development with respect to the linkage of the public transport to the commercial, administration and industrial areas and the harmonization with the individual car transport. Taking into account the economic and social factor as the two substantial factors of the city system, the transport supply then constitutes the necessary support of the function of these elements. But at the same time the transport influences its neighbourhood and so it is necessary to control other elements of the city system: land use and the transport linkage.

City activities are usually considered as main processes integrating the communication and thus also transport services. In this context one needs to choose another approach to the concept of a product or a service so that economic and social interests are better fulfilled. This problem is dealt with the marketing. The customer chooses the products and services according to their utility. The marketing should thus supply not only the product, but also the whole chain of services so that the complete supply of final utility delivery originates including the transport service.
3 City development and transport system

The transport demand has the character of a derived demand. This holds also true for the urban transport system. People use the time for the realization of many activities. All these activities have their own particular transport demand function. These activities realize in the broad city area. They are commercial, industrial and residential areas as well as hospitals, schools, theatres, libraries and sport areas. But the city area must also take into account the transport activities: the construction of the transport infrastructure as an essential factor of the transport service supply.

But various people’s activities take place at various places in various daytime. The quality of man’s satisfaction in the city is finally measured by the opportunities to take part in various activities. The result is the demand for the city transport. The logic consequence is that the demand is determined by the number of people living in the city area. The wish or need of these people is to get at the specific place in the specific time. This is why transport rush hours result in particular moments of the day. These peaks are influenced by the beginnings and ends of work and with the connected travel to commercial and industrial centres and residential areas. A tense between the supply and demand rises in various daytime.

Various transport modes covering the transport demand create pressure on the transport infrastructure in various ways. Individual car transport affects the city transport system more vigorously than e.g. the bus transport. In addition, various transport means differently influence their neighbourhood. They emit to the environment gaseous exhausts and noise emissions, they cause transport accidents and create traffic congestions. If a city shall healthy develop, it must keep a reasonable balance between the demands for further expansion of activities and for the further land take. The consequence of the city development is then also the demand for the transport development and so the demand for the land use, because the extent and quality of transport supply depends on this development.

So the transport problems are only one the factors of the city development. If the public transport can compete with the car transport, its quality will still be emphasised during the next decades. The service quality criteria include availability, accessibility, information, travel time, customer service, comfort, safety, security and environmental impact. If the individual car transport is stepwise pushed away from the city centres by suitable measures (e.g. economic measures like road toll), the quality public transport must substitute it. And this is connected with the quest for financial sources, because higher quality also means higher additional costs (e.g. many transport companies converted to low floor busses at the turn of the 20th and 21th century, but they bring higher investment and operation costs).

We summarize the basic factors influencing the city development and the transport system:

1. Economic activities of a city are usually concentrated in central areas, although many activities often move to suburbs. It always causes congestions as a result of people’s demands for travelling to the same place (whether in central or suburban regions) at the same time.
2. The deterioration of the environment can be caused by higher mention effects called externalities but also by other impacts independent on the transport.
3. The accessibility and the mobility are the basic condition of the city functioning. The accessibility is to be understood like the possibility of the access of the inhabitants to a number of activities by the access to the transport. The mobility is to be understood like the ability of the movement in the city through the transport system. The mobility can have many limitations: delays caused by congestions, high transport costs or low revenues of a transport company.
4. The losses of the public transport can be described partly by the demands for high investment into the transport infrastructure, partly for operation sources. The tariffs often do not cover these high costs and the losses of transport companies rise. The competition of the individual car transport and daytime dependent demand increase these losses.
5. Social considerations are connected with the question of accessibility and mobility for all city inhabitants.
6. The consumption of fuels and energy creates an essential factor of the transport system functioning. Nowadays the oil and natural gas supplies are a serious problem, because these commodities have been becoming scarce resources. That is why the pressure has been being put on the more effective transport systems with lower energy consumption of transport means all over the world.
4 Mobility and its control
The changes taking place in the post-industrial society towards the information and knowledge society also pressure the changes of the city system. These changes can be described by the following linkages and interactions from the viewpoint of the transport system:

1. Mobility control with the use of marketing strategies with a complex concept of system elements
2. Implementation of the transport control strategy and area planning with the accessibility to transport services
3. Harmonization of the freedom of motion (door to door) with the decision making about infrastructure investments, with the project, real estate and development decisions and with the decisions of transport companies ensuring the public transport
4. New marketing approach to commercial, industrial and administration activities
5. City system management and social responsibility

The integration of these factors can be ensured by a managerial approach using the control of these factors towards a creation of a network of activities that will ensure a competitive and effective pressure on the support of the city system development with the respect not only to economic goals, but also to the social and environmental responsibility.

The concern is in fact the connection or linkage of a city inhabitant or consumer partly with the suppliers of production values (big industrial, commercial and administration centres), partly with the suppliers of access routes (operators, deliverers and other cooperating systems). The control is made so that mainly the strategic and the planning activity lead not only to the local development of fragments with good accessibility, but also that the accessibility to all localities and city system parts is ensured.

5 Energy and transport
The world economics has been facing the increase in crude oil and nature gas prices. Nature gas’s price in-crease is usually rather delayed. The primary resources of energy, both, oil and nature gas, represent an essential raw material not only for energy and transport systems, they also have the large deal for the development of other industrial branches. In contrast to the previous crises, we have met certain opinions and predictions about the termination of cheap oil and nature period. The world economics should forget their low prices. It might seem that higher prices signals notify of the lack of oil and nature gas, although this could be false information. The contribution points out at numerous factors influencing the price of the important energy resources. Combined impact of the supply and demand is in question as well as the problem of exhaustion of the above mentioned resources and the competitiveness of alternative resources, geological and geographical conditions, reliability of the supplies and, last but not least, the political, social and terrorist aspects.

Energy remains an important production factor of economic growth. Energy resources must be safe and reliable, environment-friendly and will have to be sufficient for the future. None of the contemporary energy resources is close to any of these conditions.

The demand depends on the following factors: change in industrial structure, material changes and substitutions, transport changes, the development of energy technologies with the higher efficiency. These factors can influence the end energy using in sectors as shown: Civil Engineering (40%), Industry (30%), and Transport (30%). It is supposed that the structure will tend to the higher rate of energy used in transport and still remains based on combustion of fossil fuels. The primary energy resources are crucial for the next decision process. The condition of sustainable development based on a steady growth of primary resources exploitation leads to limited consumption in countries with higher income (energy conservation). Changes in energy production and transformation at a higher efficiency should raise the lower energy consumption in developing countries.

We face two problems: the environmental impacts of fossil fuels, and the possibility to replace these energy sources. Displacing fossil fuels from their current dominate position leads to a discussion of alternative sources based on the renewable energy. If we take into account that current fossil fuels cover about 90% of the total world supply, we can have doubts about any long-term solution. Simply restriction the use of fossil fuels will generate adequate incentives to develop and use new energy sources, and will create abundant new energy technologies that do not rely on fossil fuels. But it is apparently belief. There are reasons to doubt that changing relation of prices and thereby incentives to use fossil fuels will bring
forth alternation forms of energy in the amounts demanded.

The energy crises confirmed that the interest in alternative possibilities always rises when these crises last longer. It also verified in 1973, when the interest in use of alternative sources both in energetics and in transportation began to rise. The competitive ability of alternative sources results from the comparison with fossil (non renewable) energy resources:

- Renewable resources can still not compete with fossil fuels, as their price is lower with respect to their present surplus. But in many cases the possibility of the competition exists. [5]
- The use of actual fossil sources has its limitations. One of these limitations is the fear of the contribution of emissions to the greenhouse effect.
- Non renewable sources are a concentrated form of the sun energy.
- In the renewable sources the sun energy is dispersed.

There exist the following groups of factors that can influence the use of the natural gas and the oil:

1. Essential growth of prices
2. Growth of changes of the environment that can be influenced by the use of the fossil fuels like the dominating primary energy source.
3. Energetics problem: how to substitute these fossil fuels so that the relatively sufficient amount of these fuels is substituted by other fuels with the corresponding provision of energetic needs.

The production of the greenhouse effect with the essential contribution of the carbon dioxide and the factors influencing the carbon dioxide emissions can be expressed in the macroeconomic equation:

\[ \text{CO}_2 = \text{POP} \cdot h \cdot \text{en} \cdot e\text{CO}_2 \]  

(1)

where \( \text{CO}_2 \) = amount of carbon dioxide emissions; \( \text{POP} \) = population; \( h \) = GDP per capita; \( \text{en} \) = energy intensity of the economic system; \( e\text{CO}_2 \) = amount of carbon dioxide on the unit of energy carrier (carbon intensity). [3]

It follows from the equation (1), that the emissions grow with the population growth, with the economic growth, with the high energy set out of the economy and with the high portion of the fuels with high carbon content on the produced energy unit. The high content of carbon leads to high carbon dioxide emissions. The population and economic growth will be followed by the growth of emissions.

The emissions can be reduced by:
- the cut down of the energy intensity
- the cut down of the carbon intensity

To decrease the carbon intensity means to move from the fossil fuels to fuels with low or no carbon content.

6 Conclusions

The transport in the 21st century will have to solve the serious problem of energy sources. It is of course the problem old as the mankind itself that was solved (evidently only temporarily) in the period of the peak industrial revolution, when the oil became the ideal product for transport means propulsion.

The oil found its fatal use as motor propulsion source at the break of the 19th and 20th century. A natural source became the economic one; the mankind has known it for long, nevertheless only the technology development caused by the industrial revolution made it possible to use the oil in a truly massive way. In this context we can ask whether we are also not in the same situation in the looking for a new energy source for the future, maybe only yet next unknown technologies make it possible to use as fuel in transportation that what we have before eyes now, but we can not see it.

From many alternatives to the oil no one is sufficiently competitive, if we put on such alternative fuels four basic requirements – i.e. the technologic, energetic, environmental and economic comparability with the conventional fuels. From the technology viewpoint not only the transport means themselves are concerned, but also the construction of the infrastructure of the filling stations (in the case of electric cars the charging ones). The next problem of fuels is their energetic characteristics – so the rate of the energy won and used. This rate is the most favourable for the energetic commodities, which have the basic advantage – they can offer a big amount of energy in low volume of commodity. In the case of oil this rate was the best in the beginning of its use, but it has gradually been decreasing with the worsening of its extraction conditions.

The electricity meanwhile puts up as a possible substitution of the classical fuels in the transportation. It is nothing new, the use of it for
the transport means propulsion was already debated at the beginning of the 20th century. Today this idea comes back also with respect to a technologic shift above all in the development of accumulators. Todays ones can be loaded for 60% in 15 minutes again (the negative is the decrease of the battery lifetime). Of course the problem of electric cars remains the distance that they can travel after one charging and other running features. That is why their use is expected first in cities, where there are enough possibilities of their charging (overnight or in the workplace). As for energy sources, not only the classical ones can be used, but also the local ones, e.g. the wind or solar energy.

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