

## LOGISTICAL DEVELOPMENTS IN URBAN DISTRIBUTION AND THEIR IMPACT ON ENERGY USE AND THE ENVIRONMENT

R. ter Brugge

*Department of Logistics, INRO-TNO (Institute of Spatial Organization),  
P.O. Box 45, 2600 AA Delft, The Netherlands*

### SUMMARY

Prior to dealing with urban freight distribution, an overview will be presented of the overall freight market and the existing trends in logistics from the point of view of environmental impacts. An illustration will be given of the growing use of automobiles, to prove that this is the main problem to focus on. Subsequently the possibilities and limits of technological developments are given. In a recent study we have indicated that the use of technical improvements, that are known at the very moment, can curb energy consumption with 17 %. In other words, given the expected growth rates technical solutions are not sufficient. Based on other research it is shown that the organization of transport, i.e. the logistical organization can be instrumental in getting a much higher efficiency in transport. Based on these principles the paper evaluates the strategies for freight transport in urban areas. Also the improvement of freight transport in urban areas will ask for a better logistical organization, implementation of information technology and new transport technologies and for measures in the field of physical planning within cities. These measures will be asked for in that order and in their combination.

### 1. FREIGHT TRANSPORT IN PERSPECTIVE

#### 1.1 Introduction

It should be noted that transport is not a goal on its own. It is a result of activities that are necessary or desirable in a society. So for transport there are a great number of alternative solutions, substitutions and direct and indirect effects. For that reason to define policies, to define potentially interesting fields

---

<sup>1</sup> The author is grateful for the help given by his colleagues B.J.P. Janssen, A.A.W.G. Mulders, C.J. Ruijgrok and P.T. Tanja.

of research and also to give a technological assessment of the R&D-outcomes a system approach is needed in transport. The lack of a system approach in transport may be one of the reasons that we seem to have lost control of transport and the related negative effects. An overview of R&D in transport shows that in this field research is very diverse, fragmented and a significant proportion of it is not in the public domain (1). The need for a system approach is one of the basic philosophical assumptions in this paper. An other one is that in transport solutions are only realistic if they are market oriented i.e. not striving against economic forces in the market.

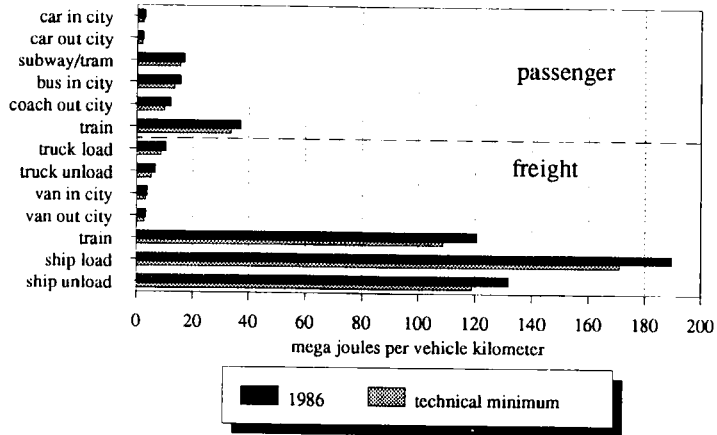


Diagram 1 Energy consumption per vehicle kilometer in 1986 and the technical minimum amount used for inland transport in the Netherlands (MJ/km).

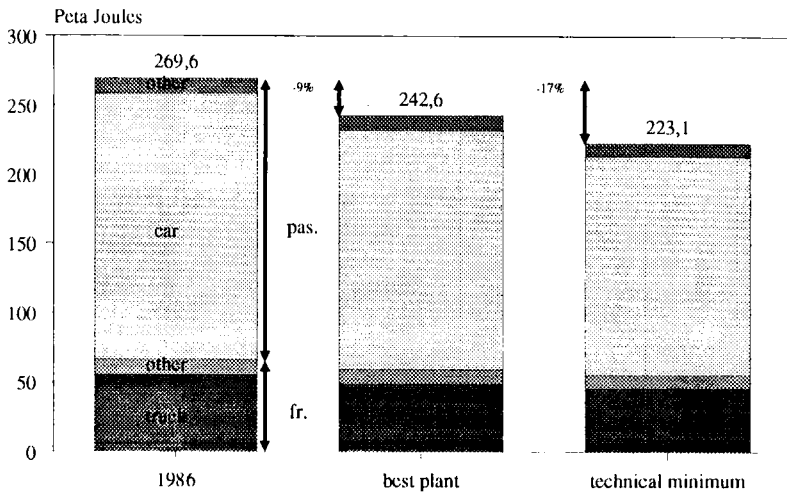


Diagram 2 Total energy consumption for passenger and freight transport by car and other transport modes in 1986, for the 'best plant situation' and the 'technical minimum' in PJ.

A good illustration of environmental losses caused by transport can be given by a study INRO-TNO recently completed on technical opportunities to reduce energy consumption in transport. The study was commissioned by the Dutch Central Bureau for Economic Planning(2). It should be noted that by doing so, we assume the energy consumption in transport is closely related to the loss of environmental quality. So, where pollution is related to the energy consumption and given the fact that energy consumption has its price, economic forces in transport will work in line with environmental goals. This statement is only true to a certain extent. Firstly not all energy consumption is related to environmental damage of transport, for instance we can mention the effects on the landscape of transport infrastructure. Secondly in some cases energy is needed to decrease pollution; as in the case for catalytic converters. Thirdly, as will be shown in the paper, there is a trade off between production and transport costs. Nevertheless an analysis of energy consumption gives a fairly good picture of several components of the transport market related to environmental quality.

### 1.2 Energy consumption per vehicle

The number of passengers or the amount of freight transported is not the prime cause of energy consumption in transport. The focus should be on vehicular movement. The efficiency of the (logistical) organization will relate the volume of traffic to the amount of freight and passengers transported. Diagram 1 shows the energy consumption per vehicle in megajoules per kilometer.

At first sight the low figures for the automobile might be confusing. In this diagram a variety of capacities are compared. Given these figures a train should at least transport 30 persons to be equal in energy consumption to a car carrying one person. The train is here defined as a locomotive with an average number of train cars behind it. Consequently, if there are 4 persons in a private car, the train should carry 120 passengers to compensate in energy consumption. Moreover, in the diagram, the comparison is made for 'a generalized kilometer'. Actually we should wonder if the train brings passengers from places where they are, to places where they want to be, i.e. here we deal with the fundamental problem in transport of spatial distribution and consolidation.

### 1.3 Existing mobility patterns

Diagram 1 also gives an indication of the potential energy savings by technical measures. We have calculated the energy consumption based on the mobility patterns and several modes used in 1986. Based on this existing mobility pattern the 'best plant' and the 'technical minimum' situation were defined. For the 'best plant' situation it was assumed that all vehicles used possess those technical features that are normal when purchased in 1990. For the 'technical minimum' we moreover assumed that all vehicles have the technical features that are available and can be used, even if they are hardly economic at this moment. By doing so the basic assumption is, that most technical possibilities available in 1990 are being used. At the same time it is postulated that all other conditions are

unchanged, i.e. people make use of comparable types of vehicles and arrange their transport as they did in 1986. On this basis the overall energy consumption is described in diagram 2 for inland transport in the Netherlands for these three situations. This diagram illustrates that 10 to 17 % of energy consumption in transport could have been saved in 1990 by merely technological measures.

A number of things can be learned from the analysis thus far:

- \* About 92 % of the total energy consumption in transport concerns private cars, trucks and vans. The share of trains, trams and inland water transport is very limited.
- \* Freight transport does ask about 30% of the overall energy consumption in transport. It may be expected that this share will increase.
- \* Analysis on energy consumption in transport contains in many cases a lot of ambiguity, because the overall figures are the result of spatial and behavioral patterns, the necessity of transport, the organization of transport. This include the number of unloaded kilometers driven and the modal choice. All those aspects are related, because transport is an integrated activity within the society.
- \* Technical solutions surely will have a significant effect on energy savings. At maximum it will give a contribution of 17 % in the savings, especially important is the efficiency of passenger transport by car.

So our analysis leads to the conclusion that it is not only technological development that may help to solve environmental problems. Since 1973 a lot of research has been done on more energy efficient vehicles. Many features have already been implemented. The limits of energy conversion for traction by employing the currently applied techniques will be reached soon. Illustrative can also be the comparison given between loaded and unloaded vehicles in diagram 1, showing that these vehicles carry their load rather efficient. Moreover it is important to realize that the use of all these newer techniques will ask for an overall replacement of the transport equipment and thus will ask for a destruction of capital. By doing so we destroy the internal energy of these existing vehicles. In a number of cases it can be more efficient, in terms of overall energy consumption, to keep the older machinery for a restricted number of jobs i.e. kilometers driven, then to replace them for more efficient ones. This also proves that 17% savings is the technological minimum.

An important part, almost half of all transport, is on a regional scale, where people live and work together in a "well known" area. Here the negative effects of transport are severely felt. This statement does however not mean that long distance transport is of no importance, nor without problems. But on long distances the share of transport in the total price of a good will be higher and so economic efficiency already will be a greater incentive to save energy and thus the environment. So it might be expected that the energy efficiency of long distance transport is higher.

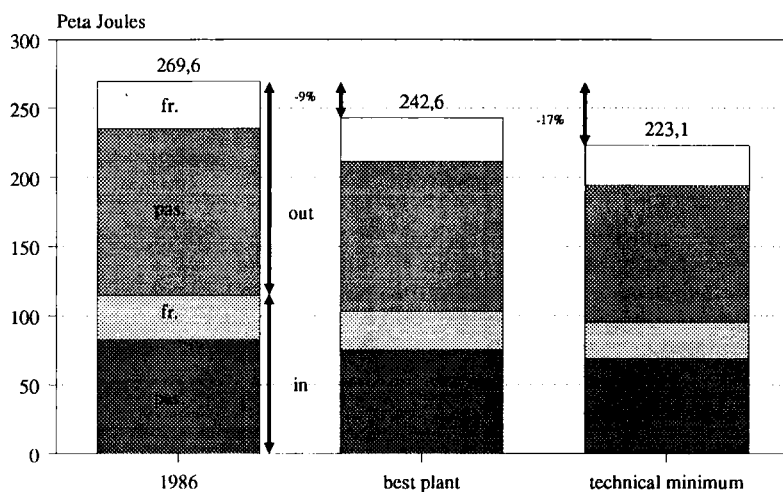


Diagram 3 Energy consumption in transport inside and outside cities in 1986 (PJ)

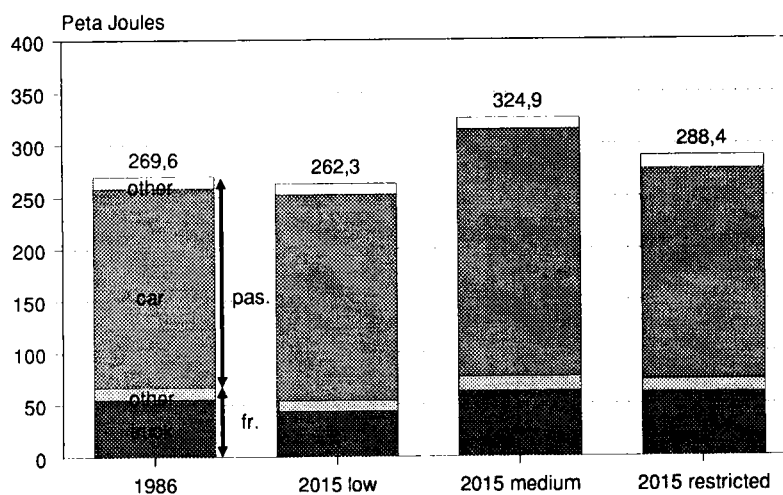


Diagram 4 Forecast of the energy consumption in transport in 2015, given the "best plant" situation for a low and medium economic scenario. For the latter also the scenario of a very restrictive policy towards energy consumption is given (in PJ)

Diagrams 3 shows that indeed nearly half of the energy consumption in transport takes place in cities and large conurbations. These figures are for inland transport in the Netherlands, including international transport in the country, but excluding the energy consumption in air traffic and marine transport.

#### 1.4 Scenarios for future mobility

Within 25 years, in the year 2015 we may expect that most of the techniques known at this moment will be implemented. To estimate the overall effects a forecast is needed of economic growth and mobility patterns. These forecasts are very uncertain. The best thing to do is to formulate possible scenarios. Diagram 4 does give such scenarios with a low economic growth (GNP growth rate till 2000 of 1,5 % and from then 2 %) and a medium one (GNP growth rate till 2000 of 2,75 % and in succession 2,88 %). Along with the economic and population forecasts some of the reasonably expected trends in mobility have been prognosticated. For the 'medium scenario' a number of additional political measures are presumed given a very restive energy policy.

Such an analysis shows that only in the low scenario the energy consumption is equal, or even some lower, than the 1986 situation. This scenario does not seem to be very likely, because a low economic growth will not be a stimulate for technical development, neither for the implementation of newer techniques, so the overall priority to preserve environmental quality probably will be less. If we believe that the pollution of today's traffic already is too high, the conclusion seems to be inevitable that all other possibilities to curb mobility will be needed. By doing so we should bare in mind that this might be in contrast with economic progress and also with a greater individual freedom of all mankind, trying to become global citizens. This statement may seem to be dramatic, but does demand serious consideration given the recent developments in the Third World and behind the former "Iron Curtain". So the fundamental question will be: "Is a less mobile society also less enjoyable, or can mobility be more efficiently organized?" This last questions concerns logistical organization.

## **2. IS LOGISTICS IN FAVOR OF ENVIRONMENTAL QUALITY ?**

### 2.1 Logistical trends of consignors

In 1989 INRO-TNO completed a research project on logistics, energy and the environment (3). Based on experts interviews and a literature review the study explores changes in energy consumption in transport caused by the expected dynamics in companies that produce and transport goods.

For a better understanding of this dynamic process a subdivision was made on the effects of:

- origins and destinations
- volumes of transport flows
- modal split
- optimizing transport in terms of sizes of the shipments, loads, frequencies and so on.

In the course of the research it turned out that there are important differences between the logistical developments taking place at the consignors and consignees (companies in production and trade) and at the shippers and carriers (logistical service organizations). Trends of the consignors are all very negative when we judge them in environmental terms and look at the amount and the type transport needed. Growing internationalization, a better customer service, greater variety in products, shorter life cycles, flexible production, just in time (JIT) production and delivery, etcetera all are leading to more transport over longer distances and with higher frequencies. The greater value of the freight, automation and economies of scale within companies will have the result that more money can be spent on transport as such. A greater energy consumption in transport can be substituted with a greater efficiency in production, but such a trade off is not necessarily one in terms of energy only. At the other hand a vicious circle can be noted. Economies of scale, also in transport itself, will lead to lower prices and thus an increased movements of freight.

Some 'positive' trends for consignors are the greater (spatial) concentration on nodal points, i.e. main ports and the stronger market orientation of a lot of activities. Developments that might lower energy consumption are moreover:

\* in the short and medium term:

- subcontracting transport and distribution
- decreasing the number of suppliers given more stable relationships
- rationalization of distribution networks by eliminating intermediate links

\* in the long term:

- separation of the early production stages and assemblage, in which the production is concentrated in a restricted number of centers and assemblage is market oriented
- spatial integration of producing companies given their JIT-relationship.

Differences in long and short term mainly concerns the possibilities for the relocation of activities.

Nevertheless it can not be denied that all this inevitably will lead to an enormous growth of freight transport. The described trends should be considered in many respects as autonomous. A point in case may be the Cecchini report (4) in which the advantages are given of the enlarged European inner market after 1992, which can only be reached when interrelations, and thus transport, will grow.

## 2.2 Potentials of logistical services organizations

In contrast to the consignors, trends in the transport services are potentially much more positive from an environmental point of

view. The only negative trends can be the growing importance of express transport and an increased usage of specialized vehicles. At the other hand the developments in transport have important potentials for operating more efficient. In general it concerns all those situations where information technology can be supportive in getting a better control, architecture or organization of transport.

- Very high potentials do exist for decision support and expert systems on load planning or route planning or allocation to vehicles
- Strong reduction of energy can be reached by hub & spoke networks and main ports, intermodal transport and other possibilities that lead to increasing consolidation by the use of standard load units (containers, swap bodies). Also tracing and tracking, on board computing, mobile communication, fleet management and transport technology like high cube containers should be mentioned.
- Energy reductions seem possible in case of public warehousing and co-makership.

Essentially it should not be a surprise that the potentials are the greatest for the transport services. Consequently these measures are in contradiction to their business, i.e. to transport goods from A to B. Only competition will force them to drive less. Moreover a lot of the solutions given, do ask for co-operation to reach a sufficient scale and have possibilities to optimize. The transport market is very fragmented, complex, with many niches. Given the variety of goods, modes, origins and destinations we can see many 'monopolists' in a free market system. Here we come to the basic problem in logistics. At the one hand severe competition is needed to force transport firms to be efficient and at the other hand there has to be co-operation to reach a sufficient scale for delivering services within enlarging networks. No wonder a balance is needed between public and private facilities. Key issues are here:

- \* logistical organization to optimize control
- \* information technology and telematics
- \* transport technology.

### 3. URBAN FREIGHT DISTRIBUTION

#### 3.1 Logistical organization to optimize control

It has been shown that trends in logistics are not primarily technology driven. The ability to control integrated logistical chains stems from the greater knowledge we have to control complex organizations. Customers do not ask for high speed in transport, nor for continuous information on their goods, nor for containers and quick load systems. They simply ask for reliability; delivery of goods at the right time, without damage and at a fair price. They need to have the feeling that their things are in good hands during transport. The example of the express companies proves that this will ask for an organizational concept. They offer a transport concept that can be used as a model for many logistical services. This concept is based on quality and so their operation is almost inelastic to an increasing price of transport, for instance by raising energy prices. A good logistical organization has potentially

incentives for a more energy efficient transport, but it will be hardly sensitive to higher energy prices, so this dimension should be brought into the process in some other way. The organizational challenge will be to make systems in which capacities can be shared in an optimal way, without diminishing in the same time competitive forces of private enterprises. Even sharing the capacities of passenger and freight transport can be of interest, given the fact that there is often a great correspondence and complement in places and in times that people and goods should be moved from one place to the other (5)

### 3.2 Information technology and telematics

Information technology is an aid or resource to accomplish the organizational requirements. Here we are confronted with a remarkable situation. At the one hand almost all the techniques for the decennia to come are available, but we have only a very vague idea about applications and consequences (6). Telematics is especially important in trade and transport having many intercompany connections, that can be facilitated by EDI-systems (Electronic Data Interchange). At the moment EDI is introduced in the bigger companies, setting standards for their subsidiaries. But in the years to come the normally, smaller transport firms and the governmental services (customs, traffic management, infrastructure management) will also be involved. The extensive programs within the scope of DRIVE, EURET, RACE, TEDIS and EUREKA might be an illustration. Information technology gives the possibility to monitor freight and vehicle flows and so control them. Main questions here will be: who is responsible and how can we protect privacy?

### 3.3 Transport technology

Transport technology is also changing very rapidly. For consolidation and distribution of inter city and intra city freight transport, interfaces between several modes and flows is the main issue. Terminals making use of quick load systems, robotica and automatic guided vehicles (AGV) for the arrangement, for sorting and for storing freight of different sizes, shapes and nature can be built. As far as the nature of freight is concerned an institution as Collomodule in the Netherlands, making standardized packing material is essential. At this moment the technological developments in industries and public research institutes are enormous.

Apart from the terminal facilities, vehicle technology is changing. For reasons of interfacing, this also concerns load units like containers and swap bodies. A main option for R&D seems to be to develop an urban car. The design requirements can easily be specified and are in many respects the same for freight and for passenger transport. We are looking for quiet, non polluting vehicles, that normally will not drive long distances every day and make frequent stops. So the solution can be a modular electrical car, built of standard components that can be replaced and recycled. Braking energy can be used for instance with fly wheels and/or by recharging batteries. But also here the main item is not the technical design, but the logistical organization in big conurbations

in which these urban cars will be used.

In looking at those technological developments we should be aware of the fact that basically, transport belongs to nobody. It is an intermediate activity. If governments have the opinion that urban transport for reasons of economy and environment is an important item, then they should take their responsibility. Transport always crosses borders, thus co-operative technological research, co-ordinated and stimulated by the European Community and elsewhere, will be asked for.

### 3.4. Physical planning

Finally the physical structure of towns has to be changed in accordance with modern transportation techniques and logistics. Spatial structures are the result of activity patterns in the past and can be shaped in accordance with future forecast of spatial organization. Changes will be only possible in the long term. These concern the locations of activities, transport infrastructure (free lanes), telematics, parking facilities and so on. Especially important are the terminals and distribution centers in the urban area.

### 3.5 Final remarks

In this paper it has been stated that:

- Industrial trends inevitably lead to a growth of freight transport with characteristics that are in conflict with environmental quality.
- There is abundant technology to save energy and protect the environment, but the impact will for itself not be sufficient, so we are forced to define the transport problem on a higher level, i.e. the generation of mobility and the organization of transport.
- On this higher level we will be confronted with fundamental conflicts between the interests of economy and ecology.
- There are good opportunities to match this conflict in a period of rapid technological change, if the organizational principles of logistics are used to solve these problems and to optimize transport operation.
- In doing so a balance will be needed between at the one hand abundant suppliers to stimulate competition and the other hand the scale of their operations, to get an optimal usage of capacities.
- The hardest case is urban distribution, where the flow of freight transported by trucks can not be shifted to another mode. Here almost half of the energy in transport is consumed and the operations are far from optimal.
- Under the recognition that transport is a combined public and private action the answers should be contrived by giving the development into modern logistics incentives to internalize aspects of energy and the environment.

Finally it should be noted that the concept of distribution centers at the edge of large conurbations is not new at all. There have been many plans and experiments. Until now the results have been poor, because of complexity of the market and because of costs involved for an extra transshipment. Interfaces (the technical

facilities to load, sort and reload) and interfacing (the organization of this process) are crucial. The enormous increase in logistical knowledge in the last decennium in combination with the newly developed technologies in transport and in informatics, make it worthwhile to re-evaluate the efficiency of such urban freight distribution systems for the near future. A first question however, that need to be answered is, who will develop and be responsible for the logistical organization of the urban freight transport system. If the outcome of an evaluation like that, turns out to be insufficient, problems of environmental quality will force us to make them sufficient. A city community can do so by delivering the infrastructure, either the information and communication systems needed, or by building the terminals or the free lanes and parking facilities in the cities.

#### REFERENCES

- 1 Rens, J. van, Research and development in the transportsector, publication of the European Society of Transport Institutes (ESTI), Brussels, 1985.
- 2 Mulders, A.A.W.G., P.T. Tanja, R.C. Rijkeboer and R. ter Brugge, Energiebesparingspotentiëlen in het verkeer en vervoer tot 2015, INRO-TNO, Delft, 1990.
- 3 Tanja, P.T., H.F.W.J. de Leijer and R. ter Brugge, Logistiek, energie en milieu: een verkenning van de opties in logistiek en transport ter vermindering van het energiegebruik en luchtverontreiniging, INRO-TNO, Delft, 1989.
- 4 Cecchini, P. (e.a.), The european Challenge 1992: The Benefits of the Single Market, Gower, Aldershot, 1989.
- 5 Bierman, M., Toekomst op het spoor. in: Plan, 20(1989)5, 9-61.
- 6 Ruijgrok, C.J., Telematics in goods logistics process, in: H. Soekha (ed) "Telematics-Transportation and Spatial Development" The Hague, 1989.